

**UNITED STATES PATENT AND TRADEMARK OFFICE**

---

**BEFORE THE PATENT TRIAL AND APPEAL BOARD**

---

TOYOTA MOTOR CORPORATION,

Petitioner,

v.

BUNKER HILL TECHNOLOGIES, LLC

Patent Owner

---

Case No.: IPR2026-00250  
U.S. Patent No. 10,549,648

**DECLARATION OF DR. MAHDI SHAHBAKHTI**

## Table of Contents

|      |                                                                                  |    |
|------|----------------------------------------------------------------------------------|----|
| I.   | INTRODUCTION.....                                                                | 1  |
| A.   | Qualifications .....                                                             | 1  |
| B.   | Materials Considered .....                                                       | 12 |
| II.  | LEGAL STANDARDS.....                                                             | 12 |
| A.   | Anticipation.....                                                                | 13 |
| B.   | Obviousness .....                                                                | 13 |
| C.   | Level of Ordinary Skill in the Art.....                                          | 17 |
| D.   | Claim Construction .....                                                         | 18 |
| III. | SUMMARY OF OPINIONS.....                                                         | 20 |
| IV.  | THE '648 PATENT.....                                                             | 21 |
| A.   | Overview of the '648 Patent .....                                                | 21 |
| B.   | Prosecution History of the '648 Patent .....                                     | 23 |
| V.   | BACKGROUND ON PLANETARY GEARS AND POWER TRANSFER<br>.....                        | 24 |
| VI.  | OVERVIEW OF PRIOR ART CONSIDERED.....                                            | 28 |
| A.   | Conlon.....                                                                      | 28 |
| B.   | Reynolds .....                                                                   | 28 |
| C.   | Ortmann .....                                                                    | 29 |
| VII. | GROUND 1: CLAIMS 1, 4, 5, 7, 8, 16, AND 18-20 ARE ANTICIPATED<br>BY CONLON ..... | 29 |
| A.   | Independent Claim 1.....                                                         | 29 |
| B.   | Dependent Claim 4 .....                                                          | 41 |
| C.   | Dependent Claim 5 .....                                                          | 41 |
| D.   | Dependent Claim 7 .....                                                          | 42 |
| E.   | Dependent Claim 8 .....                                                          | 43 |
| F.   | Independent Claim 16.....                                                        | 44 |
| G.   | Dependent Claim 18 .....                                                         | 56 |

|       |                                                                                            |     |
|-------|--------------------------------------------------------------------------------------------|-----|
| H.    | Dependent Claim 19 .....                                                                   | 57  |
| I.    | Dependent Claim 20 .....                                                                   | 58  |
| VIII. | GROUND 2: CLAIMS 1, 4, 5, 7, 8, 16, AND 18-20 ARE OBVIOUS<br>OVER CONLON .....             | 59  |
| A.    | Independent Claim 1 .....                                                                  | 59  |
| B.    | Dependent Claim 4 .....                                                                    | 72  |
| C.    | Dependent Claim 5 .....                                                                    | 72  |
| D.    | Dependent Claim 7 .....                                                                    | 73  |
| E.    | Dependent Claim 8 .....                                                                    | 74  |
| F.    | Independent Claim 16.....                                                                  | 75  |
| G.    | Dependent Claim 18 .....                                                                   | 87  |
| H.    | Dependent Claim 19 .....                                                                   | 88  |
| I.    | Dependent Claim 20 .....                                                                   | 89  |
| IX.   | GROUND 3: CLAIMS 2, 3, 6, 9-15, AND 17 ARE OBVIOUS OVER<br>CONLON IN VIEW OF REYNOLDS..... | 90  |
| A.    | Motivation to Combine Conlon and Reynolds.....                                             | 90  |
| B.    | Dependent Claim 2 .....                                                                    | 90  |
| C.    | Dependent Claim 3 .....                                                                    | 93  |
| D.    | Dependent Claim 6 .....                                                                    | 95  |
| E.    | Independent Claim 9.....                                                                   | 97  |
| F.    | Dependent Claim 10 .....                                                                   | 112 |
| G.    | Dependent Claim 11 .....                                                                   | 115 |
| H.    | Dependent Claim 12 .....                                                                   | 117 |
| I.    | Dependent Claim 13 .....                                                                   | 117 |
| J.    | Dependent Claim 14 .....                                                                   | 118 |
| K.    | Dependent Claim 15 .....                                                                   | 119 |
| L.    | Dependent Claim 17 .....                                                                   | 120 |
| X.    | GROUND 4: CLAIMS 1, 2, 4-10, AND 12-20 ARE ANTICIPATED BY<br>ORTMANN.....                  | 122 |

|      |                                                             |     |
|------|-------------------------------------------------------------|-----|
| A.   | Independent Claim 1 .....                                   | 123 |
| B.   | Dependent Claim 2.....                                      | 139 |
| C.   | Dependent Claim 4.....                                      | 139 |
| D.   | Dependent Claim 5.....                                      | 139 |
| E.   | Dependent Claim 6.....                                      | 140 |
| F.   | Dependent Claim 7.....                                      | 140 |
| G.   | Dependent Claim 8.....                                      | 141 |
| H.   | Independent Claim 9 .....                                   | 142 |
| I.   | Dependent Claim 10 .....                                    | 158 |
| J.   | Dependent Claim 12 .....                                    | 158 |
| K.   | Dependent Claim 13 .....                                    | 159 |
| L.   | Dependent Claim 14 .....                                    | 159 |
| M.   | Dependent Claim 15 .....                                    | 160 |
| N.   | Independent Claim 16.....                                   | 161 |
| O.   | Dependent Claim 17 .....                                    | 176 |
| P.   | Dependent Claim 18 .....                                    | 176 |
| Q.   | Dependent Claim 19 .....                                    | 177 |
| R.   | Dependent Claim 20 .....                                    | 177 |
| XI.  | GROUND 5: CLAIMS 3 AND 11 ARE OBVIOUS OVER ORTMANN<br>..... | 178 |
| A.   | Dependent Claim 3 .....                                     | 178 |
| B.   | Dependent Claim 11 .....                                    | 180 |
| XII. | CONCLUSION .....                                            | 181 |

## **I. INTRODUCTION**

1. I have been retained by Toyota Motor Corporation (“Toyota” or “Petitioner”) as an independent expert in this proceeding before the Patent Trial and Appeal Board (“PTAB” or “Board”). I understand that Toyota is requesting that the Board institute an *inter partes* review (“IPR”) proceeding of U.S. Patent No. 10,549,648 (“the ’648 Patent”) (EX1001), currently assigned to Bunker Hill Technologies, LLC (“Patent Owner” or “PO”).

2. I am not and have never been an employee of Toyota. I am being compensated at my usual and customary rate of \$330 per hour. No part of my compensation depends on the outcome of this proceeding, and I have no other interest in this proceeding.

3. I have been asked to provide my independent analysis of the ’648 Patent in light of the prior art publications cited below. I have also been asked to consider the state of the art and prior art available as of January 30, 2014. Based on the prior art discussed in this declaration, it is my opinion that claims 1-20 of the ’648 Patent are unpatentable for the reasons provided below.

### **A. Qualifications**

4. I am over 18 years of age and, if I am called upon to do so, I would be competent to testify as to the matters set forth herein. A copy of my current curriculum vitae, which details my education and professional and academic

experience, is Exhibit 1009 to the Petition. The following provides an overview of some of my experience that is relevant to the matters set forth in this declaration.

5. I am a Professor of Mechanical Engineering at the University of Alberta and an Adjunct Professor of Mechanical Engineering at Michigan Technological University. At the University of Alberta, I serve as the Director of the Energy Mechatronics Laboratory. The Energy Mechatronics Laboratory (EML) conducts research in a multidisciplinary area of engineering that includes mechanical and electrical systems, design of thermo-fluid systems, and control engineering. A large portion of EML research centers on automotive powertrain systems and vehicles.

6. I am also a professional engineer (PEng) registered in Alberta (license # 284744). Over the past several years, I have led various projects in the area of automotive and mechatronics systems. I currently lead several design, fabrication, and testing projects in the field of mechanical and electrical engineering including, among other things, hybrid electric and electric powertrain systems, and also internal combustion engines running with conventional and alternative fuels.

7. Before joining Michigan Technological University in 2012, I spent two years as a post-doctoral scholar at the Mechanical Engineering Department at the University of California, Berkeley. My post-doctorate work focused on model-based design and adaptive control of automotive systems, including powertrains and others and consisted of working closely with the Toyota Motor Company.

8. I earned a Ph.D. in Mechanical Engineering from the University of Alberta in 2009 and a Master of Science degree from KNT University of Technology in 2003. Both my Ph.D. and MSc. dissertations were in the area of automotive powertrain systems. A large portion of my research activities in the past 25 years have centered on design, modeling, and control of automotive propulsion systems, including conventional, hybrid electric, and electric vehicles.

9. I have direct industry experience related to the control of automotive propulsion systems. From 2001 to 2004, I worked as a researcher in the automotive industry. During this time, I was involved in the research and development of internal combustion engines and powertrain management systems for gasoline and natural gas bi-fuel vehicles. In the past 14 years, I, along with my research group, have performed a number of research projects sponsored by various companies such as Ford Motor Company, Toyota Motor Corporation, General Motors Corporation, Hyundai, Cummins, Westport, IAV GmbH, Hitachi, and Denso.

10. For example, I, along with my research group at Michigan Tech, built a hybrid electric powertrain test platform including a 100-kW AC electric motor and a 201-kW GM Ecotec engine. The testbed was used for testing various aspects of powertrain performance including real-time torque control during transient and steady state operations. In addition, I, along with my research group at Michigan Tech, tested and evaluated different hybrid electric vehicle platforms for at least

eight years. For instance, my research group in partnership with GM, worked on the Chevy Volt Gen II hybrid electric vehicle for powertrain modeling and control to maximize energy saving via utilization of vehicle connectivity data and automation. This was part of a \$2.8M funded project by the US Department of Energy Advanced Research Projects Agency-Energy (ARPA-E) program that took place from 2017 to 2020. A number of peer-reviewed journal and conference publications from my research group documented our research studies covering different hybrid electric vehicle architectures including series, parallel, and powersplit powertrains ranging from mild to full hybrid, plug-in hybrid, and extended range electric vehicles. Another example of my work is a 2014–2017 National Science Foundation (NSF)-funded project, ‘Easily Verifiable Controller Design,’ focused on automotive powertrain applications. Serving as the Principal Investigator, I led a collaborative effort among Toyota Motor North America R&D (Ann Arbor), UC Berkeley, and Michigan Tech. My research group developed adaptive control frameworks for complex and nonlinear engine control problems and engineered an online uncertainty prediction mechanism to mitigate analog-to-digital conversion (ADC) imprecision in control software.

11. I have also worked on various aspects of internal combustion engines including design, modeling, benchmarking, experimental studies, calibration, and electronic control unit (ECU) design and implementation since 2000. These include

dual fuel, bi-fuel, and single-fuel engines. I along with my research group have covered various engine types including spark ignition (*e.g.*, gasoline), compression ignition (*e.g.*, diesel), lean burn, low temperature combustion (HCCI, PPCI, RCCI) engines, and their exhaust aftertreatment systems.

12. I also have experience with automotive control systems including modeling, design, and implementation. This work encompasses numerous projects in the past 25 years for vehicles including conventional, hybrid electric, electric, and connected and automated vehicles. Many of these projects include the design of prototype systems for collecting required vehicle/powertrain data and implementing and testing designed real-time automotive controllers.

13. I have taught undergraduate and graduate courses in mechanical engineering departments in the U.S. and Canada since 2004, taking the role as a primary instructor for more than 27 academic semesters, and a teaching assistant for eight academic semesters. I have frequently taught graduate and undergraduate courses in the areas of Internal Combustion Engines, and Advanced Propulsion Systems for Electric and Hybrid Electric Vehicles in the past 17 years. For instance, I regularly taught a graduate course (MEEM 5295) on Advanced Vehicle Propulsion Systems for Hybrid Electric Vehicles at Michigan Tech (2016-2019) and have taught technical electric undergraduate course (MECE 442) on Vehicle Propulsion Systems at the University of Alberta. I am teaching MECE 442 in this semester and in this

course I discuss design of electric, hybrid electric, and conventional powertrain systems and optimal operating modes for vehicles to meet target fuel consumption and emission standards in the US and Canada. Other relevant courses include a graduate course on Internal Combustion Engines and Alternative Fuels, graduate courses in the area of Machine Learning Control, Model Predictive Control and undergraduate courses in the area of Applied Thermodynamics.

14. I have led international workshops in the areas of controls and data systems including “Methods of Easily verifiable Control Design,” “Connected and Automated Vehicles (CAVs),” and “From Data to Models and Decisions in Engineering Systems” at conferences such as the American Control Conference and ASME (American Society of Mechanical Engineers) Dynamic Systems and Controls conference.

15. I have supervised 148 graduate and undergraduate students for mechanical engineering research projects or dissertations. These include 37 Ph.D., 77 M.S., and 34 B.S. students in the mechanical engineering departments in four academic institutions from 2010 to 2026. Many of these mentorships have centered on automotive engineering, covering modeling, design, experimentation, diagnostics, and control. A large number of the graduates from my research group have joined the automotive industry after graduation. These companies include Ford Motor Company, General Motors, Fiat Chrysler Automobiles, Toyota Motor

Company, Karma Automotive, Tesla, Rivian, Cummins, Electra Vehicles, Bosch, APTIV, GKN Driveline, etc.

16. I am currently the Technical Editor for the International Journal of American Society of Mechanical Engineers (ASME)/Institute of Electrical and Electronics Engineers (IEEE) Transactions on Mechatronics. In addition, I served six years as the Associate Editor for ASME Journal of Dynamic Systems, Measurement, and Controls (2017-2023), Associate Editor (2014-2020) for the International Journal of Powertrains (Inderscience Publishers) and a guest editor for a special issue on “Optimal Design and Operation of Energy Systems” in the International Journal of Optimal Control Applications and Methods (2020-2022). In these roles, I have regularly evaluated research work in the field of mechanical and electrical engineering systems. In addition, I serve as an Editorial Board Member in the International Journal of Vehicle Autonomous Systems, International Journal of Automobiles and Automobile Technologies, International Journal of Powertrains.

17. I have also served on the United States’ National Science Foundation (NSF) and U.S. Department of Energy (DOE) review panels in the areas of mechanical engineering systems, controls, and energy systems. I have been a reviewer for: (i) international grant proposals from funding agencies from the United States, Canada, Croatia, France, Germany, Poland, and the Netherlands, (ii) the U.S. Academy of Engineering research program of the US DRIVE Partnership, (iii) 24

international engineering journals, and (iv) Springer International Publishing for books in the areas of controls and automotive systems.

18. I have been a member of the Society of Automotive Engineers (SAE) (membership #6109271569) for about 20 years. I have organized a number of technical sessions in the area of automotive systems at SAE World Congress in Detroit during 2016 and 2022. In addition, I have been a member of SAE Technical Committee on New Engines, Components, Actuators and Sensors since 2016.

19. I have been a member of the American Society of Mechanical Engineers (ASME) for the past thirteen years (membership #125958). I am a very active member of ASME's Dynamic Systems & Control Division and have served as the chair of the Energy Systems technical committee (2018–2020), chair of the Automotive Transportation Systems technical committee (2020–2022), and chaired 45 sessions and co-organized more than 70 technical sessions in the areas of modeling, design, optimization, and control of mechanical engineering systems. I am currently part of the ASME executive committee for the Dynamic Systems & Control Division.

20. I have been awarded over \$6.1 million in grants/support as a Principal Investigator (PI) and over \$9.0 million as a co-PI from international, federal, provincial, and industry sources for conducting research in the areas of design, modeling, optimization, and control of mechanical/electrical engineering systems.

Energy Mechatronics Laboratory (EML) under my supervision specializes in the instrumentation, testing, and analysis of emerging vehicle technologies — from light-duty passenger cars to heavy-duty commercial trucks and buses. To date, we have led third-party evaluations of more than \$40 million in commercial vehicle technologies, including electric, hybrid electric, fuel cell, and hydrogen-diesel platforms, benchmarking them against conventional diesel and gasoline powertrains. These projects have been supported by the automotive industry along with the federal and provincial funding agencies committed to advancing alternative vehicle technologies suited to the Canadian climate and ecosystem.

21. I have been recognized by many different awards. Some of the recognitions/awards for my work related to automotive systems include:

- Transport Canada 2023 Technology Achievement Award Finalist, 2023.
- Best Presentation Award, SAE Int. Powertrain, Fuels & Lubricants Conference, Baltimore, MD, USA, 2016.
- Best Presentation in the Session, American Control Conference (ACC), 2012 (Montreal), 2015 (Chicago).
- Society of Automotive Engineers (SAE) International Ralph R. Teetor Educational Award, 2016 (An international award recognizing top engineering educators for outstanding contributions).

- Best Paper Award, ASME Automotive and Transportation Systems  
Technical Committee – ASME Dynamic Systems Control Conference,  
Columbus, OH, USA, 2015.
- Best Paper Award, ASME Automotive and Transportation Systems  
Technical Committee – ASME Dynamic Systems Control Conference,  
Fort Lauderdale, FL, USA, 2012.
- Canada NSERC (Natural Science and Engineering Research Council)  
Postdoctoral Fellowship, 2010 – 2012.
- Zita and John Rosen Teaching Excellence Award for Principal  
Instructor, University of Alberta, 2009. I received this award for  
teaching Internal Combustion Engine (MECE 541) course. Only one  
award, across the university, is granted annually to give special  
recognition to a graduate student principal instructor who is an  
especially skilled and dedicated teacher.
- David Morris Graduate Scholarship in Automotive Engineering,  
University of Alberta, 2008.
- Winning Team (first prize) of a Total of 66 Research Teams from 26  
Canadian Universities, Canada Automotive21 High Qualified  
Personnel Competition, Windsor, Canada, June 11-13, 2007.

- Chevron Graduate Scholarship in Natural Gas Engineering, University of Alberta, 2005.
- Best Paper Award in 3rd International Conference on Internal Combustion Engines, Tehran, Iran, 2004.
- Summa Cum Laude (ranked first among graduates) in MSc Mech Eng – Powertrain (2003), K. N. Toosi University of Technology, Tehran, Iran.

22. My publications can be found at [https://sites.ualberta.ca/~mahdi/Shahbakhti\\_Publications.html](https://sites.ualberta.ca/~mahdi/Shahbakhti_Publications.html). These include more than 260 peer-reviewed publications in the field of mechanical/electrical engineering. Many of these publications are in the area of automotive systems. According to Google Scholar, these research publications have been recognized and cited over 7,000 times from more than 90 different countries.

23. I have been retained as an expert in twelve IPR proceedings and two International Trade Commission investigations in the past eight years to provide expert opinions in connection with different areas of mechanical engineering systems and mechatronics/control systems including: vehicles, powertrains, internal combustion engines, heating ventilation air conditioning (HVAC) systems, buildings, and vacuum systems.

24. Based on my experience and education, I believe that I am qualified to opine as to the knowledge and level of skill of a person of ordinary skill in the art (“POSITA”) at the time of the alleged invention of the ’648 Patent, as well as the state of the art at that time.

**B. Materials Considered**

25. In forming my opinions, I have reviewed the following documents:

|        |                                                                      |
|--------|----------------------------------------------------------------------|
| EX1001 | U.S. Patent No. 10,549,648 (“the ’648 Patent”)                       |
| EX1002 | Prosecution History of the ’648 Patent                               |
| EX1004 | U.S. Patent Application Publication No. 2009/0176610 A1 (“Conlon”)   |
| EX1005 | U.S. Patent Application Publication No. 2014/0100726 A1 (“Reynolds”) |
| EX1007 | Prosecution History of U.S. Patent No. 10,442,296                    |
| EX1008 | U.S. Patent Application Publication No. 2013/0012347 A1 (“Ortmann”)  |

**II. LEGAL STANDARDS**

26. In forming my opinions and considering the subject matter of the ’648 Patent and its claims in view of the prior art, I am relying on certain legal principles that counsel in this case explained to me. My understanding of these concepts is summarized below.

27. I understand that earlier publications and patents may act to render a patent unpatentable for one of two reasons: (1) anticipation and (2) obviousness.

**A. Anticipation**

28. It is my understanding that the claims of a patent are anticipated by a prior art reference if each and every element of the claim is found either explicitly or inherently in the reference. I understand that inherency requires a showing that the missing descriptive matter in the claim is necessarily present in the allegedly anticipating reference, and that it would have been so recognized by a POSITA.

29. I understand that when a challenged claim covers several structures, either generically or as alternatives, the claim is deemed anticipated if any of the structures within the scope of the claim is found in the prior art reference.

30. Although anticipation typically involves the analysis of a single prior art reference, I understand that additional references may be used to show that the prior art reference has enabling disclosure (*i.e.*, allows a POSITA to make the invention without undue experimentation), to explain the meaning of a term used in the prior art reference, and/or to show that a characteristic is inherent in the prior art reference.

**B. Obviousness**

31. I understand that a claim is invalid as obvious if it would have been obvious to a POSITA at the time the alleged invention was made. This means that even if all of the elements of the claim cannot be found in a single prior art reference that would anticipate the claim, a POSITA who was aware of the prior art would

have been able to come up with the claimed invention. This may be the case, for example, where the missing element represents only an insubstantial difference over the prior art or a reconfiguration of a known system. I understand that in an obviousness determination, the POSITA is presumed to have knowledge of all material prior art.

32. I understand that an obviousness analysis requires an understanding of the scope and content of the prior art, any differences between the alleged invention and the prior art, and the level of ordinary skill in evaluating the pertinent art.

33. I understand that when a product is available, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a POSITA can implement a predictable variation, obviousness likely bars its patentability. For the same reason, if a technique has been used to improve one device and a POSITA would recognize that it would improve similar devices in the same way, using the technique would have been obvious.

34. I understand that whether a prior art reference renders a patent claim unpatentable as obvious is determined from the perspective of a POSITA at the time of the alleged invention. I have been told that there is not a requirement that the prior art contain an express suggestion to combine known elements to achieve the claimed invention, but a suggestion to combine known elements to achieve the claimed invention may come from the prior art, as filtered through the knowledge of a

POSITA. In addition, I have been told that the inferences and creative steps a POSITA would employ are relevant to the determination of obviousness.

35. I understand that a POSITA may consider, for example, whether (1) the change was merely the predictable result of using prior art elements according to their known functions, or whether it was the result of true inventiveness; (2) there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; (3) the claimed innovation applies a known technique that had been used to improve a similar device or method in a similar way; (4) the claimed invention would have been obvious to try, meaning that the claimed innovation was one of a relatively small number of possible approaches to the problem with a reasonable expectation of success by those skilled in the art; (5) the invention merely substituted one known element for another known element in order to obtain predictable results; (6) the invention merely applies a known technique to a known device, method, or product to yield predictable results; or (7) known work in one field of endeavor may have prompted variations of it for use in either the same field or a different one based on design incentives or other market forces that would have been predictable to a POSITA.

36. I understand that, when determining whether a claimed combination is obvious, the correct analysis is not whether a POSITA, writing on a blank slate, would have chosen the particular combination of elements described in the claim.

Instead, I understand that the correct analysis considers whether a POSITA, facing the wide range of needs created by developments in the field of endeavor, would have seen a benefit to selecting the combination claimed.

37. I also understand that the test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference. The test for obviousness, in other words, is not whether the references could be physically combined but whether the claimed inventions are rendered obvious by the teachings of the prior art as a whole.

38. I further understand that certain factors may support or rebut the obviousness of a claim. I understand that such secondary considerations include, among other things, commercial success of the patented invention, skepticism of those having ordinary skill in the art at the time of the invention, unexpected results of the invention, any long-felt but unsolved need in the art that was satisfied by the alleged invention, the failure of others to make the alleged invention, praise of the alleged invention by those having ordinary skill in the art, and copying of the alleged invention by others in the field. I understand that there must be a nexus—that is, a connection—between any such secondary considerations and the alleged invention. I also understand that contemporaneous and independent invention by others is a secondary consideration tending to show obviousness.

39. Additionally, I understand that in considering obviousness, it is important not to use the benefit of hindsight derived from the patent under consideration.

**C. Level of Ordinary Skill in the Art**

40. When interpreting a patent, I understand that it is important to identify the relevant art pertaining to that patent, as well as the level of ordinary skill in that art at the time of the claimed invention. The “art” is the field of technology to which the patent is related.

41. I am informed and understand that a POSITA is a hypothetical person who is presumed to know the relevant prior art. I understand that the actual inventor’s skill is not determinative of the level of ordinary skill. I further understand that factors that may be considered in determining level of skill include: (i) the types of problems encountered in the art; (ii) prior art solutions to those problems; (iii) the rapidity with which innovations are made; (iv) the sophistication of the technology; and (v) the educational level of active workers in the field. I understand that not all such factors may be present in every case, and one or more of them may predominate.

42. I understand that a POSITA is one who is presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity.

43. Based on my review of the '648 Patent, and my own knowledge and skill based on my experience with the design and control of vehicle propulsion systems, it is my opinion that a POSITA in January of 2014 is someone with at least a bachelor's degree in electrical engineering or mechanical engineering and at least three years of technical experience in designing, implementing, testing, or otherwise working with, automotive powertrains, electric drive systems, or a related field. Additional higher graduate education could substitute for work experience, and additional work experience/training could substitute for formal education.

44. A POSITA in the field of the '648 Patent would have had knowledge of and experience with propulsion systems in hybrid and electric vehicles. This experience would enable the POSITA to understand, for example, vehicle propulsion systems, electric drive systems, and energy transmission between and among energy storage devices and electromechanical components of such vehicles.

45. Based on my education and experience, I meet the criteria for a POSITA.

**D. Claim Construction**

46. I understand that the United States Patent and Trademark Office ("USPTO") interprets claim terms in an IPR proceeding under the same claim construction standard that is used in a United States federal court. I also understand

that under this standard, the meaning of claim terms is considered from the viewpoint of a POSITA at the time of the alleged invention.

47. I have been informed that claim terms are generally given their ordinary and customary meaning as understood by a POSITA in light of the specification and the prosecution history pertaining to the patent. I understand, however, that claims terms are generally not limited by the embodiments described in the specification.

48. I understand that in addition to the claims, specification, and prosecution history, other evidence may be considered to ascertain the meaning of claim terms, including textbooks, encyclopedias, articles, and dictionaries. I have been informed that this other evidence is often less significant and less reliable than the claims, specification, and prosecution history.

49. **“output of the second traction/electric motor” (claims 1, 9, 16):** I have interpreted the term “output of the second traction/electric motor” to mean the “*mechanical* output of the second traction/electric motor.” The claims require that the output of the second traction/electric motor bypasses the transmission device. EX1001, 13:32-34, 14:15-17, 14:55-57. This output is mechanical power for driving the vehicle.

50. **“transmission device” (claims 1, 9, 16):** In the ’648 Patent, “[t]ransmission 90 is constructed as a gear assembly, belt assembly, or combination thereof according to various embodiments. According to one embodiment,

transmission 90 is configured as an electrically variable transmission (EVT) that couples the outputs of electromechanical devices 74, 82 through an arrangement of planetary gears *and clutches (not shown)*.” EX1001, 5:5-11 (emphasis added). “Depending on how the *clutches of transmission 90* are configured, electromechanical device 82 may be coupled to gear assembly 94 through transmission 90 or may be directly coupled to gear assembly 94 such that the output of electromechanical device 82 bypasses transmission 90.” *Id.*, 5:21-25 (emphasis added). Clutches connect and disconnect the flow of power from a motor or engine. Accordingly, a POSITA would understand the plain and ordinary meaning of “transmission device” in the context of the ’648 Patent to include clutches.

51. I have interpreted each of the remaining terms in the claims as would be understood by a POSITA in light of the specification and the prosecution history of the ’648 Patent.

### III. SUMMARY OF OPINIONS

52. For the reasons explained in more detail below, it is my opinion that:

- Claims 1, 4, 5, 7, 8, 16, and 18-20 are anticipated by Conlon;
- Claims 1, 4, 5, 7, 8, 16, and 18-20 are obvious over Conlon;
- Claims 2, 3, 6, 9-15, and 17 are obvious over Conlon in view of Reynolds;
- Claims 1, 2, 4-10, and 12-20 are anticipated by Ortmann; and

- Claims 3 and 11 are obvious over Ortmann.

53. In connection with these opinions, I have considered the scope and content of the prior art, the similarities and differences between the prior art and the patent claims, and the level of ordinary skill in the art. I am currently unaware of any objective evidence of non-obviousness of the '648 Patent claims. I reserve the right to consider and comment on any such evidence provided to me after I sign this declaration.

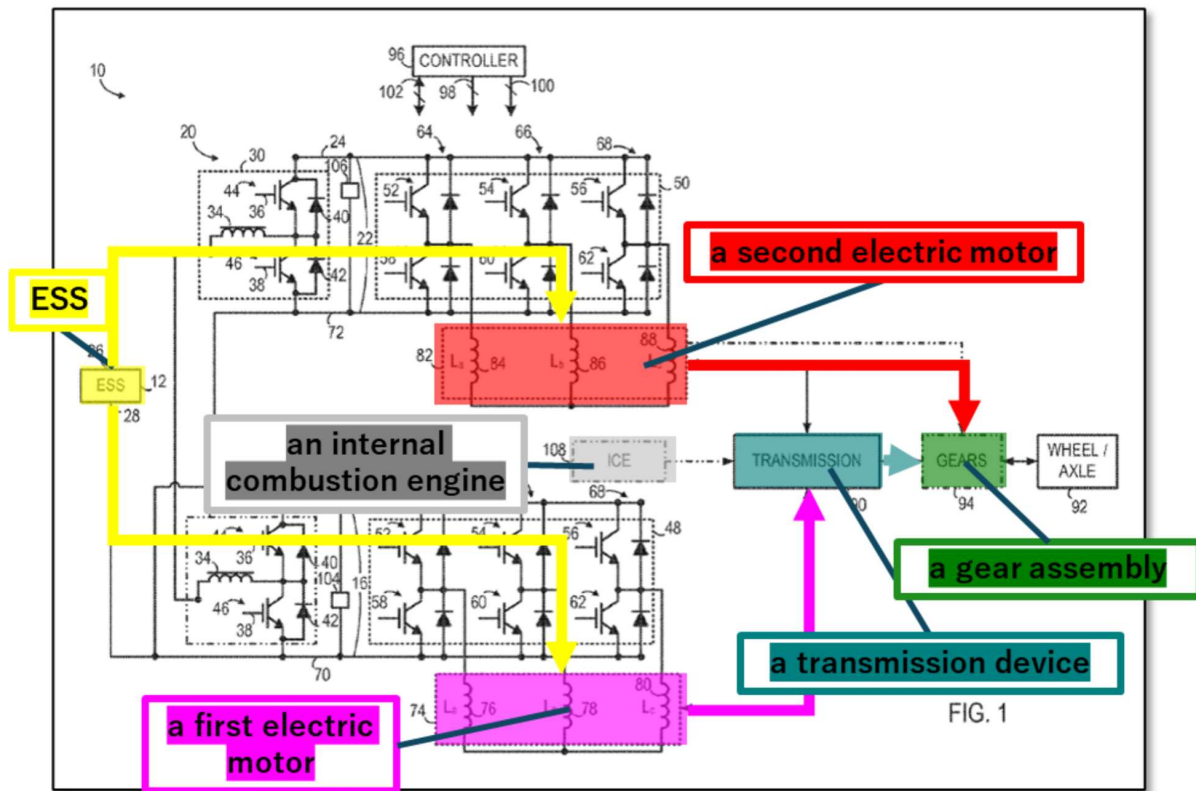
#### **IV. THE '648 PATENT**

##### **A. Overview of the '648 Patent**

54. The '648 Patent is directed to a propulsion system for electric or hybrid electric vehicles. The system includes one or more energy storage devices coupled to multiple electric motors that can be operated on independent channels to drive a vehicle and/or generate electrical power and is described as providing improved overall system efficiency. EX1001, Col. 1-2. The system may be configured in a pure electric (EV) arrangement that splits power output between two or more electric motors, or as a hybrid (HEV) propulsion system that includes an internal combustion engine in addition to multiple electric motors. *Id.* at Col. 3, lines 17-23.

55. Figure 1, annotated below, shows energy storage system 12 (ESS) [shown in yellow], a first electromechanical device (motor) [74 shown in purple], a second electromechanical device (motor) 82 [shown in red], a transmission 90

[shown in blue] coupled to the outputs of electric motors 74 and 82, a gear assembly [shown in green] 94 coupled to the output of transmission 90, and an internal combustion engine 108 [shown in gray] coupled to the output of transmission 90. *Id.* at Col. 3-5. Controller 96 monitors the operating conditions of the system, including the charging voltage of the ESS and bus voltage of each channel, and transmits control commands to other components, such as the internal combustion engine. *Id.* at Col. 5, line 26 – Col. 6, line 4.



**B. Prosecution History of the '648 Patent**

56. I understand the application for the '648 Patent was filed on August 29, 2019. I also understand that the '648 Patent claims priority to Application No. 14/168,224 filed on January 30, 2014.

57. I understand the neither the Conlon (EX1004), Reynolds (EX1005), nor Ortmann (EX1008) reference relied on in this Declaration was before the USPTO during prosecution of the '648 Patent.

58. I understand that the USPTO did not issue any Office Actions during prosecution of the '648 Patent.

59. I understand that the USPTO issued a Notice of Allowance for the '648 Patent on October 3, 2019. EX1002, 152-160. The '648 Patent issued on February 4, 2020.

60. I understand that during prosecution of U.S. Patent No. 10,442,296 ("the '296 Patent"), the parent of the '648 Patent, the USPTO allowed the claims after they were amended to require *inter alia* that the transmission device be "configured as an electrically variable transmission (EVT) that comprises an arrangement of planetary gears," and "a gear assembly coupled between the second traction[/AC] motor[/drive system] and the transmission device such that the output of the second traction[/AC] motor[/drive system] bypasses the transmission device." EX1007, 375-381, 525-533.

61. I understand neither the Conlon (EX1004), Reynolds (EX1005), nor Ortmann (EX1008) reference relied on in this Declaration was before the USPTO during prosecution of the '296 Patent.

62. As such, I understand that this Declaration presents new prior art and substantially new arguments that were not previously considered during prosecution at the USPTO.

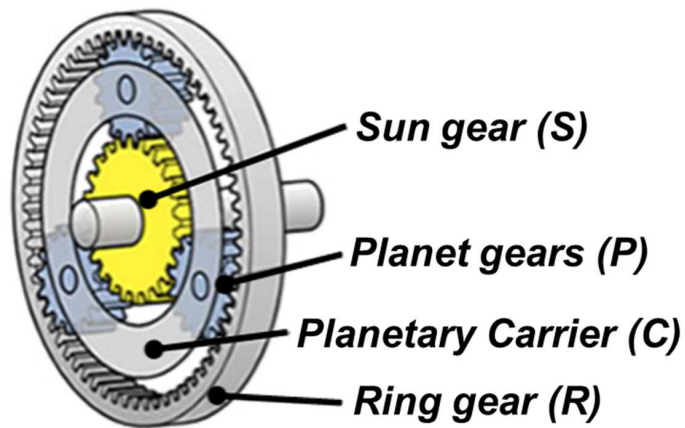
## **V. BACKGROUND ON PLANETARY GEARS AND POWER**

### **TRANSFER**

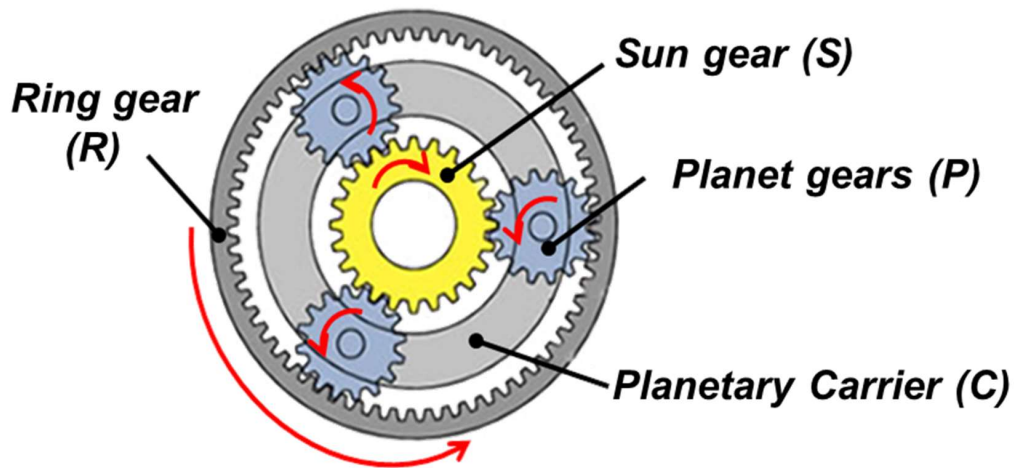
63. Here, the fundamental for the operation of planetary gear sets (epicyclic gearing), specifically focusing on their application in hybrid vehicles is explained.

64. A planetary gear set consists of four main components aligned along a concentric axis:

- Sun Gear (S): The center gear. Drives or is driven by the planet gears;
- Planet Gears (P): Multiple small gears, also called pinions, orbiting the sun gear and they are mounted on the carrier and transfer torque between sun and ring gears;
- Planet Carrier (C): Holds the planet gears which mesh with both the sun and the ring gears; and
- Ring Gear (R): Large outer gear with internal teeth.



65. The planetary gear set is an epicycloidal train. The rotational movement of the four components is illustrated in the following image, where all components can rotate:



66. In the planetary gear set, each of the following three components can be fixed: planetary carrier, ring gear, sun gear. Depending on the fixed component, the ratio and direction of movement of other components change. Below, some sample operating scenarios are described:

- Hybrid Mode (Power Split) – There are two inputs in this mode: the Planet Carrier (C), and the Sun Gear (S). For instance, the engine can drive the carrier and motor/generator 1 (MG1) can drive the sun gear. The output is taken from the Ring Gear (R), which is connected to the wheels. By varying the speed of MG1, the engine can operate at a constant, efficient speed while the vehicle speed (ring gear speed) changes. All three components rotate simultaneously. This is the “two input” scenario:
  - Input 1: Carrier (*e.g.*, power input from engine)
  - Input 2: Sun (*e.g.*, power input from MG1)
  - Output: Ring connected to wheels
- Reduction Gear (Low Speed, High Torque) – In this mode, the Sun Gear (S) is the input, driving the planet gears. The Ring Gear (R) is held stationary by a brake. The output is taken from the Planet Carrier (C), which rotates in the same direction as the sun gear but at a much slower speed and with multiplied torque.
  - Input: Sun Gear
  - Output: Carrier
  - Fixed (locked): Ring Gear

- Overdrive (High Speed, Low Torque) – This is the inverse of reduction mode. The Planet Carrier (C) is the input, and the Sun Gear (S) is held stationary. The output is taken from the Ring Gear (R), which rotates in the same direction as the carrier but at a higher speed and with reduced torque.
  - Input: Carrier
  - Output: Ring Gear
  - Fixed (locked): Sun Gear
- Reverse – To achieve reverse rotation, the Planet Carrier (C) is held stationary. The Sun Gear (S) is the input. The planet gears act as idlers, reversing the direction of rotation for the output Ring Gear (R).
  - Input: Sun Gear
  - Output: Ring Gear
  - Fixed (locked): Carrier
- Lock-up – In this mode, any two members of the gear set are locked together (*e.g.*, the Sun Gear and the Ring Gear are connected by a clutch). This forces the entire assembly to rotate as a single, solid unit at the same speed as the input.
  - Input: Any two members locked together (*e.g.*, Sun and Ring)
  - Output: Carrier (or remaining member)

- Condition: The entire unit rotates as a solid block.

## **VI. OVERVIEW OF PRIOR ART CONSIDERED**

67. The prior art references I reviewed confirm that each limitation of the '648 Patent claims was known before the patent's priority date of January 30, 2014.

### **A. Conlon**

68. Conlon was filed on January 7, 2008, and published on July 9, 2009. EX1004, cover page. Therefore, Conlon was published more than one year before the priority date of the '648 Patent.

69. Similar to the '648 Patent, Conlon relates to “a two-mode electrically variable transmission (EVT) suitable for a large battery application, the EVT having an input split mode, a compound split mode, an electric-only mode using two motors, and a neutral mode.” EX1004, ¶ 0001.

### **B. Reynolds**

70. Reynolds was filed on October 5, 2012, and published on April 10, 2014. EX1005, cover page. Therefore, Reynolds was effectively filed before the priority date of the '648 Patent.

71. Reynolds describes “a system for controlling an electric machine in an electric vehicle.” EX1005, ¶ 0001. The system includes a generator and a motor that are each electrically powered through separate inverters. *Id.*, ¶¶ 0013-0014, Fig. 1.

Electrical power is stored in a battery and sent through a DC/DC converter to modify the vehicle voltage level according to the devices being powered. *Id.*, ¶ 0013.

**C. Ortmann**

72. Ortmann was filed on July 5, 2011, and published on January 10, 2013. EX1008, cover page. Therefore, Ortmann was published more than one year before the priority date of the '648 Patent.

73. Ortmann discloses a multi-mode powersplit powertrain for an electric vehicle similar to the system of the '648 Patent. EX1008, Title, Abstract. The powertrain includes a battery, multiple motor-generators, an engine, a planetary gearset, and layshaft gearing. *Id.*, ¶¶ 0019-0038. The various operating modes of the powertrain include one motor electric drive, two motor electric drive, series, powersplit, and direct drive. *Id.*

**VII. GROUND 1: CLAIMS 1, 4, 5, 7, 8, 16, AND 18-20 ARE ANTICIPATED BY CONLON**

74. It is my opinion that the subject matter of claims 1, 4, 5, 7, 8, 16, and 18-20 are anticipated by Conlon.

**A. Independent Claim 1**

*Limitation 1[p]: A system for a hybrid electric vehicle, comprising:*

75. Conlon discloses a system for a hybrid electric vehicle. For example, Conlon describes an electrically variable transmission (EVT) “for use with relatively

large battery power and/or a relatively small engine, with reduced motor speed requirements.” EX1004, ¶ 0006. “The EVT has an increased EV mode capability using both motor/generators, a forward low-range electric-only operating mode in which the engine is off, a forward low-range electrically variable input split operating mode, a forward high-range compound split operating mode, and a neutral operating mode.” *Id.* Figure 2 of Conlon depicts the powertrain and EVT system.

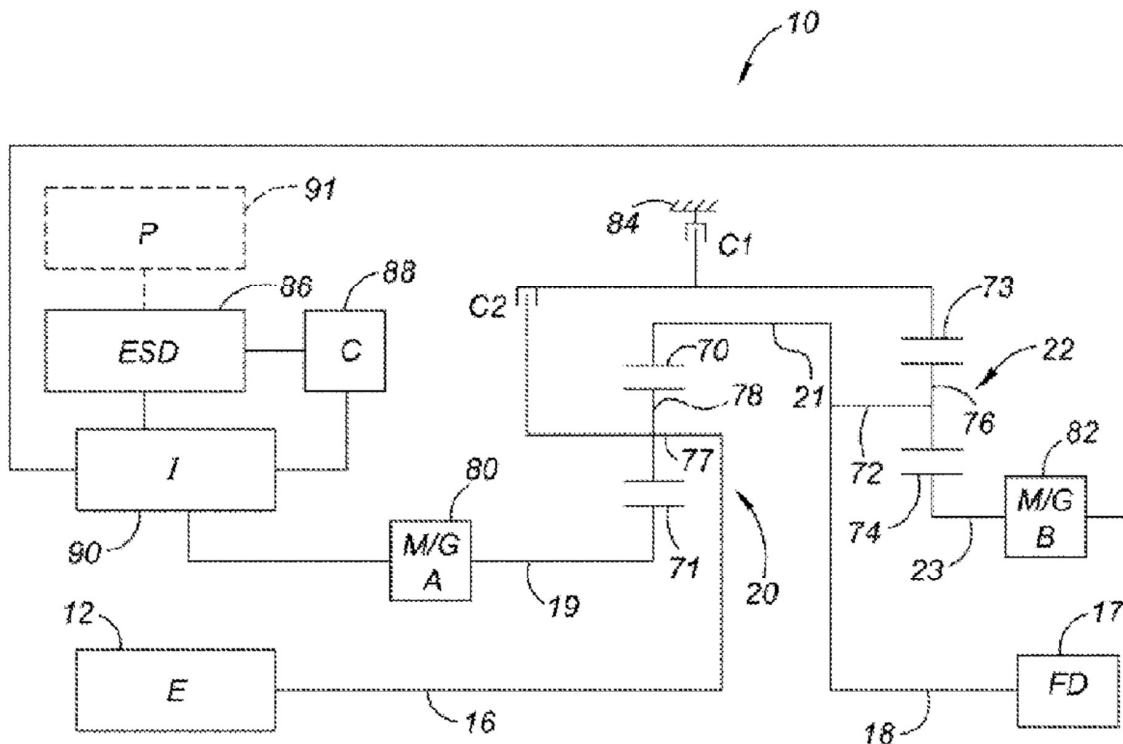


FIG. 2

76. Therefore, limitation 1[p] is disclosed by Conlon.

*Limitation 1[a]: an energy storage system;*

77. Conlon discloses an energy storage system. Referring to Figure 2, the system includes energy storage device or ESD 86 [shown in yellow]. EX1004, ¶ 0036.

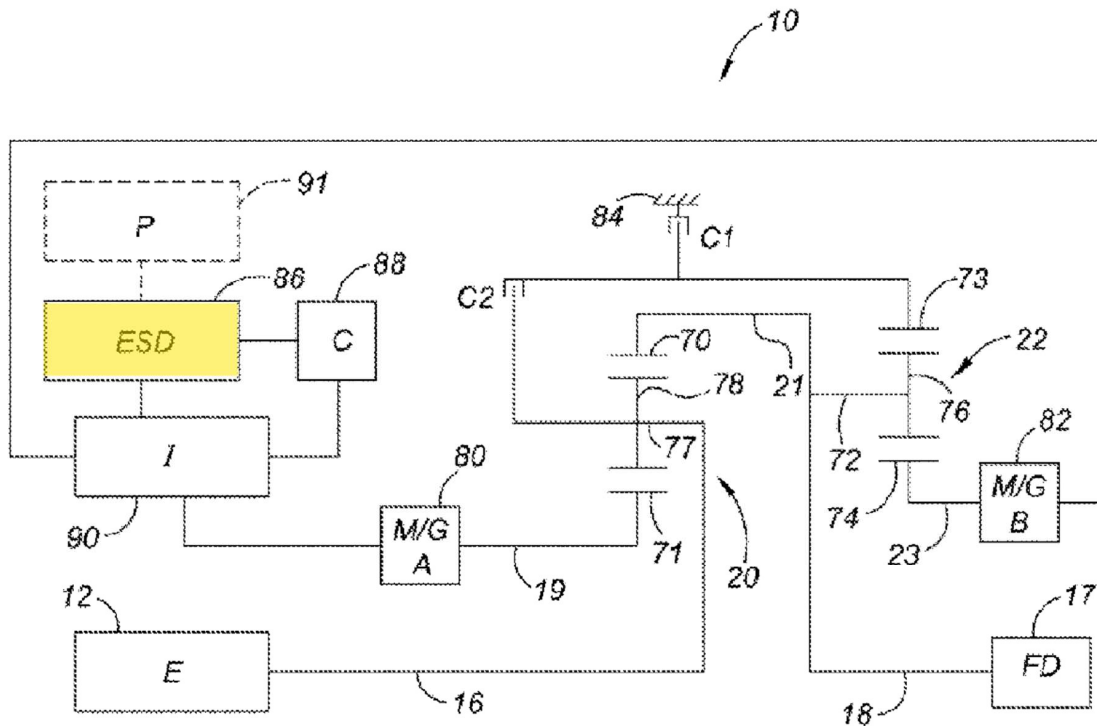


FIG. 2

78. Therefore, limitation 1[a] is disclosed by Conlon.

*Limitation 1[b]: a first traction motor coupled to the energy storage system;*

79. Conlon discloses a first traction motor coupled to the energy storage system. Referring to Figure 2, the first motor/generator 80 (M/G A) [shown in purple] is operatively connected to ESD 86. EX1004, ¶ 0036. M/G A is a traction motor.

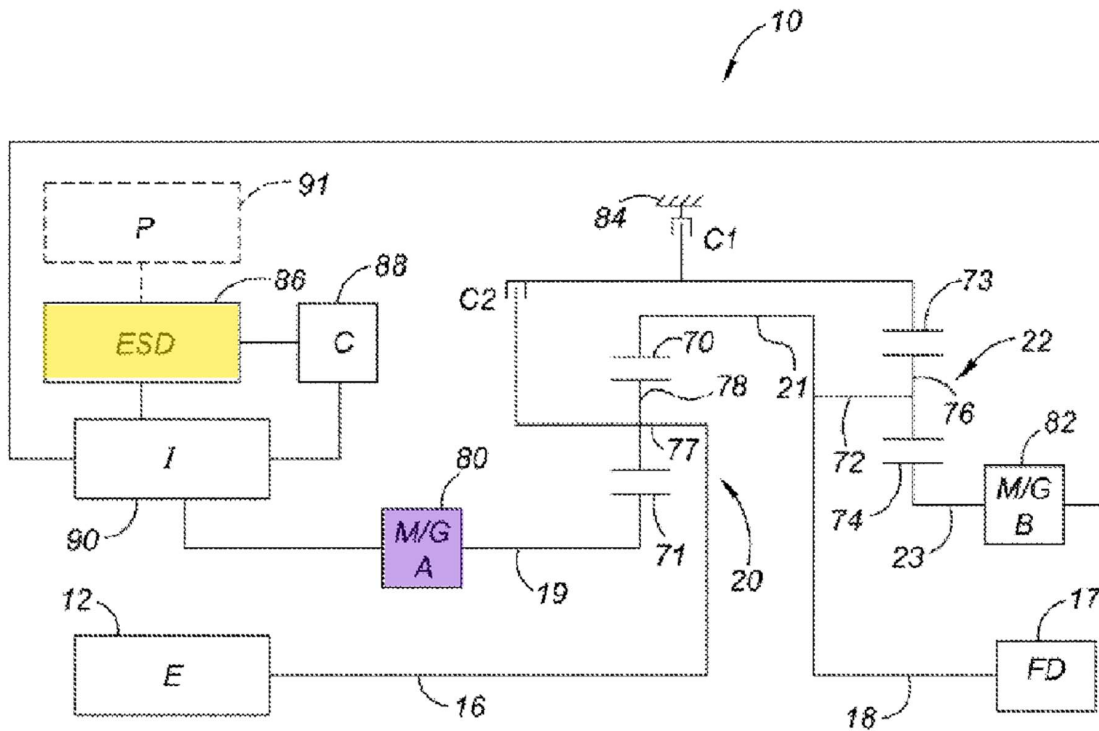


FIG. 2

80. Therefore, limitation 1[b] is disclosed by Conlon.

*Limitation 1[c]: a second traction motor coupled to the energy storage system;*

81. Conlon discloses a second traction motor coupled to the energy storage system. Referring to Figure 2, the second motor/generator 82 (M/G B) [shown in red] is operatively connected to ESD 86. EX1004, ¶ 0036. M/G B is a traction motor.

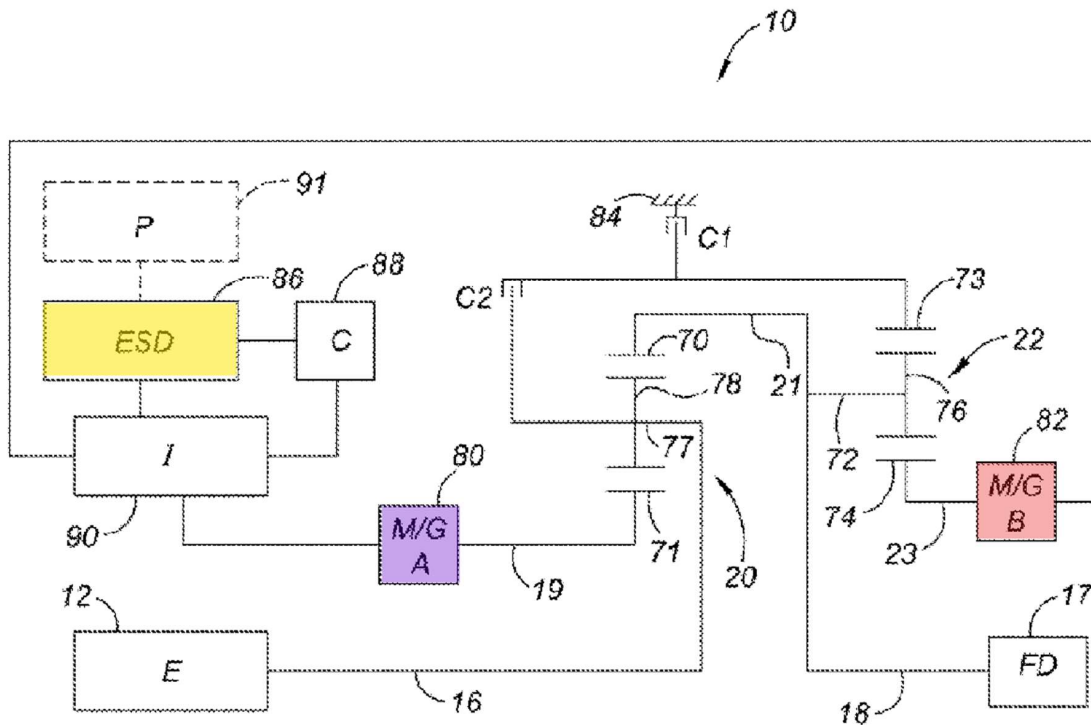


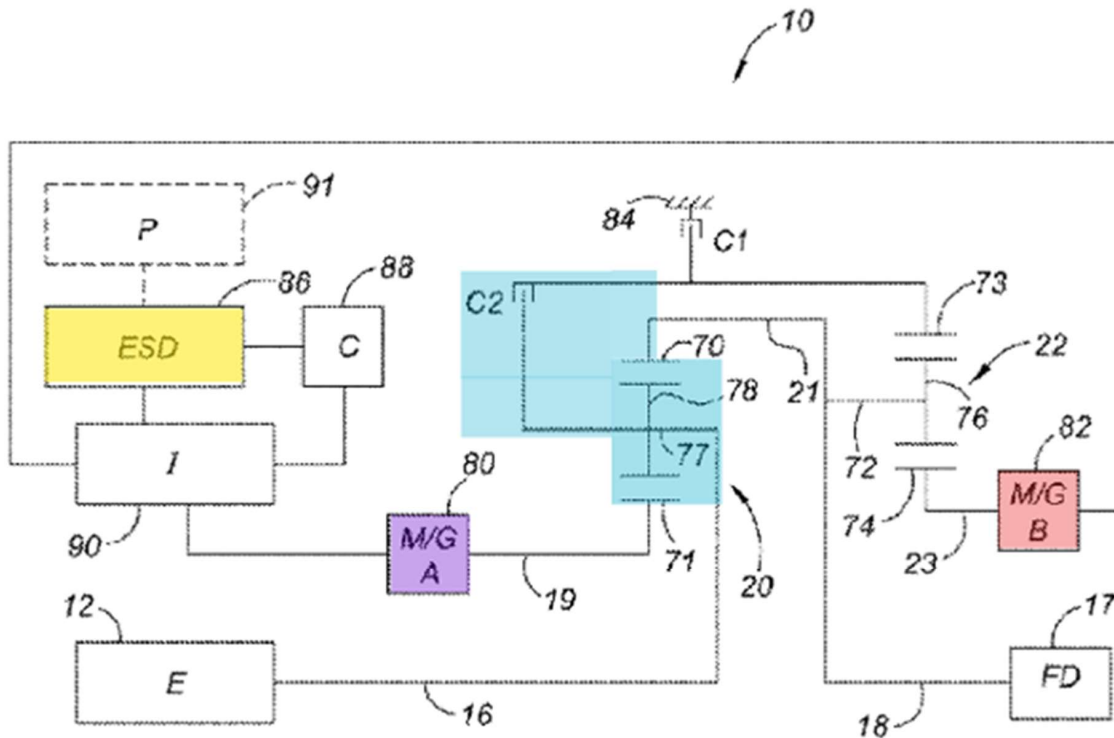
FIG. 2

82. Therefore, limitation 1[c] is disclosed by Conlon.

*Limitation 1[d]: a transmission device coupled to the first traction motor, the transmission device comprising an arrangement of planetary gears;*

83. Conlon discloses a transmission device coupled to the first traction motor where the transmission device comprises an arrangement of planetary gears. Referring to Figure 2, “the first motor/generator (M/G A) 80 is continuously connected to the sun gear member 71 of the first planetary gear set 20 via the interconnecting member 19.” EX1004, ¶ 0035. Planetary gear set 20 [shown in blue]

is a transmission device comprising sun gear 71, ring gear 70, carrier member 77, a plurality of pinion gears 78, and clutch C2. *Id.*, ¶¶ 0033-0035.



84. Therefore, limitation 1[d] is disclosed by Conlon.

*Limitation 1[e]: a gear assembly coupled between the second traction motor and the transmission device such that the output of the second traction motor bypasses the transmission device;*

85. Conlon discloses a gear assembly coupled between the second traction motor and the transmission device such that the output of the second traction motor bypasses the transmission device. The claimed gear assembly is a separate and distinct element from the transmission device recited in limitation 1[d]. First, the

claim lists the transmission device and gear assembly as separate elements. Second, the claim recites that the gear assembly is positioned “between” the second motor and the transmission device, indicating three distinct components arranged in sequence. Third, the claim requires that the second motor’s output “bypasses the transmission device,” further indicating the transmission and gear assembly are separate because the output of the second motor cannot bypass the transmission device if the gear assembly to which the motor is coupled is part of the transmission device.

86. Conlon’s “second planetary gear set 22 has a sun gear 74, a ring gear 73, and a carrier member 72 having a plurality of pinion gears 76.” *Id.*, ¶ 0034. Referring to Figure 2, “[t]he second motor/generator 82 (M/G B) is continuously connected to the sun gear member 74 of the second planetary gear set 22, and is operable for transmitting torque to the output member 18.” EX1004, ¶ 0035. The second planetary gear set 22 [shown in green] is located between M/G B [shown in red] and the first planetary gear set 20 (transmission device) [shown in blue]. In Mode 1, for example, the mechanical power of M/G B is transmitted to output member 18 [shown in brown] without passing through (*i.e.*, bypassing) first planetary gear set 20 (transmission device), as shown by the red arrow. In this mode, clutch C1 is engaged and clutch C2 is disengaged; thus, no power is transmitted from M/G A to the output member 18. In this mode, the power from M/G B is transmitted

to the planetary carrier member 72 which then transfers the power to the final drive via output member 18.

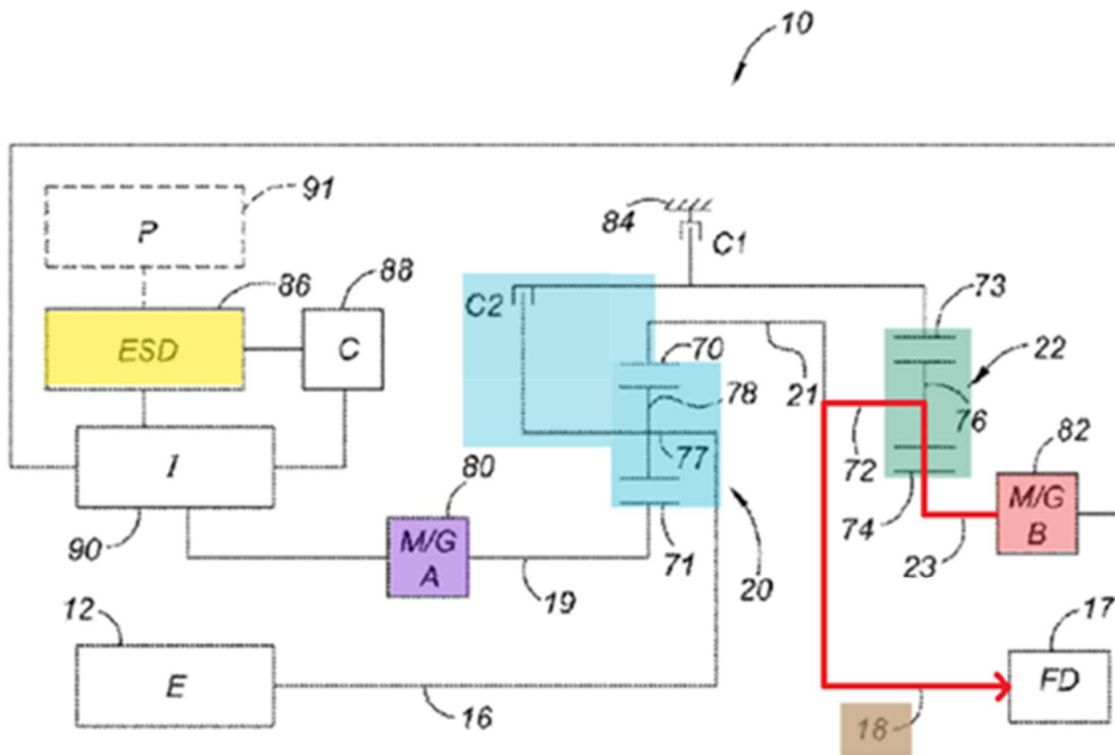


FIG. 2

87. Therefore, limitation 1[e] is disclosed by Conlon.

*Limitation 1[f]: an internal combustion engine coupled to the transmission device via a path that does not include the first traction motor and second traction motor;*

88. Conlon discloses an internal combustion engine coupled to the transmission device via a path that does not include the first traction motor and second traction motor. Referring to Figure 2, “engine 12, [shown in gray] is

continuously connected to the carrier member 77 of the first planetary gear set 20”  
(transmission device) via a path that does not include M/G A and M/G B, as shown  
by the red arrow. EX1004, ¶ 0035.

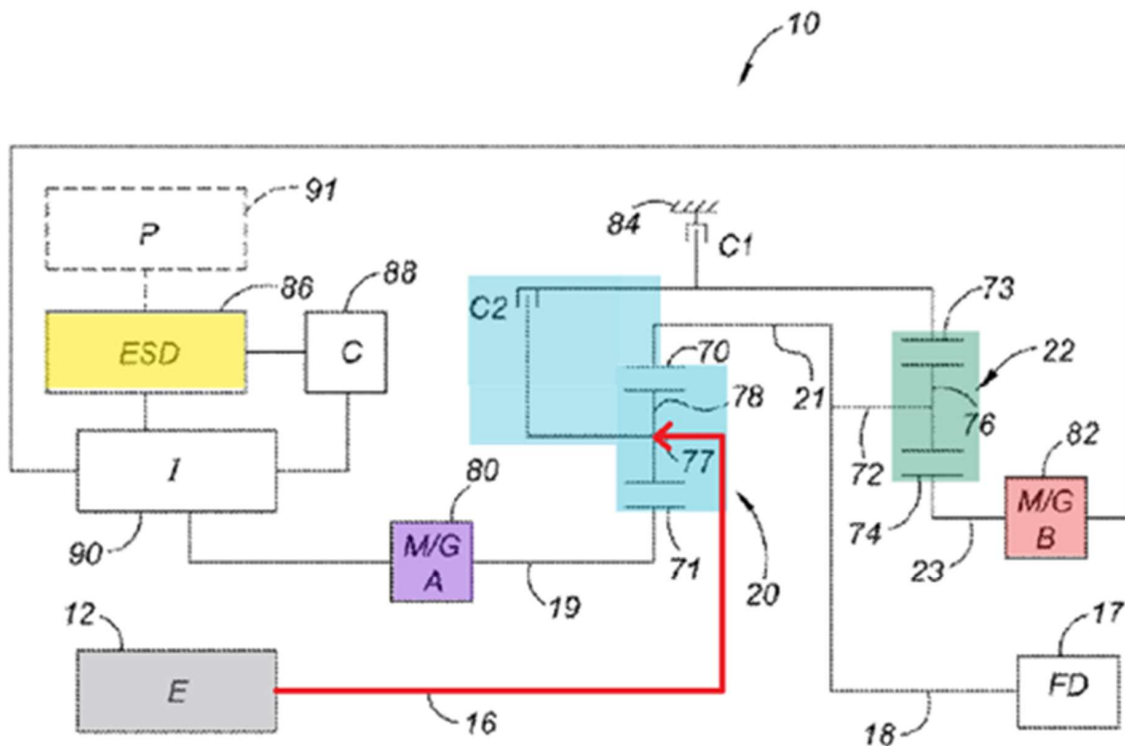


FIG. 2

89. Therefore, limitation 1[f] is disclosed by Conlon.

*Limitation 1[g]: a control system configured to selectively:*

90. The powertrain of Conlon is capable of operating in several modes: Mode 1 (input-split mode, which is an electrically variable mode normally used with the engine turned off, such as during low vehicle speeds), Mode 2 (compound-split mode, which is normally used when the engine is turned on, such as during high

vehicle speeds), Mode 3 (two-motor electric-only mode, which is used with both of the motor/generators driving the output member 18 at a fixed ratio for electric-only propulsion when the engine is turned off), and Mode 4 (neutral mode, which effectively disconnects the second motor/generator from output member 18, or otherwise prevents or minimizes the amount of torque the second motor/generator is able to transmit to output member 18). EX1004, ¶ 0042; Figs. 1-3.

91. At rest, the system is in Mode 3, and then “transitions to Mode 1” once the engine reaches operating speed. *Id.*, ¶ 0044. At relatively high rates of speed, the EVT may shift from Mode 1 to Mode 2 by releasing the brake C1 and applying the clutch C2, or alternately, the power of the first motor/generator may be supplied by the ESD, allowing the system to shift between Modes 1 and 2 without any torque being transmitted across slipping clutches. *Id.*, ¶ 0045; Figs. 2-3. The system can easily transition from either Mode 1 or Mode 2 to Mode 3 by a synchronous shift to the appropriate speed ratio, and then by engaging the appropriate brake C1 and/or clutch C2. *Id.*, ¶ 0047; Figs. 2-3. The shift between Mode 1 or Mode 2 to Mode 3 may also be achieved as an energy shift by engaging the appropriate brake C1 or clutch C2 to shift directly to Mode 3. *Id.*

92. Conlon necessarily teaches a control system for switching between these modes. A POSITA would have understood that a control system is required to monitor operating conditions such as vehicle speed, motor speed, speed ratio, and

power supplied from the ESD. In addition, a POSITA would have understood that a control system is required to engage and disengage clutches C1/D1 and C2/D2 as needed to shift the EVT between respective modes. *Id.*, ¶¶ 0006, 0017, 0033, 0043-0048, 0054-0058, Fig. 3. Accordingly, Conlon inherently discloses the claimed control system.

93. Therefore, limitation 1[g] is disclosed by Conlon.

*Limitation 1[g][i]: operate the first traction motor and second traction motor to drive the vehicle through the transmission device and gear assembly, respectively;*

94. As explained above, Conlon is capable of operating in Mode 3 (two-motor electric-only) where both motors drive the output member 18 (which is operatively connected to final drive assembly 17) at a fixed ratio for electric-only propulsion when the engine is turned off. EX1004, ¶¶ 0028, 0035, 0042, Figs. 1-3. As shown in Figure 2, the first motor 80 (M/G A) drives output member 18 and final drive assembly 17 through the first planetary gear set 20 (transmission device), and the second motor 82 (M/G B) drives output member 18 and final drive assembly 17 through the second planetary gear set 22, as shown by the red arrows.

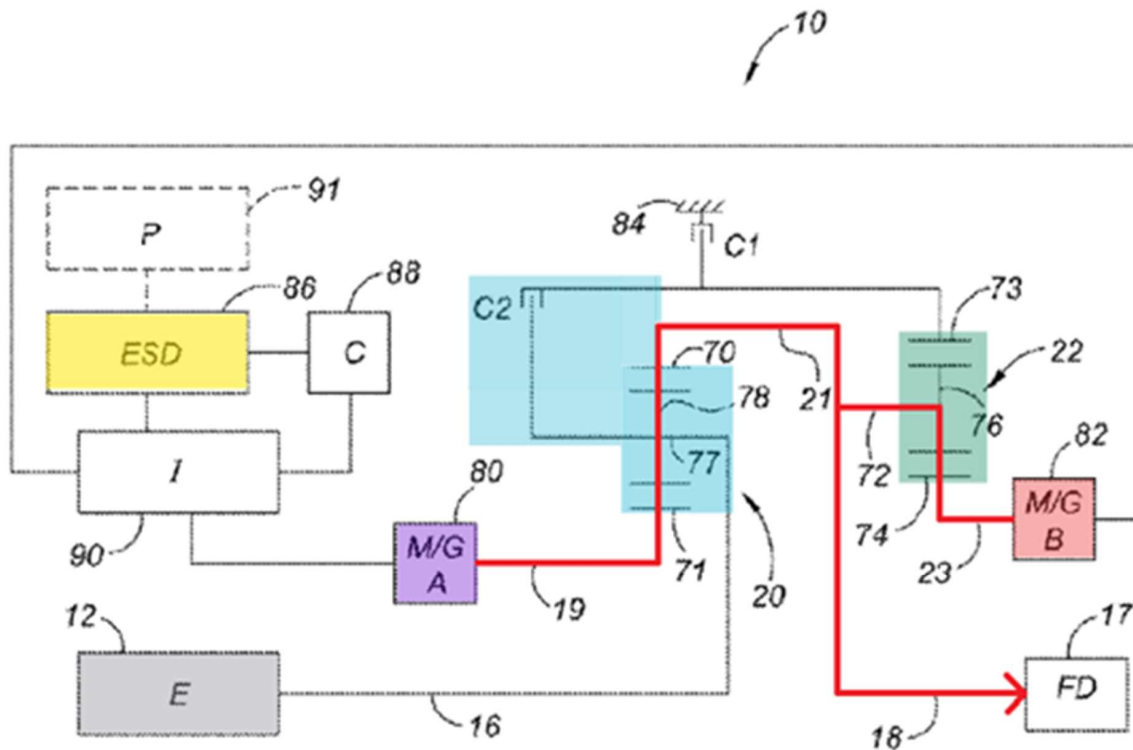


FIG. 2

95. Therefore, limitation 1[g][i] is disclosed by Conlon.

*Limitation 1 [g][ii]: operate the first traction motor as a generator to generate electrical power while operating the second traction motor to drive the vehicle through the gear assembly; and*

96. As explained above, Conlon is capable of operating in Mode 1, which is an electrically variable mode normally used with the engine turned off. EX1004, ¶ 0042; Figs. 1-3. “When operating in Mode 1 (EVT 1/Input Split), the motor/generator 80 (M/G A) acts as a generator, and the motor/generator 82 (M/G B) acts as a motor.” *Id.*, ¶ 0044. The second motor 82 (M/G B) drives output member

18 (and final drive assembly 17) of the vehicle through the second planetary gear set 22. *See* Fig. 2.

97. Therefore, limitation 1[g][ii] is disclosed by Conlon.

*Limitation 1[g][iii]: operate the second traction motor as a generator to generate electrical power.*

98. As explained above, Conlon is capable of operating in Mode 2 (compound-split), which is normally used when the engine is turned on. EX1004, ¶ 0042; Figs. 1-3. In this mode, “[t]he EVT 114 may then operate with the motor/generator 82 (M/G [B]) acting as a generator . . . .” *Id.*, ¶ 0051; *see also* ¶¶ 0046, 0052.

99. Therefore, limitation 1[g][iii] is disclosed by Conlon.

#### **B. Dependent Claim 4**

*4. The system of claim 1, wherein the energy storage system comprises a battery.*

100. As explained above, Conlon discloses all the limitations of claim 1.

101. Conlon discloses that “ESD 86 may be, for example, one or more batteries or battery packs.” EX1004, ¶ 0036.

102. Therefore, the limitations of claim 4 are disclosed by Conlon.

#### **C. Dependent Claim 5**

*5. The system of claim 1, further comprising a wheel/axle assembly coupled to the gear assembly.*

103. As explained above, Conlon discloses all the limitations of claim 1.

104. Conlon discloses a wheel/axle assembly coupled to the gear assembly. The second planetary gear set 22 is connected to and “operable for transmitting torque to the output member 18” (EX1004, ¶ 0035), which in turn is connected to final drive assembly 17 “for propelling the vehicle.” *Id.*, ¶ 0028. Figure 1 shows the output of final drive assembly 17 “to wheels.” The second planetary gear set 22 is thus coupled to a wheel/axle assembly, as shown by the red line.

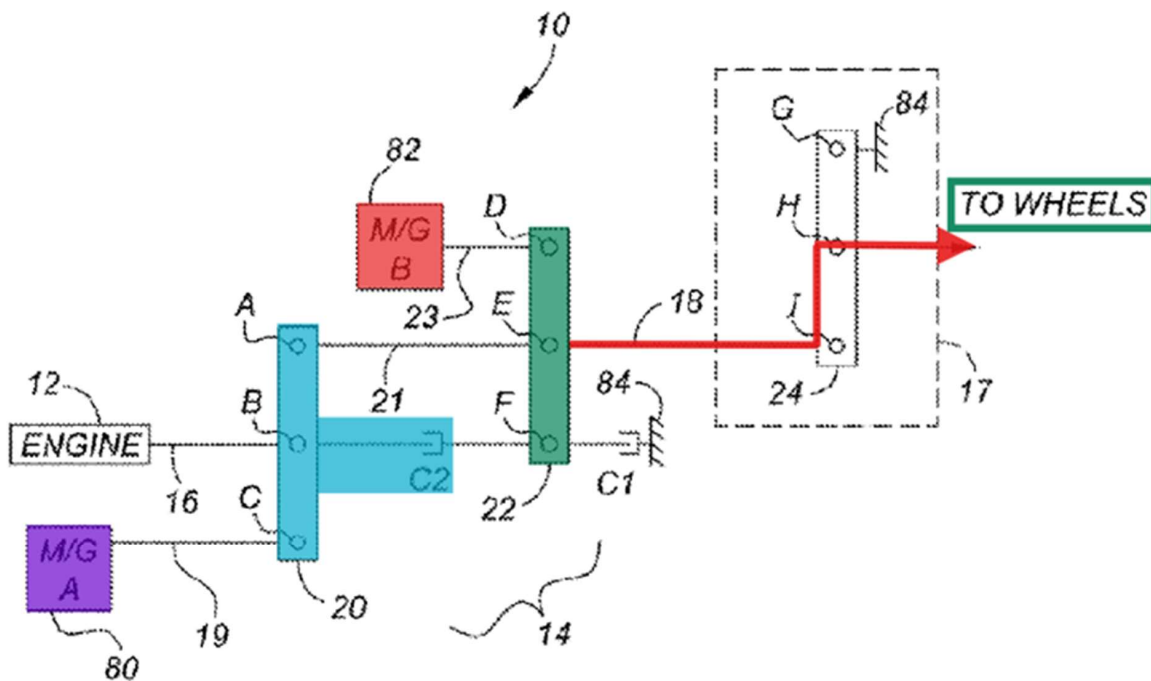


FIG. 1

105. Therefore, the limitations of claim 5 are disclosed by Conlon.

#### D. Dependent Claim 7

*7. The system of claim 1, wherein the electrical power generated by the first traction motor is provided to the second traction motor.*

106. As explained above, Conlon discloses all the limitations of claim 1.

107. Conlon discloses that the electrical power generated by the first traction motor is provided to the second traction motor. In Mode 1 (input-split), “the motor/generator 80 (M/G A) acts as a generator, and the motor/generator 82 (M/G B) acts as a motor.” EX1004, ¶ 0044. “ESD 86 . . . is operatively connected to each of the respective motor/ generators 80, 82 such that motor/ generators 80, 82 may selectively transfer power to or receive power from the ESD 86.” *Id.*, ¶ 0036. Further, as shown in Figure 2, motor/generators 80, 82 are operatively connected to each other through inverter 90. *Id.*, ¶ 0038. Thus, electrical power generated by motor/generator 80 (M/G A) can be supplied to motor/generator 82 (M/G B) through ESD 86 via inverter 90. The electrical power generated by M/G A is thus provided to M/G B.

108. Therefore, the limitations of claim 7 are disclosed by Conlon.

#### **E. Dependent Claim 8**

*8. The system of claim 1, wherein the electrical power generated by the second traction motor is provided to the energy storage system.*

109. As explained above, Conlon discloses all the limitations of claim 1.

110. Conlon discloses that the electrical power generated by the second traction motor is provided to the energy storage system. EX1004, ¶ 0013 (“the EVT

includes an energy storage device (ESD) that is connected to the first and second motor/generators for providing power thereto and *receiving power therefrom*”) (emphasis added); ¶ 0036 (“The powertrain 10 may be further configured with an onboard energy storage device or ESD 86 that is operatively connected to each of the respective motor/generators 80, 82 such that motor/generators 80, 82 may selectively *transfer power to* or receive power from the ESD 86.”) (emphasis added).

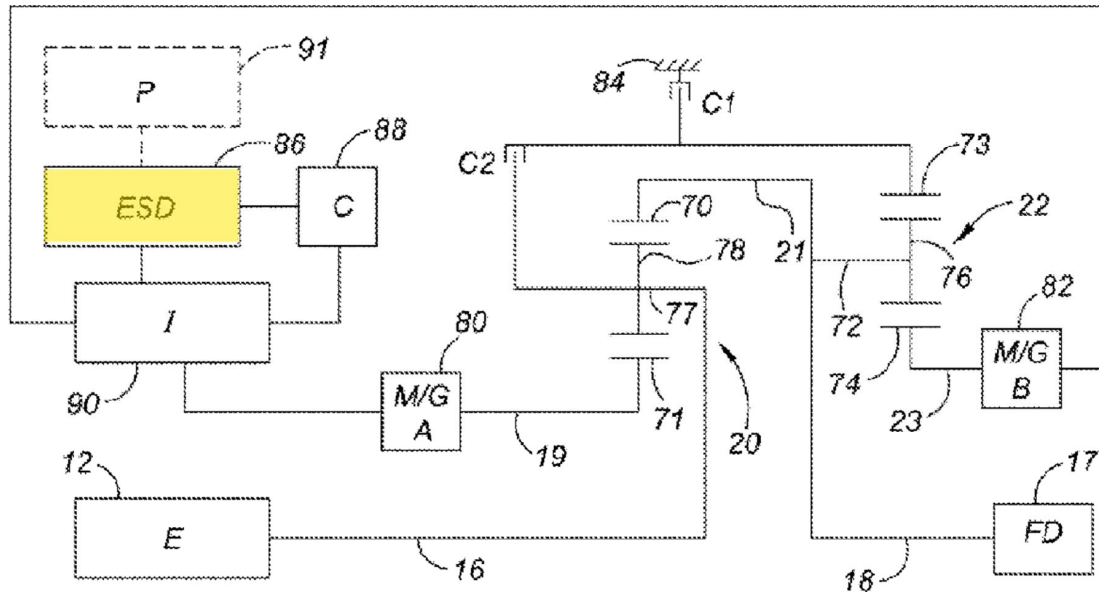
111. Therefore, the limitations of claim 8 are disclosed by Conlon.

**F. Independent Claim 16**

*Limitation 16[p]: A hybrid electric vehicle propulsion system, comprising:*

112. Conlon discloses a hybrid electric vehicle propulsion system. For example, Conlon describes an electrically variable transmission (EVT) “for use with relatively large battery power and/or a relatively small engine, with reduced motor speed requirements.” EX1004, ¶ 0006. “The EVT has an increased EV mode capability using both motor/generators, a forward low-range electric-only operating mode in which the engine is off, a forward low-range electrically variable input split operating mode, a forward high-range compound split operating mode, and a neutral operating mode.” *Id.* Figure 2 of Conlon depicts the powertrain and EVT propulsion system.





115. Therefore, limitation 16[a] is disclosed by Conlon.

116. Conlon discloses a first electric motor coupled to the energy storage system. Referring to Figure 2, the first motor/generator 80 (M/G A) [shown in purple] is operatively connected to ESD 86. EX1004, ¶ 0036.

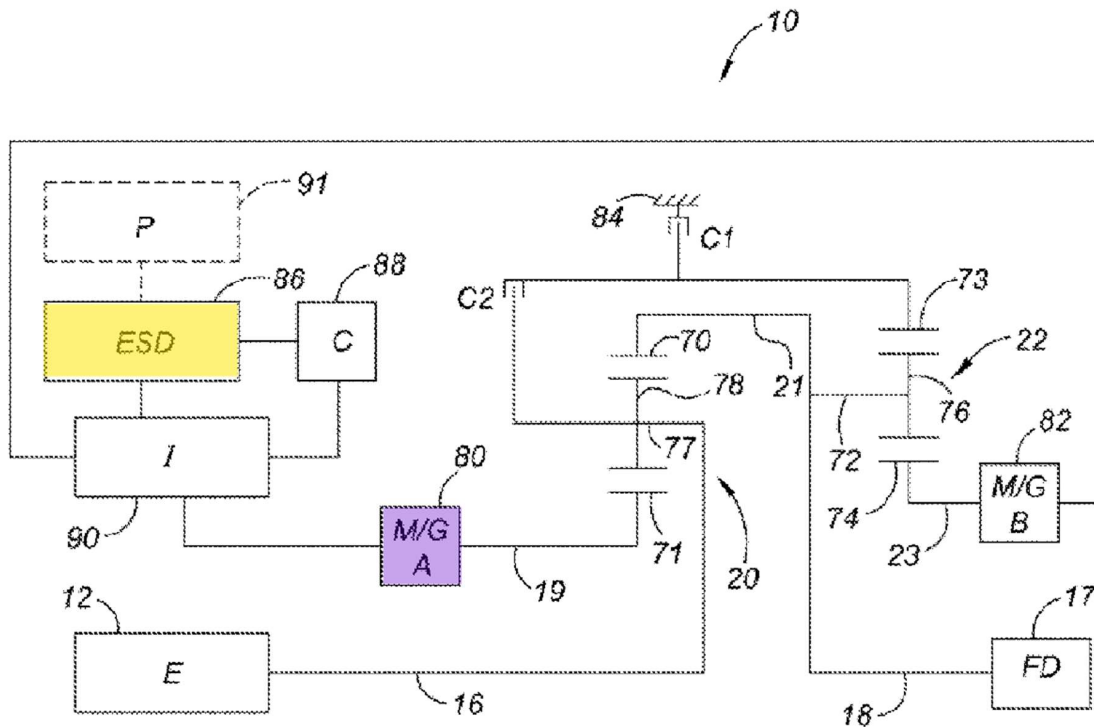


FIG. 2

117. Therefore, limitation 16[b] is disclosed by Conlon.

*Limitation 16[c]: a second electric motor coupled to the energy storage system;*

118. Conlon discloses a second electric motor coupled to the energy storage system. Referring to Figure 2, the second motor/generator 82 (M/G B) [shown in red] is operatively connected to ESD 86. EX1004, ¶ 0036.

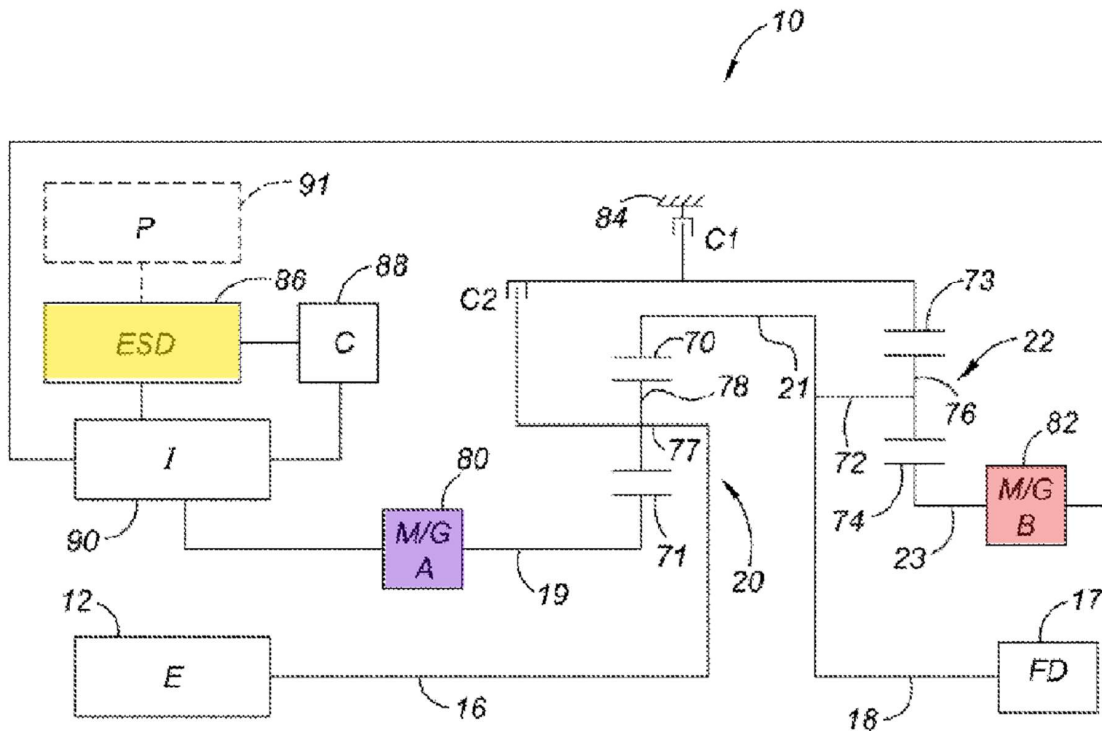


FIG. 2

119. Therefore, limitation 16[c] is disclosed by Conlon.

*Limitation 16[d]: a transmission device coupled to the first electric motor, the transmission device comprising an arrangement of planetary gears;*

120. Conlon discloses a transmission device coupled to the first electric motor where the transmission device comprises an arrangement of planetary gears. Referring to Figure 2, “the first motor/generator (M/G A) 80 is continuously connected to the sun gear member 71 of the first planetary gear set 20 via the interconnecting member 19.” EX1004, ¶ 0035. Planetary gear set 20 [shown in blue]

is a transmission device comprising sun gear 71, ring gear 70, carrier member 77, a plurality of pinion gears 78, and clutch C2. *Id.*, ¶¶ 0033-0035.

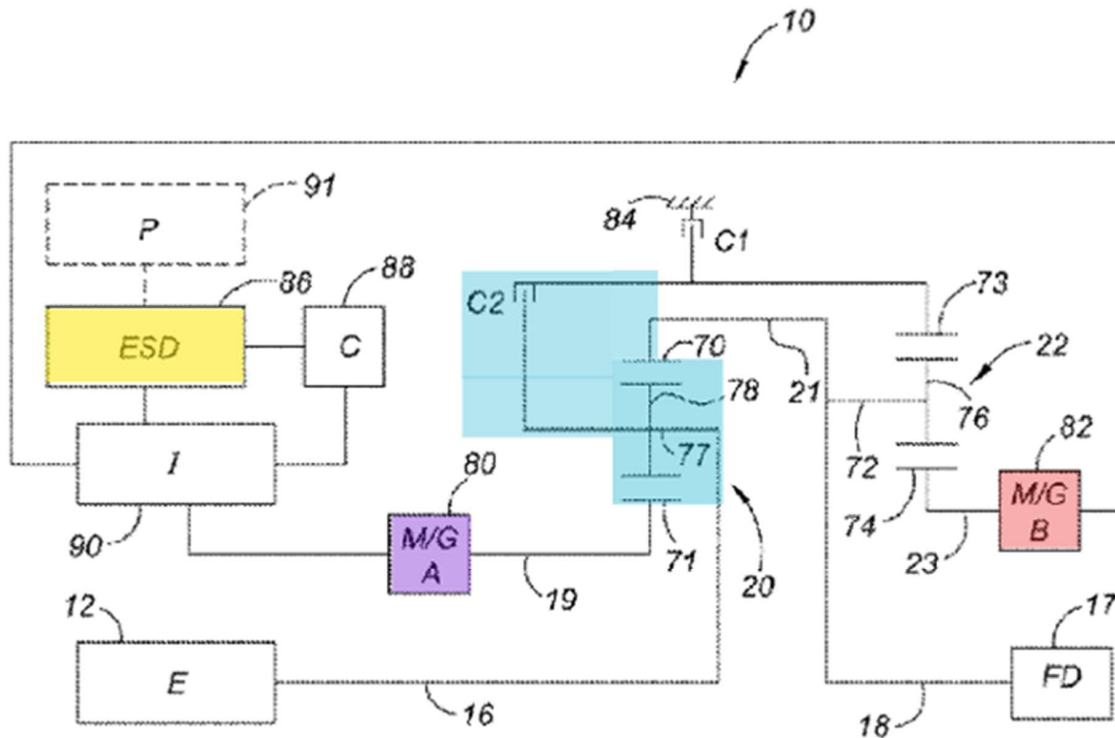


FIG. 2

121. Therefore, limitation 16[d] is disclosed by Conlon.

*Limitation 16[e]: a gear assembly coupled between the second electric motor and the transmission device such that the output of the second electric motor bypasses the transmission device;*

122. Conlon discloses a gear assembly coupled between the second electric motor and the transmission device such that the output of the second electric motor bypasses the transmission device. The claimed gear assembly is a separate and distinct element from the transmission device recited in limitation 16[d]. First, the

claim lists the transmission device and gear assembly as separate elements. Second, the claim recites that the gear assembly is positioned “between” the second motor and the transmission device, indicating three distinct components arranged in sequence. Third, the claim requires that the second motor’s output “bypasses the transmission device,” further indicating the transmission and gear assembly are separate because the output of the second motor cannot bypass the transmission device if the gear assembly to which the motor is coupled is part of the transmission device.

123. Conlon’s “second planetary gear set 22 has a sun gear 74, a ring gear 73, and a carrier member 72 having a plurality of pinion gears 76.” *Id.*, ¶ 0034. Referring to Figure 2, “[t]he second motor/generator 82 (M/G B) is continuously connected to the sun gear member 74 of the second planetary gear set 22, and is operable for transmitting torque to the output member 18.” EX1004, ¶ 0035. The second planetary gear set 22 [shown in green] is located between M/G B [shown in red] and the first planetary gear set 20 (transmission device) [shown in blue]. In Mode 1, for example, the mechanical power of M/G B is transmitted to output member 18 [shown in brown] without passing through (*i.e.*, bypassing) first planetary gear set 20 (transmission device), as shown by the red arrow. In this mode, clutch C1 is engaged and clutch C2 is disengaged; thus, no power is transmitted from M/G A to the output member 18. In this mode, the power from M/G B is transmitted

to the planetary carrier member 72 which then transfers the power to the final drive via output member 18.

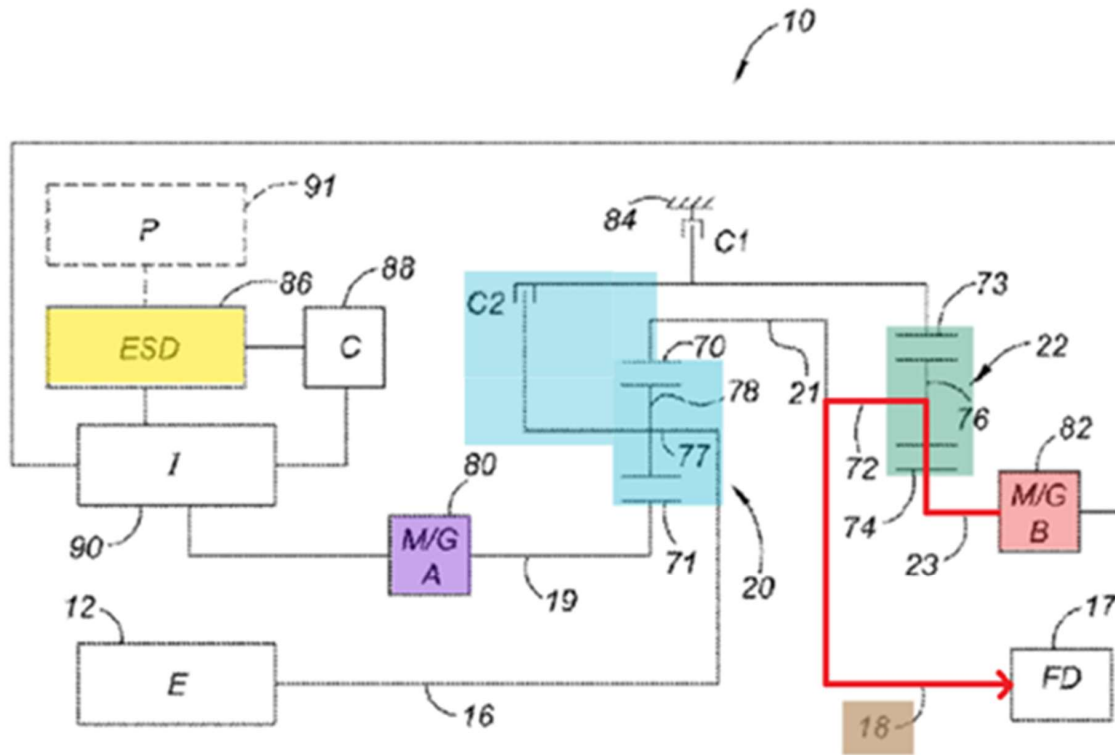


FIG. 2

124. Therefore, limitation 16[e] is disclosed by Conlon.

*Limitation 16[f]: an internal combustion engine coupled to the transmission device;*

125. Conlon discloses an internal combustion engine coupled to the transmission device. Referring to Figure 2, “engine 12, [shown in gray] is continuously connected to the carrier member 77 of the first planetary gear set 20” (transmission device). EX1004, ¶ 0035.

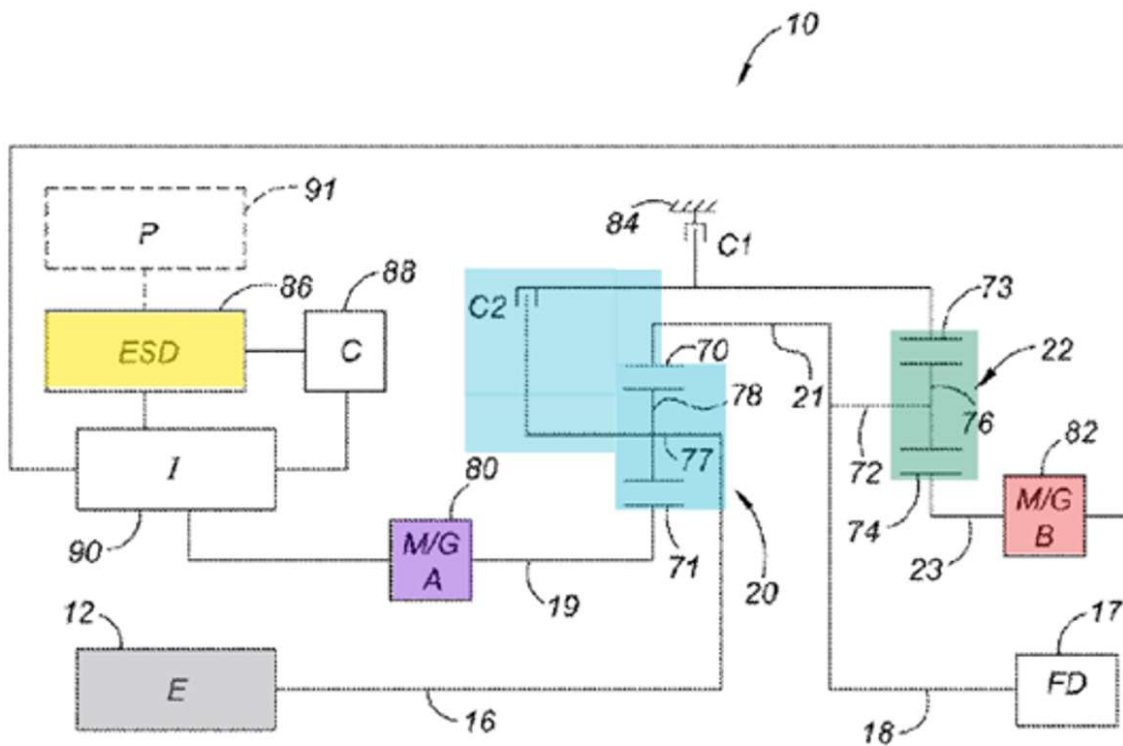


FIG. 2

126. Therefore, limitation 16[f] is disclosed by Conlon.

*Limitation 16[g]: a control system configured to selectively:*

127. The powertrain and EVT of Conlon are capable of operating in several modes: Mode 1 (input-split mode, which is an electrically variable mode normally used with the engine turned off, such as during low vehicle speeds), Mode 2 (compound-split mode, which is normally used when the engine is turned on, such as during high vehicle speeds), Mode 3 (two-motor electric-only mode, which is used with both of the motor/generators driving the output member 18 at a fixed ratio for electric-only propulsion when the engine is turned off), and Mode 4 (neutral

mode, which effectively disconnects the second motor/generator from output member 18, or otherwise prevents or minimizes the amount of torque the second motor/generator is able to transmit to output member 18). EX1004, ¶ 0042; Figs. 1-3.

128. At rest, the EVT is in Mode 3, and then “transitions to Mode 1” once the engine reaches operating speed. *Id.*, ¶ 0044. At relatively high rates of speed, the EVT may shift from Mode 1 to Mode 2 by releasing the brake C1 and applying the clutch C2, or alternately, the power of the first motor/generator may be supplied by the ESD, allowing the EVT to shift between Modes 1 and 2 without any torque being transmitted across slipping clutches. *Id.*, ¶ 0045; Figs. 2-3. The EVT can easily transition from either Mode 1 or Mode 2 to Mode 3 by a synchronous shift to the appropriate speed ratio, and then by engaging the appropriate brake C1 and/or clutch C2. *Id.*, ¶ 0047; Figs. 2-3. The shift between Mode 1 or Mode 2 to Mode 3 may also be achieved as an energy shift by engaging the appropriate brake C1 or clutch C2 to shift directly to Mode 3. *Id.*

129. Conlon necessarily teaches a control system for switching the EVT between these modes. A POSITA would have understood that a control system is required to monitor operating conditions such as vehicle speed, motor speed, speed ratio, and power supplied from the ESD. In addition, a POSITA would have understood that a control system is required to engage and disengage clutches C1/D1

and C2/D2 as needed to shift the EVT between respective modes. *Id.*, ¶¶ 0006, 0017, 0033, 0043-0048, 0054-0058, Fig. 3. Accordingly, Conlon inherently discloses the claimed control system.

130. Therefore, limitation 16[g] is disclosed by Conlon.

*Limitation 16[g][i]: operate the first electric motor and second electric motor to drive the vehicle through the transmission device and gear assembly, respectively;*

131. As explained above, Conlon is capable of operating in Mode 3 (two-motor electric-only) in which both motors drive the output member 18 (which is operatively connected to final drive assembly 17) at a fixed ratio for electric-only propulsion when the engine is turned off. EX1004, ¶¶ 0028, 0035, 0042, Figs. 1-3. As shown in Figure 2, the first motor 80 (M/G A) drives output member 18 and final drive assembly 17 through the first planetary gear set 20 (transmission device), and the second motor 82 (M/G B) drives output member 18 and final drive assembly 17 through the second planetary gear set 22, as shown by the red arrows.

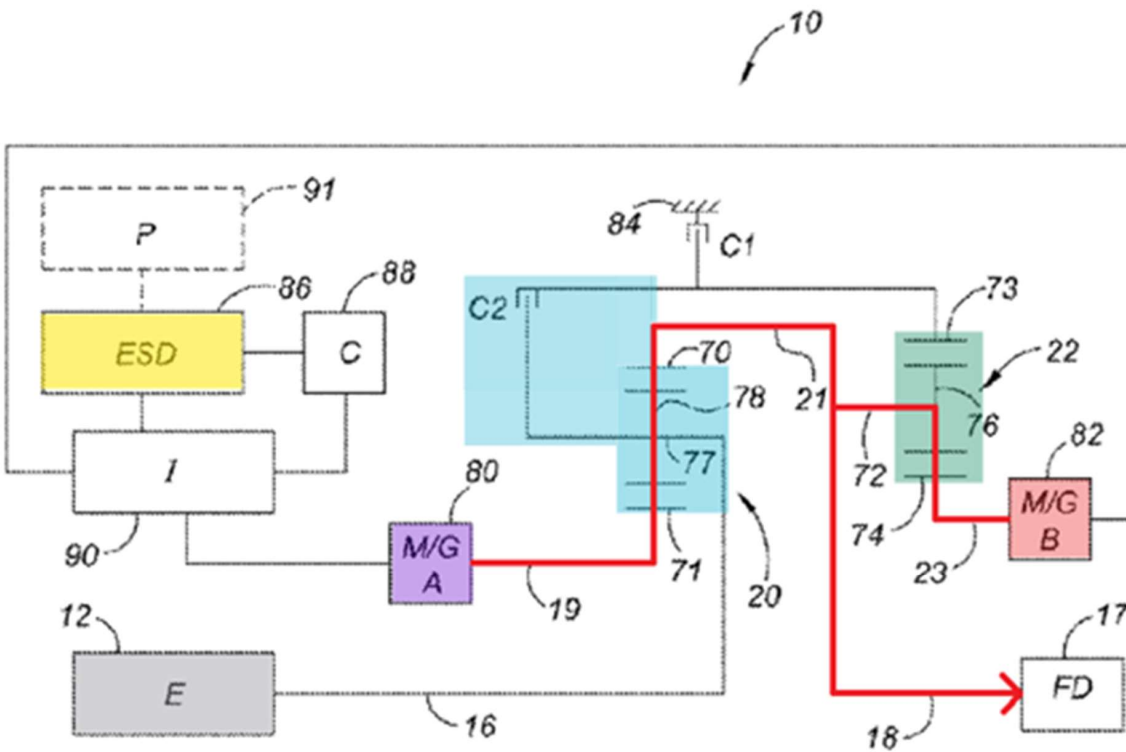


FIG. 2

132. Therefore, limitation 16[g][i] is disclosed by Conlon.

*Limitation 16[g][ii]: operate the first electric motor as a generator to generate electrical power while operating the second electric motor to drive the vehicle through the gear assembly; and*

133. As explained above, Conlon is capable of operating in Mode 1, which is an electrically variable mode normally used with the engine turned off. EX1004, ¶ 0042, Figs. 1-3. “When operating in Mode 1 (EVT 1/Input Split), the motor/generator 80 (M/G A) acts as a generator, and the motor/generator 82 (M/G B) acts as a motor.” *Id.*, ¶ 0044. The second motor 82 (M/G B) drives output member

18 (and final drive assembly 17) of the vehicle through the second planetary gear set 22. *See* Fig. 2.

134. Therefore, limitation 16[g][ii] is disclosed by Conlon.

*Limitation 16[g][iii]: operate the second electric motor as a generator to generate electrical power.*

135. As explained above, Conlon is capable of operating in Mode 2 (compound-split), which is normally used when the engine is turned on. EX1004, ¶ 0042; Figs. 1-3. In this mode, “[t]he EVT 114 may then operate with the motor/generator 82 (M/G [B]) acting as a generator . . . .” *Id.*, ¶ 0051; *see also* ¶¶ 0046, 0052.

136. Therefore, limitation 16[g][iii] is disclosed by Conlon.

#### **G. Dependent Claim 18**

*18. The system of claim 16, further comprising a wheel/axle assembly coupled to the gear assembly.*

137. As explained above, Conlon discloses all the limitations of claim 16.

138. Conlon discloses a wheel/axle assembly coupled to the gear assembly.

The second planetary gear set 22 is connected to and “operable for transmitting torque to the output member 18” (EX1004, ¶ 0035), which in turn is connected to final drive assembly 17 “for propelling the vehicle.” *Id.*, ¶ 0028. Figure 1 shows the output of final drive assembly 17 “to wheels.” The second planetary gear set 22 is thus coupled to a wheel/axle assembly.

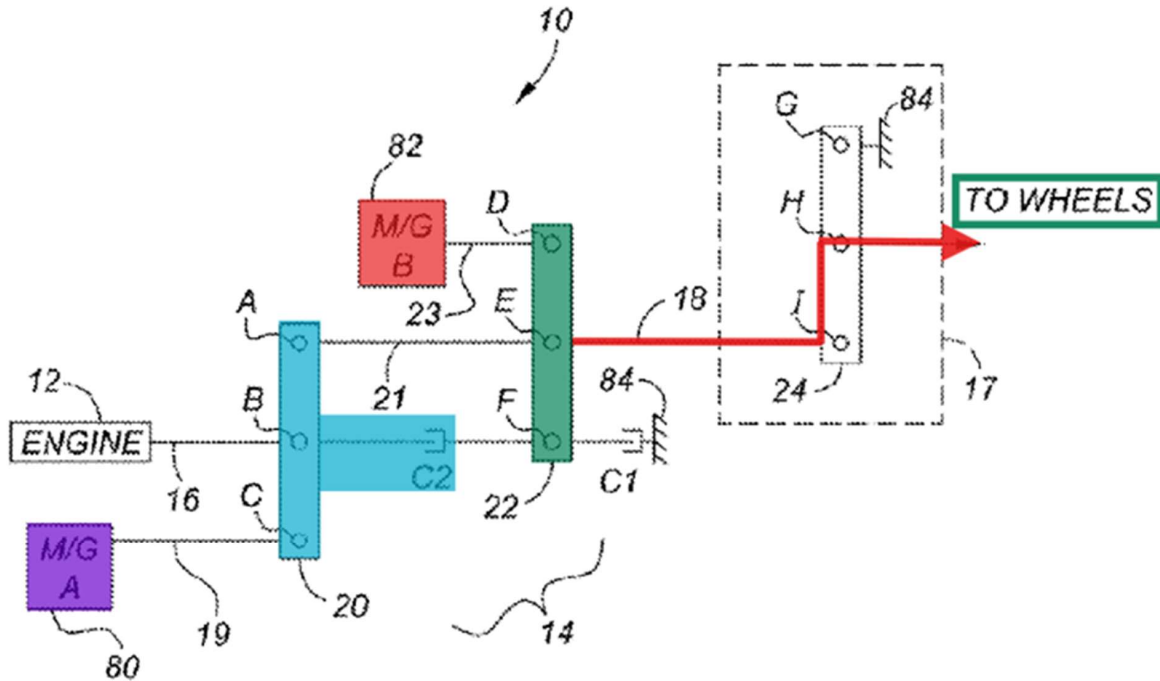


FIG. 1

139. Therefore, the limitations of claim 18 are disclosed by Conlon.

#### H. Dependent Claim 19

19. The system of claim 16, wherein the electrical power generated by the first electric motor is provided to the second electric motor.

140. As explained above, Conlon discloses all the limitations of claim 16.

141. Conlon discloses that the electrical power generated by the first electric motor is provided to the second electric motor. In Mode 1 (input-split), “the motor/generator 80 (M/G A) acts as a generator, and the motor/generator 82 (M/G B) acts as a motor.” EX1004, ¶ 0044. “ESD 86 . . . is operatively connected to each of the respective motor/ generators 80, 82 such that motor/ generators 80, 82 may

selectively transfer power to or receive power from the ESD 86.” *Id.*, ¶ 0036. Further, as shown in Figure 2, motor/generators 80, 82 are operatively connected to each other through inverter 90. *Id.*, ¶ 0038. Thus, electrical power generated by motor/generator 80 (M/G A) can be supplied to motor/generator 82 (M/G B) through ESD 86 via inverter 90. The electrical power generated by M/G A is thus provided to M/G B.

142. Therefore, the limitations of claim 19 are disclosed by Conlon.

**I. Dependent Claim 20**

*20. The system of claim 16, wherein the electrical power generated by the second electric motor is provided to the energy storage system.*

143. As explained above, Conlon discloses all the limitations of claim 16.

144. Conlon discloses that the electrical power generated by the second electric motor is provided to the energy storage system. EX1004, ¶ 0013 (“the EVT includes an energy storage device (ESD) that is connected to the first and second motor/generators for providing power thereto and ***receiving power therefrom***”) (emphasis added); ¶ 0036 (“The powertrain 10 may be further configured with an onboard energy storage device or ESD 86 that is operatively connected to each of the respective motor/generators 80, 82 such that motor/generators 80, 82 may selectively ***transfer power to*** or receive power from the ESD 86.”) (emphasis added).

145. Therefore, the limitations of claim 20 are disclosed by Conlon.

**VIII. GROUND 2: CLAIMS 1, 4, 5, 7, 8, 16, AND 18-20 ARE OBVIOUS  
OVER CONLON**

146. It is my opinion that the subject matter of claims 1, 4, 5, 7, 8, 16, and 18-20 would have been obvious to a POSITA based on the teachings of Conlon.

**A. Independent Claim 1**

*Limitation 1[p]: A system for a hybrid electric vehicle, comprising:*

147. Conlon discloses a system for a hybrid electric vehicle. For example, Conlon describes an electrically variable transmission (EVT) “for use with relatively large battery power and/or a relatively small engine, with reduced motor speed requirements.” EX1004, ¶ 0006. “The EVT has an increased EV mode capability using both motor/generators, a forward low-range electric-only operating mode in which the engine is off, a forward low-range electrically variable input split operating mode, a forward high-range compound split operating mode, and a neutral operating mode.” *Id.* Figure 2 of Conlon depicts the powertrain and EVT system.

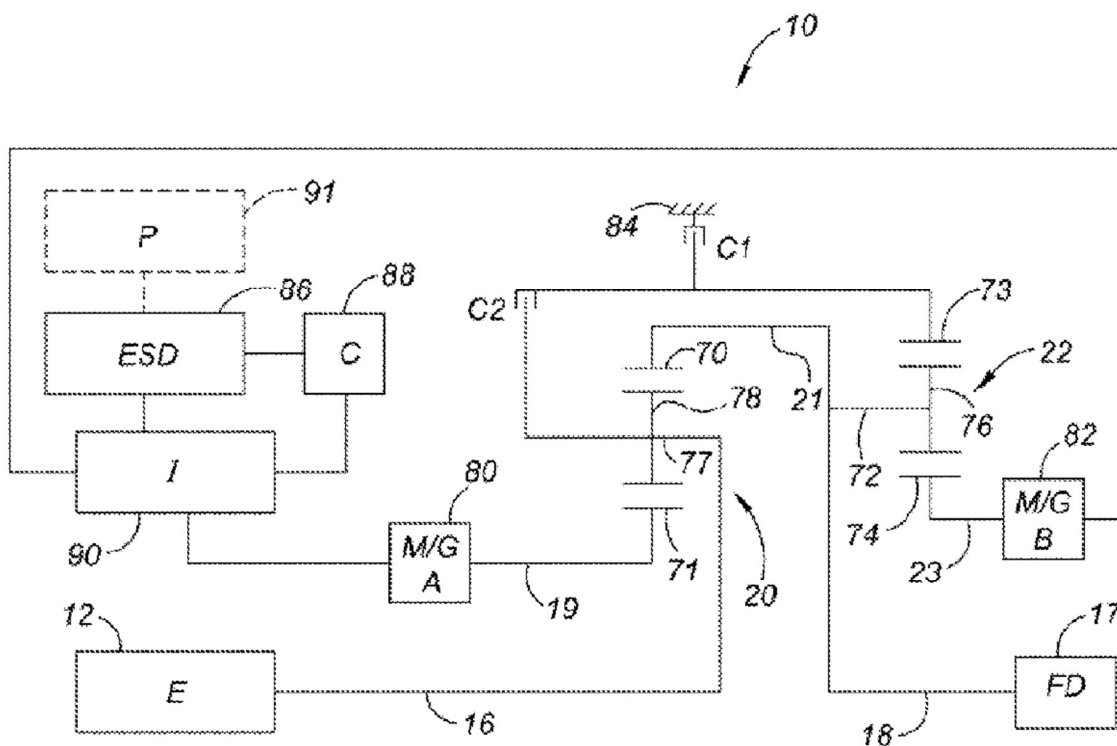


FIG. 2

148. Therefore, limitation 1[p] is disclosed by Conlon.

*Limitation 1[a]: an energy storage system;*

149. Conlon discloses an energy storage system. Referring to Figure 2, the system includes energy storage device or ESD 86 [shown in yellow]. EX1004, ¶ 0036.

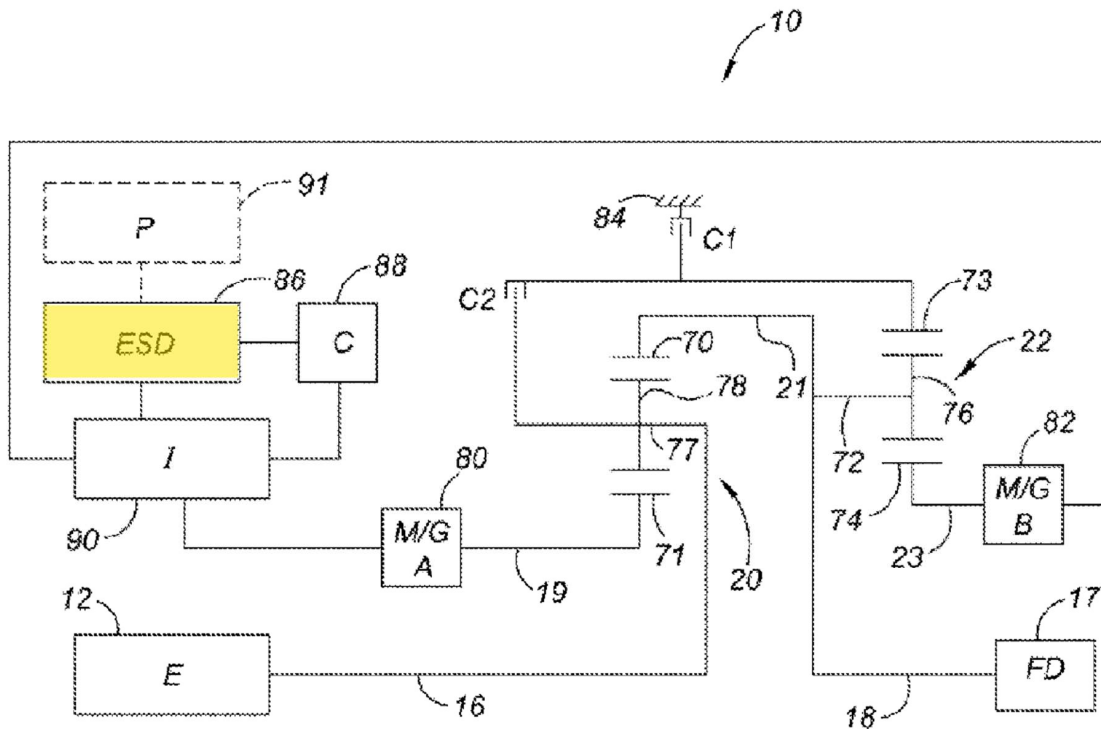


FIG. 2

150. Therefore, limitation 1[a] is disclosed by Conlon.

*Limitation 1[b]: a first traction motor coupled to the energy storage system;*

151. Conlon discloses a first traction motor coupled to the energy storage system. Referring to Figure 2, the first motor/generator 80 (M/G A) [shown in purple] is operatively connected to ESD 86. EX1004, ¶ 0036. M/G A is a traction motor.

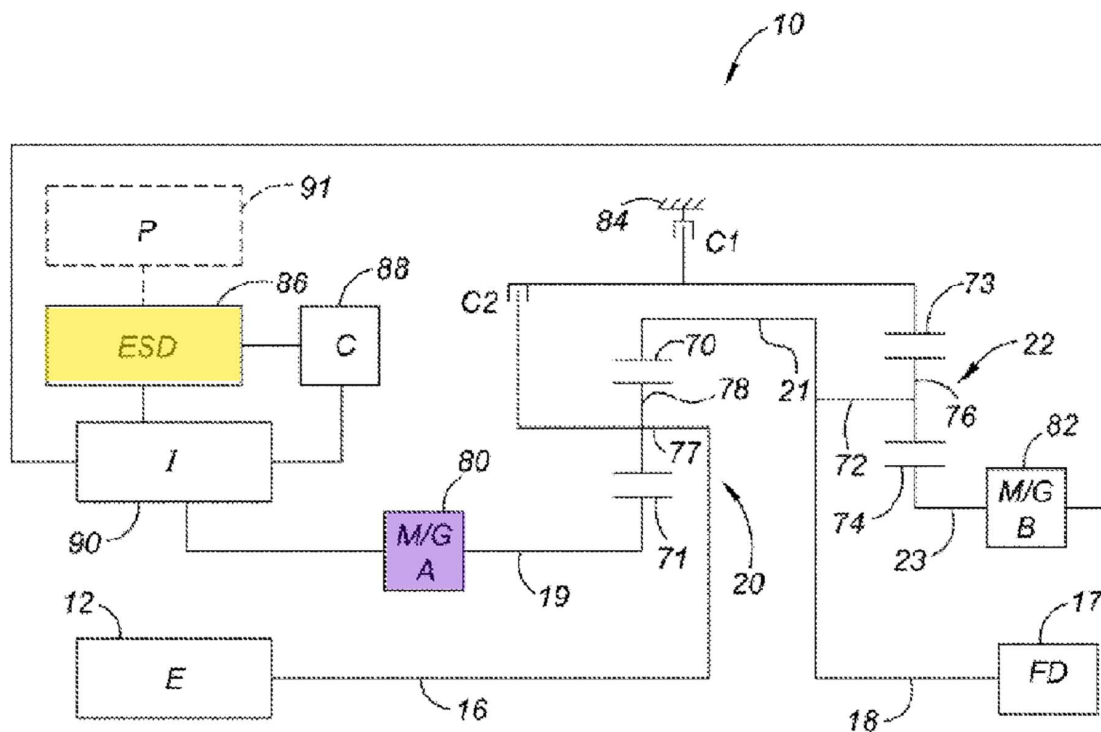


FIG. 2

152. Therefore, limitation 1[b] is disclosed by Conlon.

*Limitation 1[c]: a second traction motor coupled to the energy storage system;*

153. Conlon discloses a second traction motor coupled to the energy storage system. Referring to Figure 2, the second motor/generator 82 (M/G B) [shown in red] is operatively connected to ESD 86. EX1004, ¶ 0036. M/G B is a traction motor.

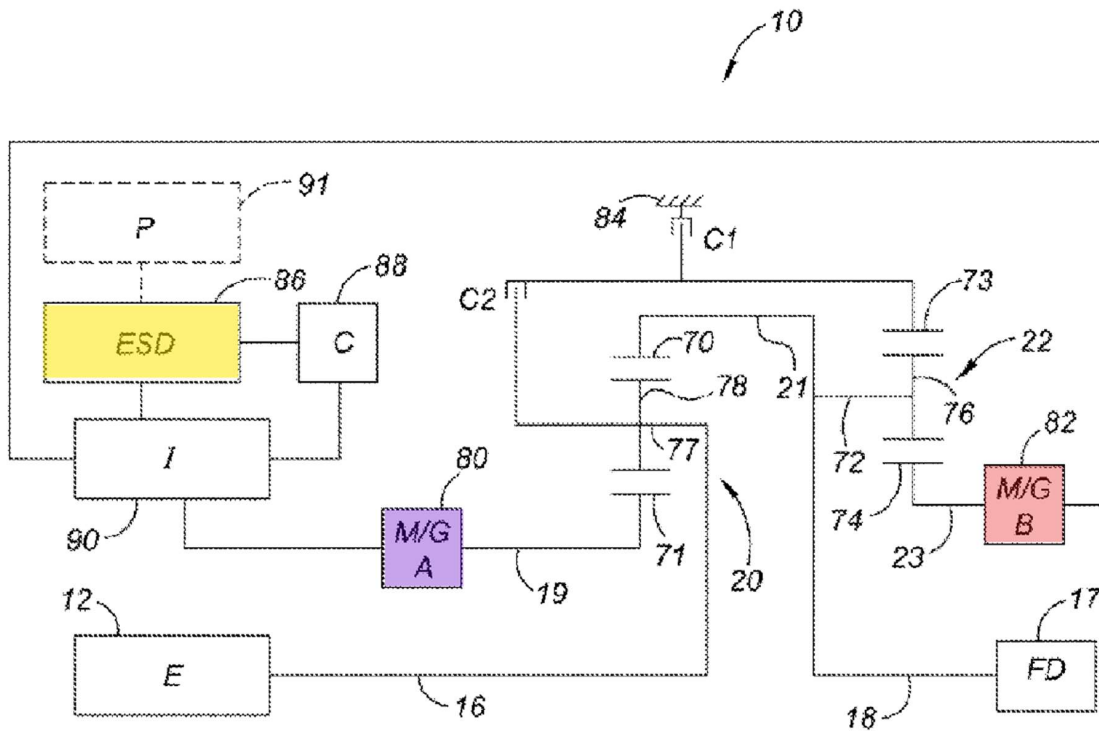


FIG. 2

154. Therefore, limitation 1[c] is disclosed by Conlon.

*Limitation 1[d]: a transmission device coupled to the first traction motor, the transmission device comprising an arrangement of planetary gears;*

155. Conlon discloses a transmission device coupled to the first traction motor where the transmission device comprises an arrangement of planetary gears. Referring to Figure 2, “the first motor/generator (M/G A) 80 is continuously connected to the sun gear member 71 of the first planetary gear set 20 via the interconnecting member 19.” EX1004, ¶ 0035. Planetary gear set 20 [shown in blue]

is a transmission device comprising sun gear 71, ring gear 70, carrier member 77, a plurality of pinion gears 78, and clutch C2. *Id.*, ¶¶ 0033-0035.

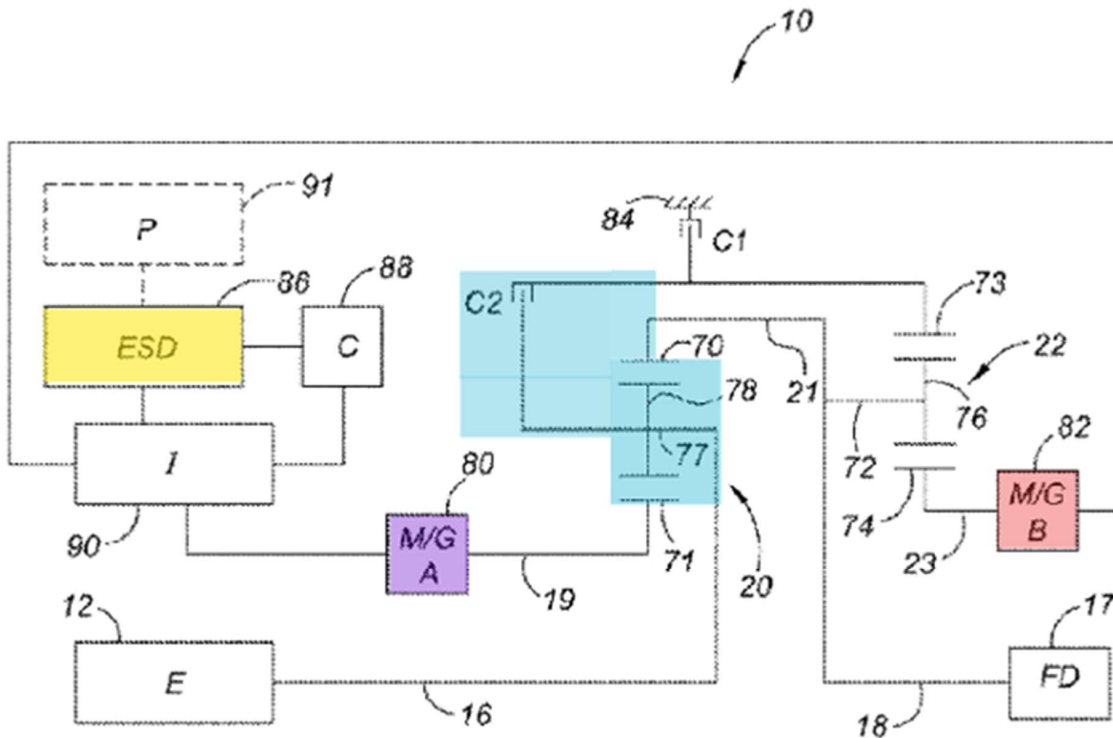


FIG. 2

156. Therefore, limitation 1[d] is disclosed by Conlon.

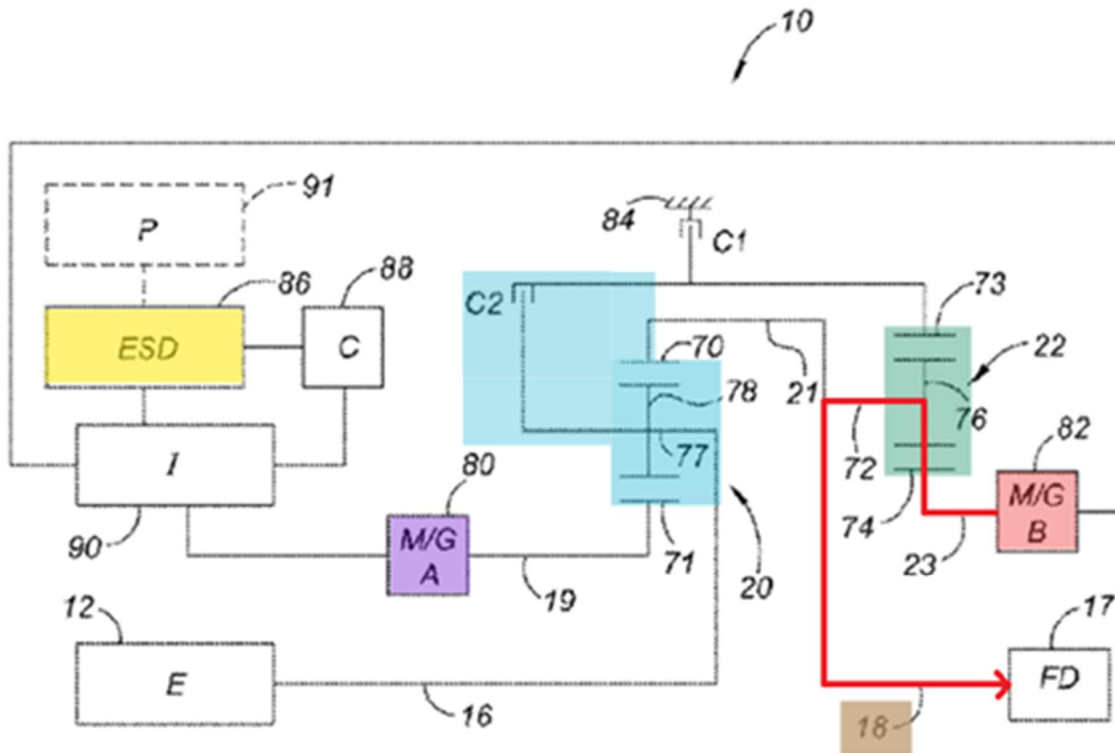
*Limitation 1[e]: a gear assembly coupled between the second traction motor and the transmission device such that the output of the second traction motor bypasses the transmission device;*

157. Conlon discloses a gear assembly coupled between the second traction motor and the transmission device such that the output of the second traction motor bypasses the transmission device. The claimed gear assembly is a separate and distinct element from the transmission device recited in limitation 1[d]. First, the

claim lists the transmission device and gear assembly as separate elements. Second, the claim recites that the gear assembly is positioned “between” the second motor and the transmission device, indicating three distinct components arranged in sequence. Third, the claim requires that the second motor’s output “bypasses the transmission device,” further indicating the transmission and gear assembly are separate because the output of the second motor cannot bypass the transmission device if the gear assembly to which the motor is coupled is part of the transmission device.

158. Conlon’s “second planetary gear set 22 has a sun gear 74, a ring gear 73, and a carrier member 72 having a plurality of pinion gears 76.” EX1004, ¶ 0034. Referring to Figure 2, “[t]he second motor/generator 82 (M/G B) is continuously connected to the sun gear member 74 of the second planetary gear set 22, and is operable for transmitting torque to the output member 18.” *Id.*, ¶ 0035. The second planetary gear set 22 [shown in green] is located between M/G B [shown in red] and the first planetary gear set 20 (transmission device) [shown in blue]. In Mode 1, for example, the mechanical power of M/G B is transmitted to output member 18 [shown in brown] without passing through (*i.e.*, bypassing) first planetary gear set 20 (transmission device), as shown by the red arrow. In this mode, clutch C1 is engaged and clutch C2 is disengaged; thus, no power is transmitted from M/G A to the output member 18. In this mode, the power from M/G B is transmitted

to the planetary carrier member 72 which then transfers the power to the final drive via output member 18.



159. Therefore, limitation 1[e] is disclosed by Conlon.

*Limitation 1[f]: an internal combustion engine coupled to the transmission device via a path that does not include the first traction motor and second traction motor;*

160. Conlon discloses an internal combustion engine coupled to the transmission device via a path that does not include the first traction motor and second traction motor. Referring to Figure 2, “engine 12, [shown in gray] is

continuously connected to the carrier member 77 of the first planetary gear set 20 (transmission device) via a path that does not include M/G A and M/G B, as shown by the red arrow. EX1004, ¶ 0035.

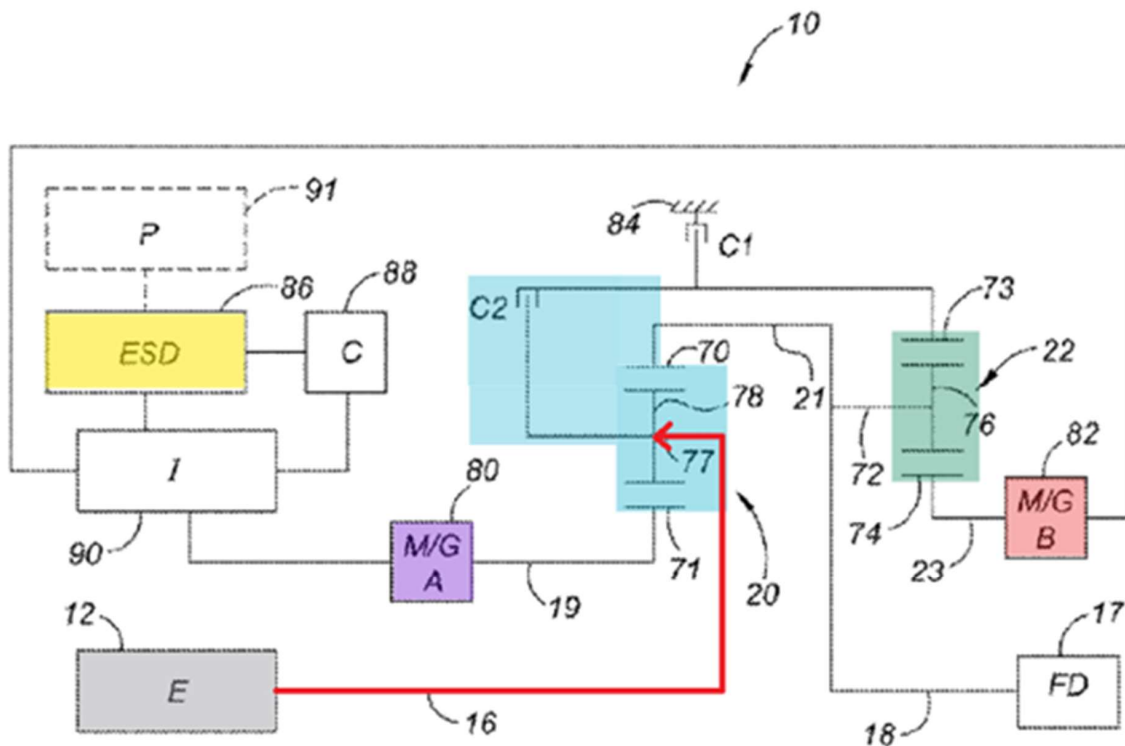


FIG. 2

161. Therefore, limitation 1[f] is disclosed by Conlon.

*Limitation 1[g]: a control system configured to selectively:*

162. The powertrain and EVT of Conlon are capable of operating in several modes: Mode 1 (input-split mode, which is an electrically variable mode normally used with the engine turned off, such as during low vehicle speeds), Mode 2 (compound-split mode, which is normally used when the engine is turned on, such

as during high vehicle speeds), Mode 3 (two-motor electric-only mode, which is used with both of the motor/generators driving the output member 18 at a fixed ratio for electric-only propulsion when the engine is turned off), and Mode 4 (neutral mode, which effectively disconnects the second motor/generator from output member 18, or otherwise prevents or minimizes the amount of torque the second motor/generator is able to transmit to output member 18). EX1004, ¶ 0042; Figs. 1-3.

163. At rest, the EVT is in Mode 3, and then “transitions to Mode 1” once the engine reaches operating speed. *Id.*, ¶ 0044. At relatively high rates of speed, the EVT may shift from Mode 1 to Mode 2 by releasing the brake C1 and applying the clutch C2, or alternately, the power of the first motor/generator may be supplied by the ESD, allowing the EVT to shift between Modes 1 and 2 without any torque being transmitted across slipping clutches. *Id.*, ¶ 0045, Figs. 2-3. The EVT can easily transition from either Mode 1 or Mode 2 to Mode 3 by a synchronous shift to the appropriate speed ratio, and then by engaging the appropriate brake C1 and/or clutch C2. *Id.*, ¶ 0047, Figs. 2-3. The shift between Mode 1 or Mode 2 to Mode 3 may also be achieved as an energy shift by engaging the appropriate brake C1 or clutch C2 to shift directly to Mode 3. *Id.*

164. As explained above in Section VII(A), Conlon inherently discloses the claimed control system. However, to the extent Conlon is found not disclose a

control system, it would have been obvious to a POSITA to include a control system for switching the EVT between modes. A POSITA would have understood that a control system would be beneficial to monitor operating conditions such as vehicle speed, motor speed, speed ratio, and power supplied from the ESD, and to shift the EVT between respective modes as appropriate to maximize efficiency. Control systems for EV and HEV powertrains were well known in the industry before the January 2014 priority date of the '648 Patent. Indeed, Conlon discloses a control unit to control power distribution to or from the ESD, and “to balance input torque from the engine 12, from the motor/generator 80 (M/G A), and/or from the motor/generator 82 (M/G B) during braking in order to provide a desired rate of deceleration of the output member 18, and/or one or more individual braking units.” EX1004, ¶ 0037. A POSITA would have been motivated to incorporate a control system to selectively operate M/G A and M/G B according to the modes disclosed by Conlon for better efficiency and enhanced performance of the system.

165. For at least these reasons, limitation 1[g] would have been obvious to a POSITA based on the teachings of Conlon.

*Limitation 1[g][i]: operate the first traction motor and second traction motor to drive the vehicle through the transmission device and gear assembly, respectively;*

166. As explained above, Conlon is capable of operating in Mode 3 (two-motor electric-only) in which both motors drive the output member 18 (which is

operatively connected to final drive assembly 17) at a fixed ratio for electric-only propulsion when the engine is turned off. EX1004, ¶¶ 0028, 0035, 0042, Figs. 1-3. As shown in Figure 2, the first motor 80 (M/G A) drives output member 18 and final drive assembly 17 through the first planetary gear set 20 (transmission device), and the second motor 82 (M/G B) drives output member 18 and final drive assembly 17 through the second planetary gear set 22, as shown by the red arrows.

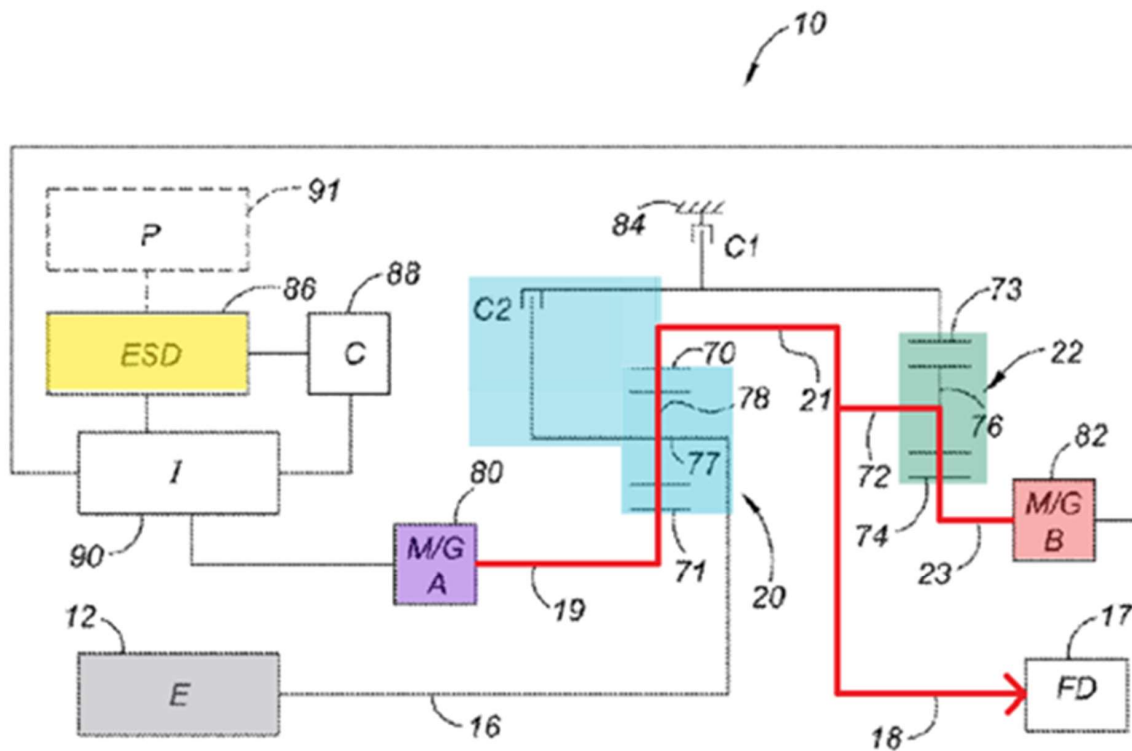


FIG. 2

167. Therefore, limitation 1[g][i] is disclosed by Conlon.

*Limitation 1[g][ii]: operate the first traction motor as a generator to generate electrical power while operating the second traction motor to drive the vehicle through the gear assembly; and*

168. As explained above, Conlon is capable of operating in Mode 1, which is an electrically variable mode normally used with the engine turned off. EX1004, ¶ 0042, Figs. 1-3. “When operating in Mode 1 (EVT 1/Input Split), the motor/generator 80 (M/G A) acts as a generator, and the motor/generator 82 (M/G B) acts as a motor.” *Id.*, ¶ 0044. The second motor 82 (M/G B) drives output member 18 (and final drive assembly 17) of the vehicle through the second planetary gear set 22. *See* Fig. 2.

169. Therefore, limitation 1[g][ii] is disclosed by Conlon.

*Limitation 1[g][iii]: operate the second traction motor as a generator to generate electrical power.*

170. As explained above, Conlon is capable of operating in Mode 2 (compound-split), which is normally used when the engine is turned on. EX1004, ¶ 0042, Figs. 1-3. In this mode, “[t]he EVT 114 may then operate with the motor/generator 82 (M/G [B]) acting as a generator . . . .” *Id.*, ¶ 0051; *see also* ¶¶ 0046, 0052.

171. Therefore, limitation 1[g][iii] is disclosed by Conlon.

**B. Dependent Claim 4**

*4. The system of claim 1, wherein the energy storage system comprises a battery.*

172. As explained above, claim 1 is obvious over Conlon.

173. Conlon discloses that “ESD 86 may be, for example, one or more batteries or battery packs.” EX1004, ¶ 0036.

174. For at least these reasons, claim 4 is obvious over Conlon.

**C. Dependent Claim 5**

*5. The system of claim 1, further comprising a wheel/axle assembly coupled to the gear assembly.*

175. As explained above, claim 1 is obvious over Conlon.

176. Conlon discloses a wheel/axle assembly coupled to the gear assembly.

The second planetary gear set 22 is connected to and “operable for transmitting torque to the output member 18” (EX1004, ¶ 0035), which in turn is connected to final drive assembly 17 “for propelling the vehicle.” *Id.*, ¶ 0028. Figure 1 shows the output of final drive assembly 17 “to wheels.” The second planetary gear set 22 is thus coupled to a wheel/axle assembly, as shown by the red line.

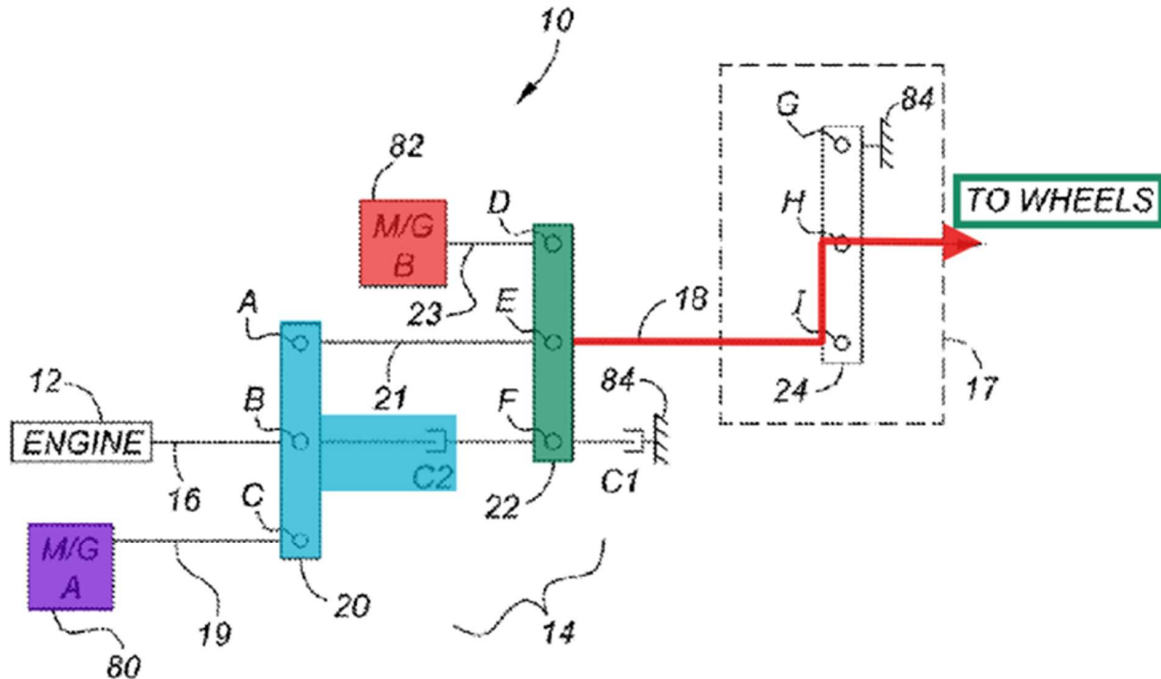


FIG. 1

177. For at least these reasons, claim 5 is obvious over Conlon.

#### D. Dependent Claim 7

7. The system of claim 1, wherein the electrical power generated by the first traction motor is provided to the second traction motor.

178. As explained above, claim 1 is obvious over Conlon.

179. Conlon discloses that the electrical power generated by the first traction motor is provided to the second traction motor. In Mode 1 (input-split), “the motor/generator 80 (M/G A) acts as a generator, and the motor/generator 82 (M/G B) acts as a motor.” EX1004, ¶ 0044. “ESD 86 . . . is operatively connected to each of the respective motor/ generators 80, 82 such that motor/ generators 80, 82 may

selectively transfer power to or receive power from the ESD 86.” *Id.*, ¶ 0036. Further, as shown in Figure 2, motor/generators 80, 82 are operatively connected to each other through inverter 90. *Id.*, ¶ 0038. Thus, electrical power generated by motor/generator 80 (M/G A) can be supplied to motor/generator 82 (M/G B) through ESD 86 via inverter 90. The electrical power generated by M/G A is thus provided to M/G B.

180. For at least these reasons, claim 7 is obvious over Conlon.

**E. Dependent Claim 8**

8. *The system of claim 1, wherein the electrical power generated by the second traction motor is provided to the energy storage system.*

181. As explained above, claim 1 is obvious over Conlon.

182. Conlon discloses that the electrical power generated by the second traction motor is provided to the energy storage system. EX1004, ¶ 0013 (“the EVT includes an energy storage device (ESD) that is connected to the first and second motor/generators for providing power thereto and ***receiving power therefrom***”) (emphasis added); ¶ 0036 (“The powertrain 10 may be further configured with an onboard energy storage device or ESD 86 that is operatively connected to each of the respective motor/generators 80, 82 such that motor/generators 80, 82 may selectively ***transfer power to*** or receive power from the ESD 86.”) (emphasis added).

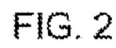
183. For at least these reasons, claim 8 is obvious over Conlon.

**F. Independent Claim 16**

*Limitation 16[p]: A hybrid electric vehicle propulsion system, comprising:*

184. Conlon discloses a hybrid electric vehicle propulsion system. For example, Conlon describes an electrically variable transmission (EVT) “for use with relatively large battery power and/or a relatively small engine, with reduced motor speed requirements.” EX1004, ¶ 0006. “The EVT has an increased EV mode capability using both motor/generators, a forward low-range electric-only operating mode in which the engine is off, a forward low-range electrically variable input split operating mode, a forward high-range compound split operating mode, and a neutral operating mode.” *Id.* Figure 2 of Conlon depicts the powertrain and EVT propulsion system.





*Limitation 16[b]: a first electric motor coupled to the energy storage system;*

77



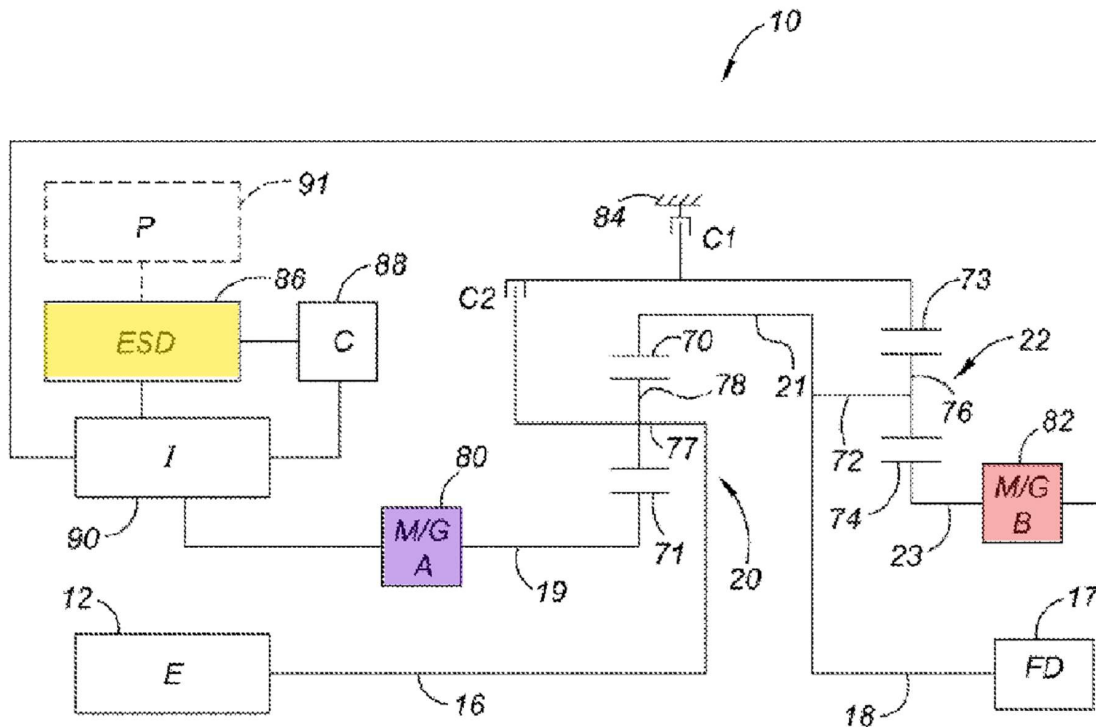


FIG. 2

191. Therefore, limitation 16[c] is disclosed by Conlon.

*Limitation 16[d]: a transmission device coupled to the first electric motor, the transmission device comprising an arrangement of planetary gears;*

192. Conlon discloses a transmission device coupled to the first electric motor where the transmission device comprises an arrangement of planetary gears. Referring to Figure 2, “the first motor/generator (M/G A) 80 is continuously connected to the sun gear member 71 of the first planetary gear set 20 via the interconnecting member 19.” EX1004, ¶ 0035. Planetary gear set 20 [shown in blue]

is a transmission device comprising sun gear 71, ring gear 70, carrier member 77, a plurality of pinion gears 78, and clutch C2. *Id.*, ¶¶ 0033-0035.

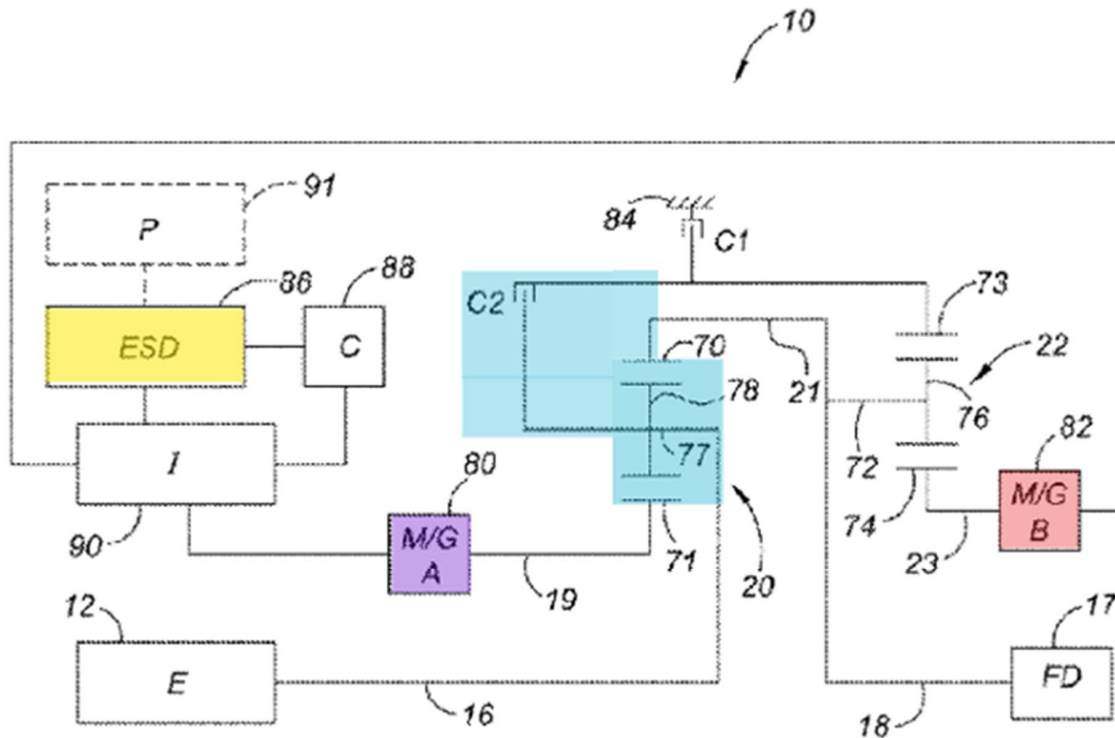


FIG. 2

193. Therefore, limitation 16[d] is disclosed by Conlon.

*Limitation 16[e]: a gear assembly coupled between the second electric motor and the transmission device such that the output of the second electric motor bypasses the transmission device;*

194. Conlon discloses a gear assembly coupled between the second electric motor and the transmission device such that the output of the second electric motor bypasses the transmission device. The claimed gear assembly is a separate and distinct element from the transmission device recited in limitation 16[d]. First, the

claim lists the transmission device and gear assembly as separate elements. Second, the claim recites that the gear assembly is positioned “between” the second motor and the transmission device, indicating three distinct components arranged in sequence. Third, the claim requires that the second motor’s output “bypasses the transmission device,” further indicating the transmission and gear assembly are separate because the output of the second motor cannot bypass the transmission device if the gear assembly to which the motor is coupled is part of the transmission device.

195. Conlon’s “second planetary gear set 22 has a sun gear 74, a ring gear 73, and a carrier member 72 having a plurality of pinion gears 76.” EX1004, ¶ 0034. Referring to Figure 2, “[t]he second motor/generator 82 (M/G B) is continuously connected to the sun gear member 74 of the second planetary gear set 22, and is operable for transmitting torque to the output member 18.” *Id.*, ¶ 0035. The second planetary gear set 22 [shown in green] is located between M/G B [shown in red] and the first planetary gear set 20 (transmission device) [shown in blue]. In Mode 1, for example, the mechanical power of M/G B is transmitted to output member 18 [shown in brown] without passing through (*i.e.*, bypassing) first planetary gear set 20 (transmission device), as shown by the red arrow. In this mode, clutch C1 is engaged and clutch C2 is disengaged; thus, no power is transmitted from M/G A to the output member 18. In this mode, the power from M/G B is transmitted

to the planetary carrier member 72 which then transfers the power to the final drive via output member 18.

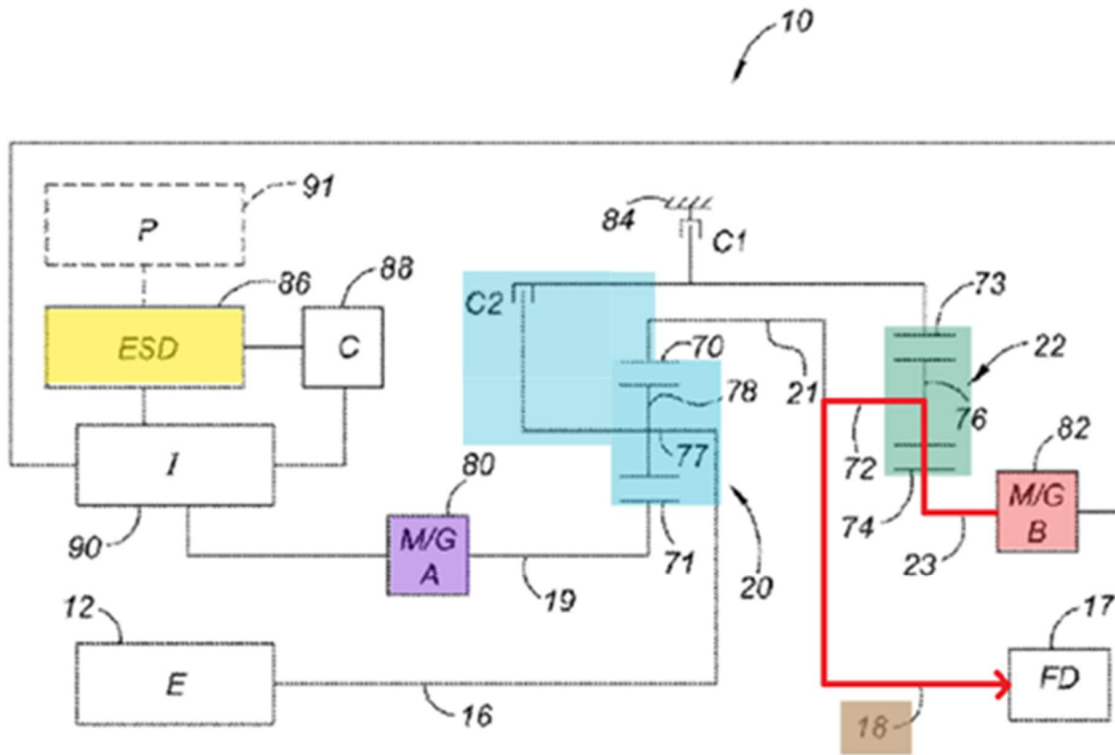


FIG. 2

196. Therefore, limitation 16[e] is disclosed by Conlon.

*Limitation 16[f]: an internal combustion engine coupled to the transmission device;*

197. Conlon discloses an internal combustion engine coupled to the transmission device. Referring to Figure 2, “engine 12, [shown in gray] is continuously connected to the carrier member 77 of the first planetary gear set 20” (transmission device). EX1004, ¶ 0035.

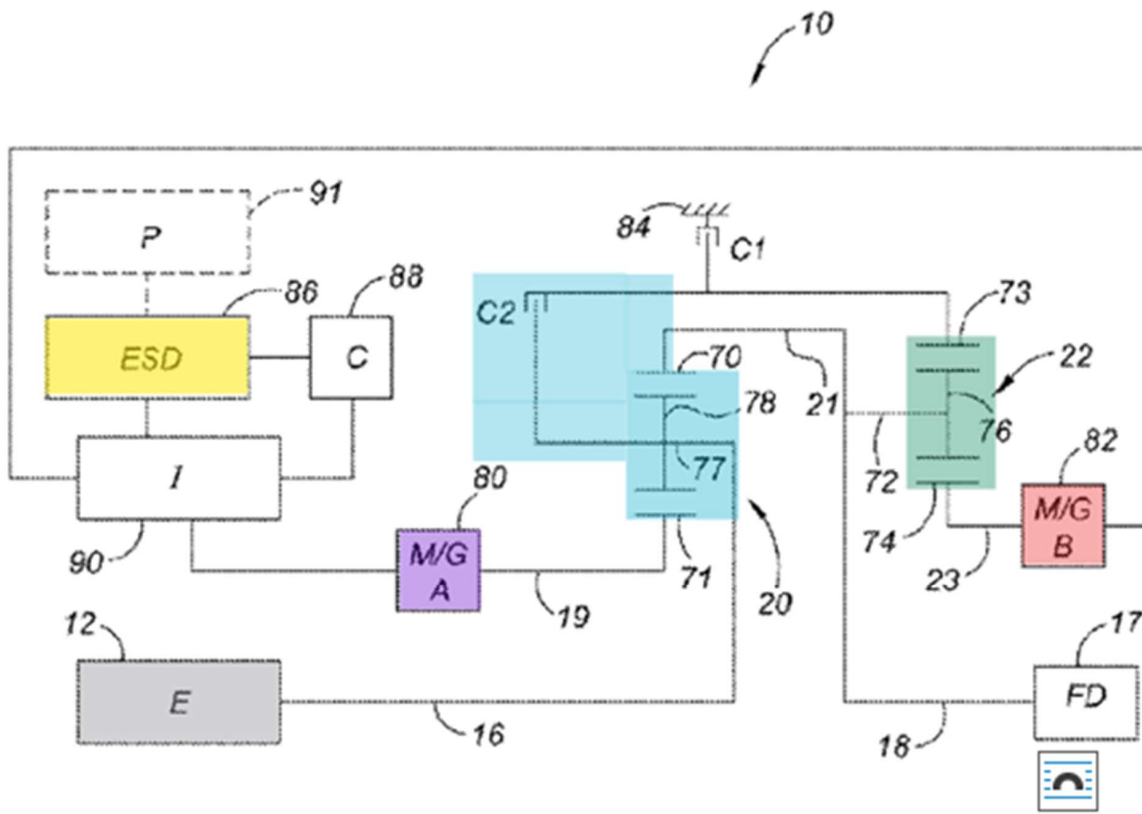


FIG. 2

198. Therefore, limitation 16[f] is disclosed by Conlon.

*Limitation 16[g]: a control system configured to selectively:*

199. The powertrain and EVT of Conlon are capable of operating in several modes: Mode 1 (input-split mode, which is an electrically variable mode normally used with the engine turned off, such as during low vehicle speeds), Mode 2 (compound-split mode, which is normally used when the engine is turned on, such as during high vehicle speeds), Mode 3 (two-motor electric-only mode, which is used with both of the motor/generators driving the output member 18 at a fixed ratio

for electric-only propulsion when the engine is turned off), and Mode 4 (neutral mode, which effectively disconnects the second motor/generator from output member 18, or otherwise prevents or minimizes the amount of torque the second motor/generator is able to transmit to output member 18). EX1004, ¶ 0042; Figs. 1-3.

200. At rest, the EVT is in Mode 3, and then “transitions to Mode 1” once the engine reaches operating speed. *Id.*, ¶ 0044. At relatively high rates of speed, the EVT may shift from Mode 1 to Mode 2 by releasing the brake C1 and applying the clutch C2, or alternately, the power of the first motor/generator may be supplied by the ESD, allowing the EVT to shift between Modes 1 and 2 without any torque being transmitted across slipping clutches. *Id.*, ¶ 0045; Figs. 2-3. The EVT can easily transition from either Mode 1 or Mode 2 to Mode 3 by a synchronous shift to the appropriate speed ratio, and then by engaging the appropriate brake C1 and/or clutch C2. *Id.*, ¶ 0047; Figs. 2-3. The shift between Mode 1 or Mode 2 to Mode 3 may also be achieved as an energy shift by engaging the appropriate brake C1 or clutch C2 to shift directly to Mode 3. *Id.*

201. As explained above in Section VII(A), Conlon inherently discloses the claimed control system. However, to the extent Conlon is found not disclose a control system, it would have been obvious to a POSITA to include a control system for switching the EVT between modes. A POSITA would have understood that a

control system would be beneficial to monitor operating conditions such as vehicle speed, motor speed, speed ratio, and power supplied from the ESD, and to shift the EVT between respective modes as appropriate to maximize efficiency. Control systems for EV and HEV powertrains were well known in the industry before the January 2014 priority date of the '648 Patent. Indeed, Conlon discloses a control unit to control power distribution to or from the ESD, and “to balance input torque from the engine 12, from the motor/generator 80 (M/G A), and/or from the motor/generator 82 (M/G B) during braking in order to provide a desired rate of deceleration of the output member 18, and/or one or more individual braking units.” EX1004, ¶ 0037. A POSITA would have been motivated to incorporate a control system to selectively operate M/G A and M/G B according to the modes disclosed by Conlon for better efficiency and enhanced performance of the EVT.

202. For at least these reasons, limitation 16[g] would have been obvious to a POSITA based on the teachings of Conlon.

*Limitation 16[g][i]: operate the first electric motor and second electric motor to drive the vehicle through the transmission device and gear assembly, respectively;*

203. As explained above, Conlon is capable of operating in Mode 3 (two-motor electric-only) in which both motors drive the output member 18 (which is operatively connected to final drive assembly 17) at a fixed ratio for electric-only propulsion when the engine is turned off. EX1004, ¶¶ 0028, 0035, 0042, Figs. 1-3.

As shown in Figure 2, the first motor 80 (M/G A) drives output member 18 and final drive assembly 17 through the first planetary gear set 20 (transmission device), and the second motor 82 (M/G B) drives output member 18 and final drive assembly 17 through the second planetary gear set 22, as shown by the red arrows.

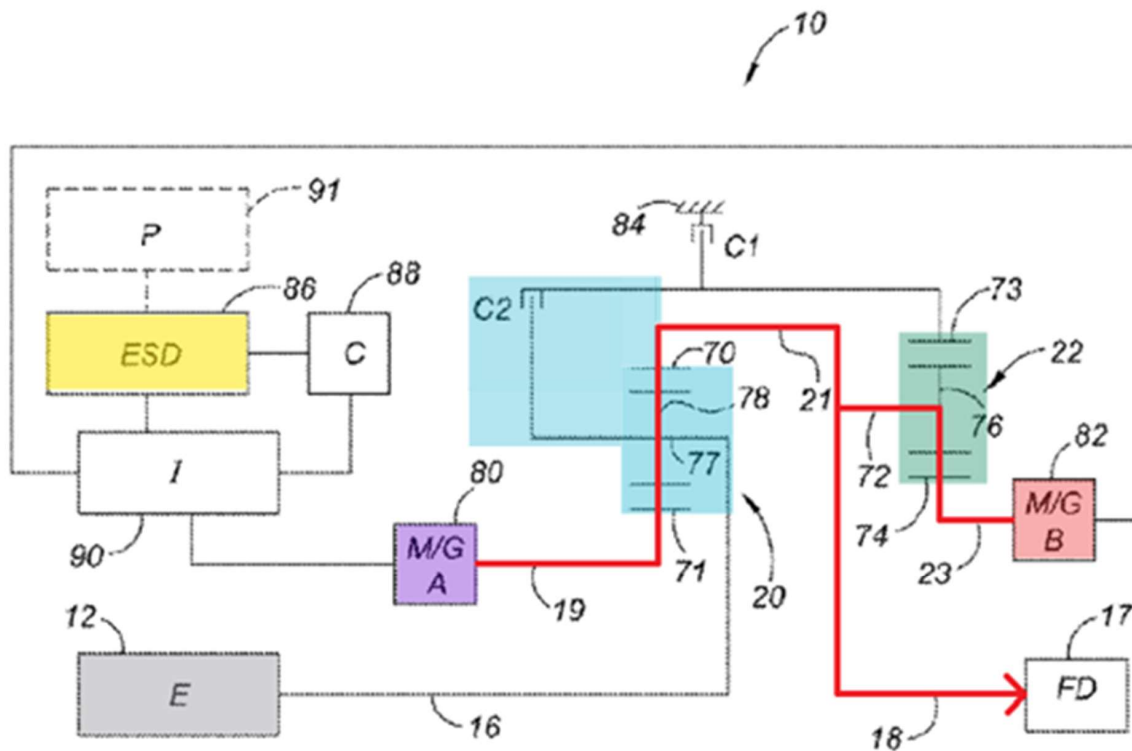


FIG. 2

204. Therefore, limitation 16[g][i] is disclosed by Conlon.

*Limitation 16[g][ii]: operate the first electric motor as a generator to generate electrical power while operating the second electric motor to drive the vehicle through the gear assembly; and*

205. As explained above, Conlon is capable of operating in Mode 1, which is an electrically variable mode normally used with the engine turned off. EX1004,

¶ 0042, Figs. 1-3. “When operating in Mode 1 (EVT 1/Input Split), the motor/generator 80 (M/G A) acts as a generator, and the motor/generator 82 (M/G B) acts as a motor.” *Id.*, ¶ 0044. The second motor 82 (M/G B) drives output member 18 (and final drive assembly 17) of the vehicle through the second planetary gear set 22. *See* Fig. 2.

206. Therefore, limitation 16[g][ii] is disclosed by Conlon.

*Limitation 16[g][iii]: operate the second electric motor as a generator to generate electrical power.*

207. As explained above, Conlon is capable of operating in Mode 2 (compound-split), which is normally used when the engine is turned on. EX1004, ¶ 0042, Figs. 1-3. In this mode, “[t]he EVT 114 may then operate with the motor/generator 82 (M/G [B]) acting as a generator . . . .” *Id.*, ¶ 0051; *see also* ¶¶ 0046, 0052.

208. Therefore, limitation 16[g][iii] is disclosed by Conlon.

#### **G. Dependent Claim 18**

*18. The system of claim 16, further comprising a wheel/axle assembly coupled to the gear assembly.*

209. As explained above, claim 16 is obvious over Conlon.

210. Conlon discloses a wheel/axle assembly coupled to the gear assembly.

The second planetary gear set 22 is connected to and “operable for transmitting torque to the output member 18” (EX1004, ¶ 0035), which in turn is connected to

final drive assembly 17 “for propelling the vehicle.” *Id.*, ¶ 0028. Figure 1 shows the output of final drive assembly 17 “to wheels.” The second planetary gear set 22 is thus coupled to a wheel/axle assembly, as shown by the red line.

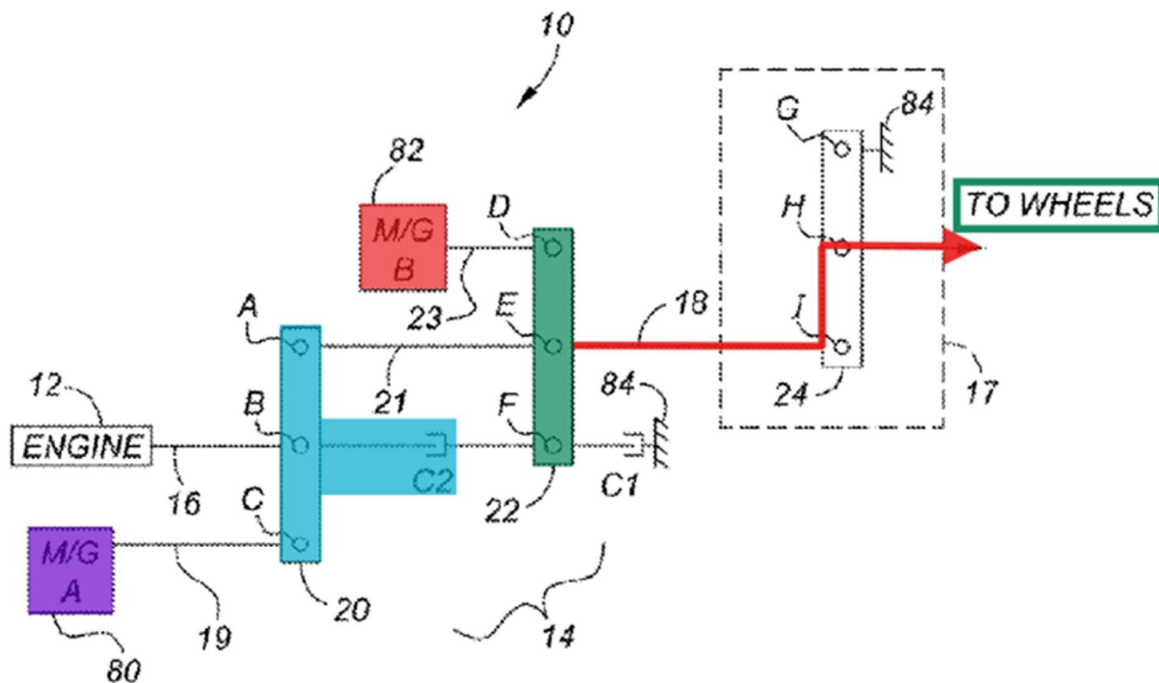


FIG. 1

211. For at least these reasons, claim 18 is obvious over Conlon.

#### H. Dependent Claim 19

19. The system of claim 16, wherein the electrical power generated by the first electric motor is provided to the second electric motor.

212. As explained above, claim 16 is obvious over Conlon.

213. Conlon discloses that the electrical power generated by the first traction motor is provided to the second traction motor. In Mode 1 (input-split), “the

motor/generator 80 (M/G A) acts as a generator, and the motor/generator 82 (M/G B) acts as a motor.” EX1004, ¶ 0044. “ESD 86 . . . is operatively connected to each of the respective motor/ generators 80, 82 such that motor/ generators 80, 82 may selectively transfer power to or receive power from the ESD 86.” *Id.*, ¶ 0036. Further, as shown in Figure 2, motor/generators 80, 82 are operatively connected to each other through inverter 90. *Id.*, ¶ 0038. Thus, electrical power generated by motor/generator 80 (M/G A) can be supplied to motor/generator 82 (M/G B) through ESD 86 via inverter 90. The electrical power generated by M/G A is thus provided to M/G B.

214. For at least these reasons, claim 19 is obvious over Conlon.

**I. Dependent Claim 20**

*20. The system of claim 16, wherein the electrical power generated by the second electric motor is provided to the energy storage system.*

215. As explained above, claim 16 is obvious over Conlon.

216. Conlon discloses that the electrical power generated by the second electric motor is provided to the energy storage system. EX1004, ¶ 0013 (“the EVT includes an energy storage device (ESD) that is connected to the first and second motor/generators for providing power thereto and *receiving power therefrom*”) (emphasis added); ¶ 0036 (“The powertrain 10 may be further configured with an onboard energy storage device or ESD 86 that is operatively connected to each of

the respective motor/generators 80, 82 such that motor/generators 80, 82 may selectively *transfer power to* or receive power from the ESD 86.”) (emphasis added).

217. For at least these reasons, claim 20 is obvious over Conlon.

**IX. GROUND 3: CLAIMS 2, 3, 6, 9-15, AND 17 ARE OBVIOUS OVER CONLON IN VIEW OF REYNOLDS**

218. It is my opinion that the subject matter of claims 2, 3, 6, 9-15, and 17 would have been obvious to a POSITA based on the teachings of Conlon in view of Reynolds.

**A. Motivation to Combine Conlon and Reynolds**

219. As set forth below in more detail with respect to specific limitations, a POSITA would have found it obvious to combine Conlon and Reynolds. In particular, both references are in the same technical field. Thus, I understand that Conlon and Reynolds are analogous references, and a POSITA would have found combining these references to be one of a finite number of identified means for transferring energy between multiple energy storage devices and electromechanical devices in electric and hybrid electric vehicles, and further, would have had a reasonable expectation of success in combining their teachings.

**B. Dependent Claim 2**

*2. The system of claim 1, further comprising a DC/DC converter coupled to the energy storage device.*

220. As explained above, Conlon discloses or renders obvious all the limitations of claim 1.

221. Reynolds discloses a DC/DC converter coupled to an energy storage device. “Electrical power stored in battery 46 is sent through a DC-DC voltage converter to modify the vehicle voltage level according to the devices being powered. The variable voltage control (VVC) 48 converts the DC voltage level of battery 46 to the DC desired voltage level of high-voltage electrical bus 50.” EX1005, ¶ 0013; *see also* Fig. 1.

222. It would have been obvious to a POSITA to incorporate Reynolds’ DC/DC converter into Conlon. A DC-DC converter is a standard device for converting direct current from one voltage to another. For hybrid and electric vehicles, it was well known in January 2014 that a DC-DC converter could be used to manage power flow between a battery and other systems. For example, a DC-DC converter can step-down (buck) high voltage (*e.g.*, 250 V) from a battery to a lower voltage (*e.g.*, 12 V) for powering onboard devices such as lights, infotainment systems, or other accessories. A DC-DC converter can also step-up (boost) voltage, *e.g.*, from 250 V to 650 V to supply high power to electric motors via an inverter when it is necessary (*e.g.*, during heavy accelerations). This will allow an automotive manufacturer to use a smaller, lighter physical battery pack while still achieving high-performance motor output. A POSITA would have at least been motivated by

Reynolds to include a DC-DC converter that has variable voltage control (VVC) function for use in Conlon's powertrain to buck or boost voltage to/from the vehicle battery as needed, as shown by Reynolds' teaching that "battery 46 further includes a two-way electrical connection, such that it can also receive and store energy provided through regenerative braking, for example, and then supply the energy to an electric machine." *Id.*, ¶ 0017. Accordingly, it would have been obvious to a POSITA to include the DC-DC converter taught by Reynolds in the powertrain disclosed in Conlon to power onboard devices as well as turn braking energy back into electricity for charging the battery.

223. In addition, a POSITA would have recognized the drawback of Conlon's single inverter 90 powering motors and generators simultaneously (*i.e.*, simultaneous "push and pull"). Motors and generators have different electrical and control requirements. For example, motors are optimized for torque production and a wide range of speeds, while generators are optimized for voltage regulation and efficiently exporting electrical power. A single inverter cannot simultaneously support a motor and a generator as required in Mode 1 of operation in Conlon's powertrain due to such different electrical and control requirements. A POSITA incorporating Reynolds' DC-DC converter into Conlon's powertrain would have been motivated to replace inverter 90 with Reynolds' DC-DC converter 48 and two-inverter system 42 and 44. Separate inverters will be essential and would provide a

stable and reliable system by allowing M/G A and M/G B to run under their own optimal voltage and current conditions, and by allowing independent regulation of power flow to/from each motor/generator.

224. For at least these reasons, claim 2 is obvious over Conlon in view of Reynolds.

**C. Dependent Claim 3**

*3. The system of claim 2, further comprising a second energy storage system coupled to the DC/DC converter.*

225. As explained above, Conlon in view of Reynolds discloses all the limitations of claim 2.

226. Conlon discloses that “ESD 86 may be, for example, one or more batteries or battery packs.” EX1004, ¶ 0036. Thus, a POSITA would have understood that Conlon teaches a second energy storage system, and further, that the second energy storage system could be coupled to Reynolds’ DC-DC converter for the same reasons discussed above for claim 2.

227. However, even if Conlon discloses only a single ESD with multiple batteries, it would have been obvious to a POSITA to further modify Conlon by including a second ESD coupled to the DC-DC converter taught by Reynolds. Use of two energy storage systems (*i.e.*, batteries) was common in HEVs and PHEVs before 2014. Some examples include model year (MY) 1997 Toyota Prius (Gen 1),

MY 1999 Honda Insight (Gen 1), MY 2003 Honda Civic Hybrid (Gen 1), MY 2004 Toyota Prius (Gen 2), MY 2004 Ford Escape Hybrid, MY 2006 Saturn Vue Green Line, MY 2007 Nissan Altima Hybrid, and MY 2011 Chevrolet Volt (Gen 1). These vehicles include a high-voltage (HV) battery (*e.g.*, 200 V to 700 V), and a low-voltage (LV) battery (*e.g.*, 12 V to 14 V). The HV battery is used for vehicle propulsion, while the LV battery is used to power the accessories in the vehicle. This dual-battery system is advantageous over a single-battery system, due to i) improved safety and isolation of functions, ii) component compatibility since many parts (headlights, wipers, airbag, power windows, door locks, etc.) are standardized to run on 12 V, and expecting them to run on high voltage (*e.g.*, 400 V) would require expensive and custom step-down converters for every single component, and iii) higher reliability to support “fail-safe” for critical non-propulsion systems. A DC-DC converter is also commonly used between these two batteries (*e.g.*, the HV battery charges the LV battery). A POSITA would have been motivated to include a second energy storage system coupled to the DC-DC converter to provide power for auxiliary applications such as heating, cooling, and cabin accessories that run on lower voltage and which were common in EV and HEV vehicles in 2014. Incorporating a second energy storage system in Conlon—and coupling the second energy storage system to the DC-DC converter taught by Reynolds—would yield

predictable results, and a POSITA would have had a reasonable expectation of success in doing so.

228. For at least these reasons, claim 3 is obvious over Conlon in view of Reynolds.

**D. Dependent Claim 6**

*6. The system of claim 1, further comprising: a first inverter coupled between the energy storage device and first traction motor; and a second inverter coupled between the energy storage device and second traction motor.*

229. As explained above, Conlon discloses or renders obvious all the limitations of claim 1.

230. Conlon also discloses inverter 90 coupled between ESD 86 and M/G A and M/G B. EX1004, ¶ 0038, Fig. 2.

231. A POSITA would have recognized the drawback of Conlon's single inverter 90 powering motors and generators simultaneously (*i.e.*, simultaneous "push and pull"). Motors and generators have different electrical and control requirements. For example, motors are optimized for torque production and a wide range of speeds, while generators are optimized for voltage regulation and efficiently exporting electrical power. A single inverter cannot simultaneously support a motor and a generator as required in the Mode 1 of operation in Conlon's powertrain due to such different electrical and control requirements.

232. Reynolds discloses two inverters 42 and 44 coupled between battery 46 and generator 32 and motor 34, respectively. EX1005, ¶¶ 0013, 0014, Fig. 1. A POSITA would have been motivated to replace inverter 90 with Reynolds' DC-DC converter 48 and two-inverter system 42 and 44. Separate inverters would be essential and would provide a stable and reliable system by allowing M/G A and M/G B to run under their own optimal voltage and current conditions, and by allowing independent regulation of power flow to/from each motor/generator.

233. It would have been obvious to a POSITA to incorporate a two-inverter system as taught by Reynolds into Conlon's powertrain. An inverter is a standard component that converts direct current (DC) from the energy storage system (*e.g.*, battery) into the alternating current (AC) needed to power the electric motor, and performs the reverse (AC to DC) during regenerative braking and battery recharging. Using separate inverters as taught by Reynolds to manage power flow to and from each motor in Conlon would be well within the knowledge of a POSITA as a way to support the operating modes in Conlon's powertrain—for example, by splitting the load so that a single inverter does not handle the load of both motors, which may be operating in different modes as discussed above (*e.g.*, motoring operation in M/G B vs regen operation in M/G A). Replacing inverter 90 in Conlon with a two-inverter system would yield predictable results, and a POSITA would have had a reasonable expectation of success in doing so.

234. For at least these reasons, claim 6 is obvious over Conlon in view of Reynolds.

**E. Independent Claim 9**

*Limitation 9[p]: A vehicle propulsion system, comprising:*

235. Conlon discloses a vehicle propulsion system. For example, Conlon describes an electrically variable transmission (EVT) “for use with relatively large battery power and/or a relatively small engine, with reduced motor speed requirements.” EX1004, ¶ 0006. “The EVT has an increased EV mode capability using both motor/generators, a forward low-range electric-only operating mode in which the engine is off, a forward low-range electrically variable input split operating mode, a forward high-range compound split operating mode, and a neutral operating mode.” *Id.* Figure 2 of Conlon depicts the powertrain and EVT propulsion system.

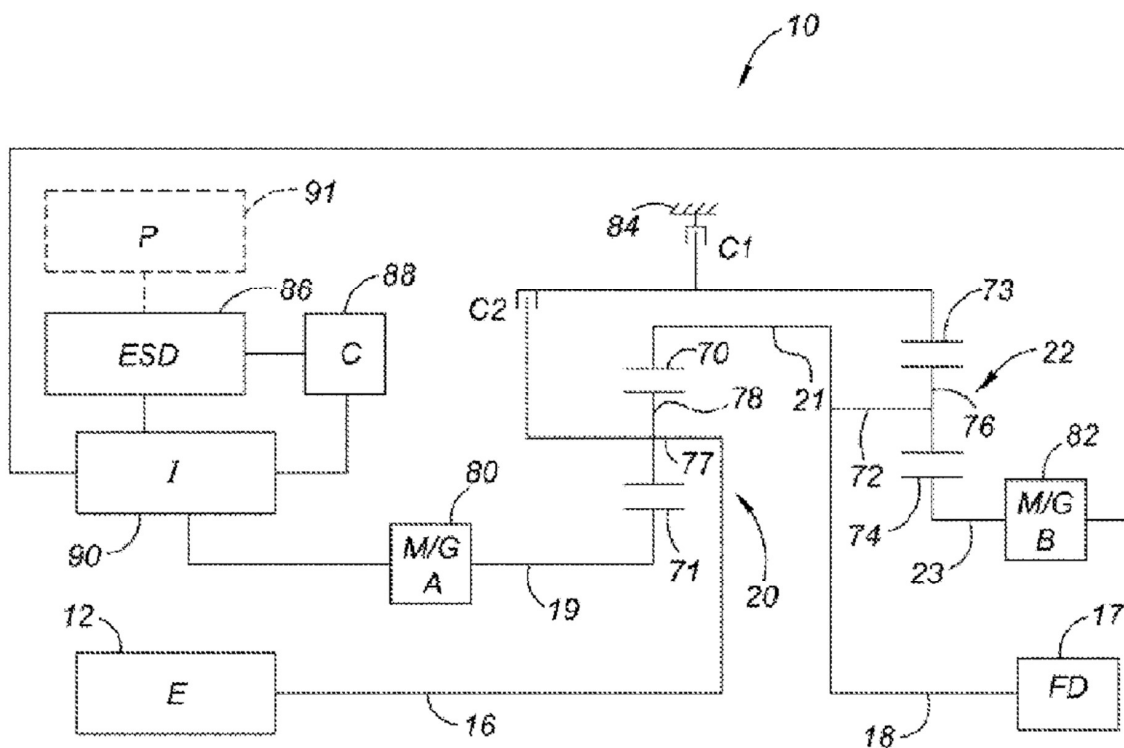
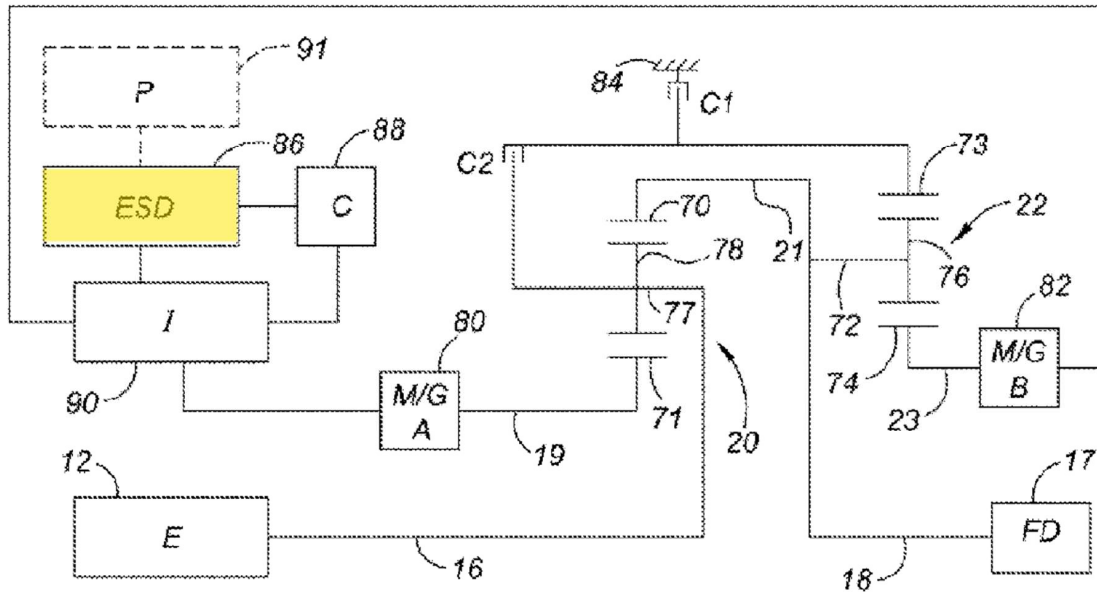


FIG. 2

236. Therefore, limitation 9[p] is disclosed by Conlon.

*Limitation 9[a]: an energy storage system;*

237. Conlon discloses an energy storage system. Referring to Figure 2, the system includes energy storage device or ESD 86 [shown in yellow]. EX1004, ¶ 0036.



238. Therefore, limitation 9[a] is disclosed by Conlon.

239. Conlon discloses a first traction drive system coupled to the energy storage system where the first traction drive system comprises a first inverter coupled to a first AC motor. Referring to Figure 2, the first motor/generator 80 (M/G A) [shown in purple] is operatively connected to ESD 86. EX1004, ¶ 0036. Conlon also discloses DC-AC inverter 90 [also shown in purple] coupled between ESD 86

and M/G A and M/G B. *Id.*, ¶ 0038, Fig. 2. Conlon’s description of inverter 90 as “DC-to-AC” indicates that the motors are AC motors.

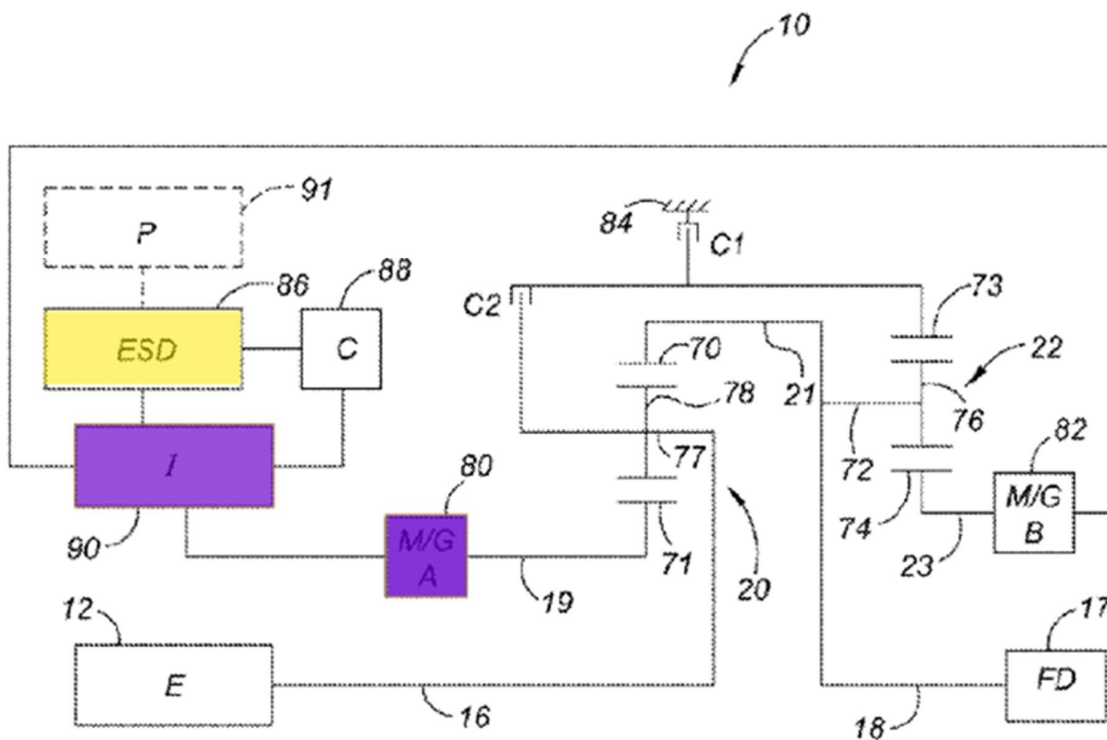


FIG. 2

240. Therefore, limitation 9[b] is disclosed by Conlon.

*Limitation 9[c]: a second traction drive system coupled to the energy storage system, the second traction drive system comprising a second inverter coupled to a second AC motor;*

241. Conlon discloses a second AC motor coupled to the energy storage system. Referring to Figure 2, the second AC motor 82 (M/G B) [shown in red] is operatively connected to ESD 86. EX1004, ¶ 0036.

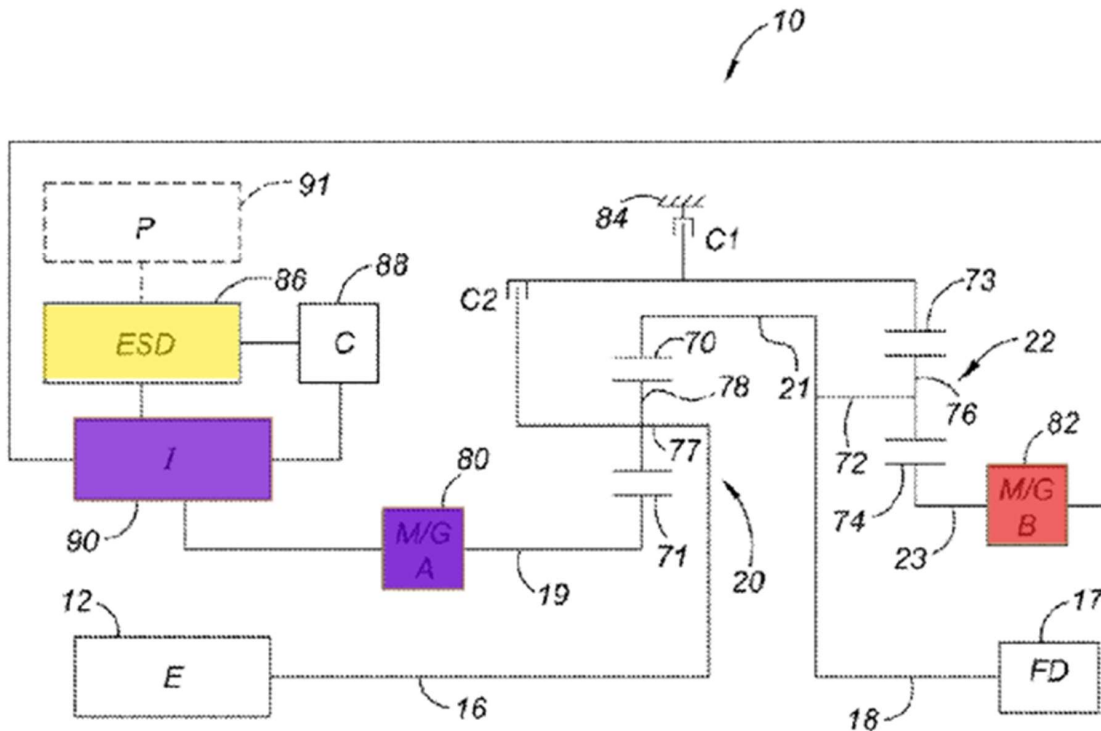


FIG. 2

242. Conlon does not disclose a second inverter. However, Reynolds discloses two inverters 42 and 44 coupled between battery 46 and generator 32 and motor 34, respectively. EX1005, ¶¶ 0013, 0014, Fig. 1. It would have been obvious to a POSITA to incorporate a second inverter as taught by Reynolds into Conlon's EVT between ESD 86 and the second AC motor. An inverter is a standard component that converts direct current (DC) from the energy storage system (*e.g.*, battery) into the alternating current (AC) needed to power the electric motor, and performs the reverse (AC to DC) during regenerative braking and battery recharging.

Using separate inverters to manage power flow to and from each motor in Conlon would be well within the knowledge of a POSITA as a way to support the operating modes in Conlon's powertrain—for example, by splitting the load so that a single inverter does not handle the load of both motors, which may be operating in different modes as discussed above (*e.g.*, motoring operation in M/G B vs regen operation in M/G A). Incorporating a second inverter in Conlon would yield predictable results, and a POSITA would have had a reasonable expectation of success in doing so.

243. In addition, a POSITA would have recognized the drawback of Conlon's single inverter 90 powering motors and generators simultaneously (*i.e.*, simultaneous “push and pull”). Motors and generators have different electrical and control requirements. For example, motors are optimized for torque production and a wide range of speeds, while generators are optimized for voltage regulation and efficiently exporting electrical power. A single inverter cannot simultaneously support a motor and a generator as required in Mode 1 of operation in Conlon's powertrain due to such different electrical and control requirements. A POSITA would have been motivated to replace inverter 90 with Reynolds' DC-DC converter 48 and two-inverter system 42 and 44. Separate inverters would be essential and would provide a stable and reliable system by allowing M/G A and M/G B to run under their own optimal voltage and current conditions, and by allowing independent regulation of power flow to/from each motor/generator.

244. For at least these reasons, limitation 9[c] is obvious over Conlon in view of Reynolds.

*Limitation 9[d]: a transmission device coupled to the first traction drive system, the transmission device comprising an arrangement of planetary gears;*

245. Conlon discloses a transmission device coupled to the first traction drive system where the transmission device comprises an arrangement of planetary gears. Referring to Figure 2, “the first motor/generator (M/G A) 80 is continuously connected to the sun gear member 71 of the first planetary gear set 20 via the interconnecting member 19.” EX1004, ¶ 0035. Planetary gear set 20 [shown in blue] is a transmission device comprising sun gear 71, ring gear 70, carrier member 77, a plurality of pinion gears 78, and clutch C2. *Id.*, ¶¶ 0033-0035.

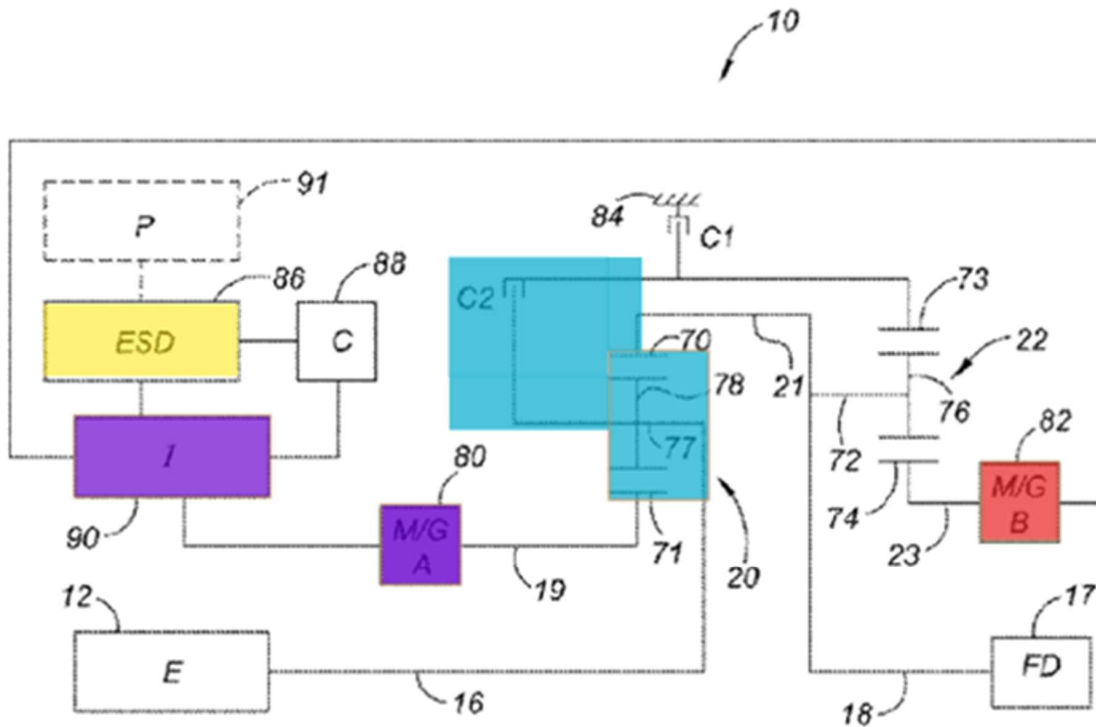


FIG. 2

246. Therefore, limitation 9[d] is disclosed by Conlon.

*Limitation 9[e]: a gear assembly coupled between the second traction drive system and the transmission device such that the output of the second traction motor bypasses the transmission device;*

247. As an initial matter, I note that there is no antecedent basis in claim 9 for “the second traction motor.”

248. Conlon discloses a gear assembly coupled between the second traction drive system and the transmission device such that the output of the second traction drive system bypasses the transmission device. The claimed gear assembly is a separate and distinct element from the transmission device in limitation 9[d]. First,

the claim lists the transmission device and gear assembly as separate elements. Second, the claim recites that the gear assembly is positioned “between” the second motor and the transmission device, indicating three distinct components arranged in sequence. Third, the claim requires that the second motor’s output “bypasses the transmission device,” further indicating the transmission and gear assembly are separate because the output of the second motor cannot bypass the transmission device if the gear assembly to which the motor is coupled is part of the transmission device.

249. Conlon’s “second planetary gear set 22 has a sun gear 74, a ring gear 73, and a carrier member 72 having a plurality of pinion gears 76.” EX1004, ¶ 0034. Referring to Figure 2, “[t]he second motor/generator 82 (M/G B) is continuously connected to the sun gear member 74 of the second planetary gear set 22, and is operable for transmitting torque to the output member 18.” *Id.*, ¶ 0035. The second planetary gear set 22 [shown in green] is located between M/G B [shown in red] and the first planetary gear set 20 (transmission device) [shown in blue]. In Mode 1, for example, the mechanical power of M/G B is transmitted to output member 18 [shown in brown] without passing through (*i.e.*, bypassing) first planetary gear set 20 (transmission device), as shown by the red arrow. In this mode, clutch C1 is engaged and clutch C2 is disengaged; thus, no power is transmitted from M/G A to the output member 18. In this mode, the power from M/G B is transmitted

to the planetary carrier member 72 which then transfers the power to the final drive via output member 18.

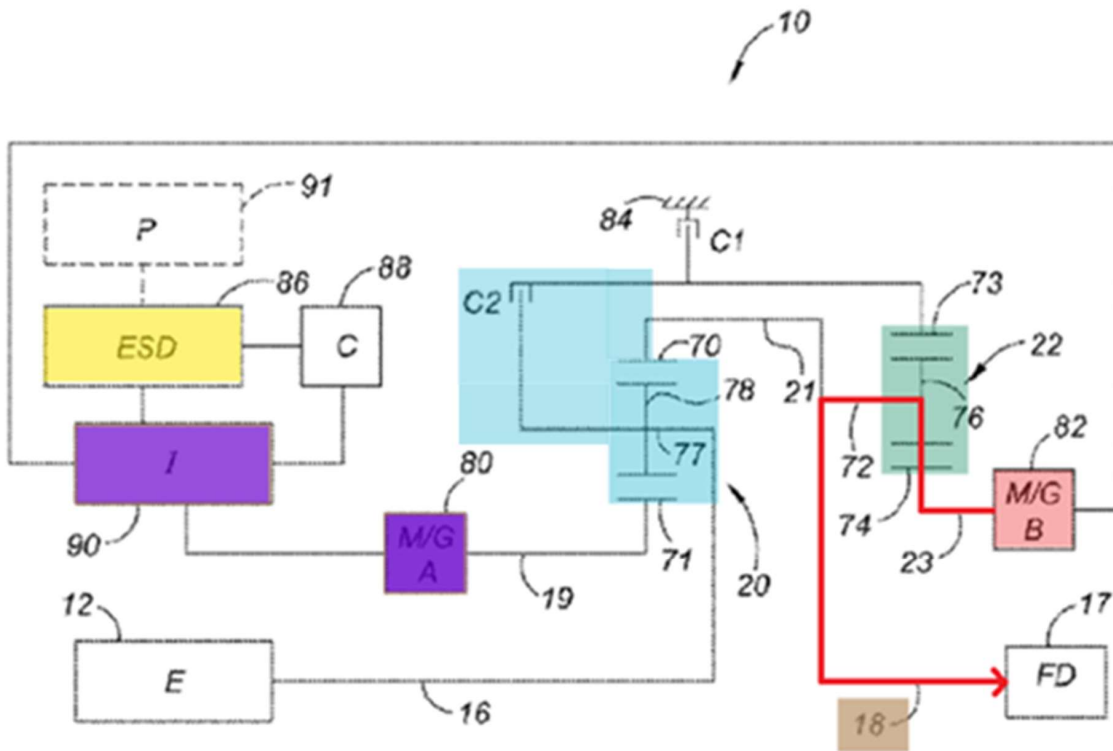


FIG. 2

250. Therefore, limitation 9[e] is disclosed by Conlon.

*Limitation 9[f]: an internal combustion engine coupled to the transmission device via a path that does not include the first AC motor and second AC motor;*

251. Conlon discloses an internal combustion engine coupled to the transmission device via a path that does not include the first AC motor and second AC motor. Referring to Figure 2, “engine 12, [shown in gray] is continuously connected to the carrier member 77 of the first planetary gear set 20” (transmission

device) via a path that does not include M/G A and M/G B, as shown by the red arrow. EX1004, ¶ 0035.

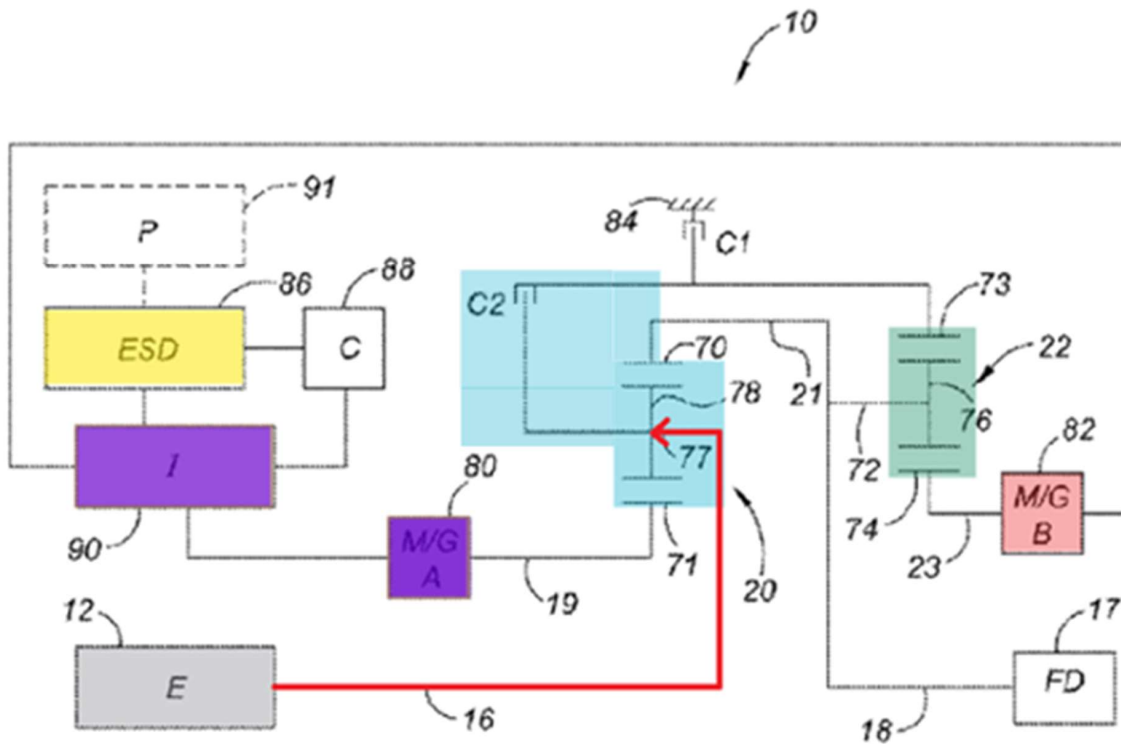


FIG. 2

252. Therefore, limitation 9[f] is disclosed by Conlon.

*Limitation 9[g]: a control system configured to selectively:*

253. The powertrain and EVT of Conlon are capable of operating in several modes: Mode 1 (input-split mode, which is an electrically variable mode normally used with the engine turned off, such as during low vehicle speeds), Mode 2 (compound-split mode, which is normally used when the engine is turned on, such

as during high vehicle speeds), Mode 3 (two-motor electric-only mode, which is used with both of the motor/generators driving the output member 18 at a fixed ratio for electric-only propulsion when the engine is turned off), and Mode 4 (neutral mode, which effectively disconnects the second motor/generator from output member 18, or otherwise prevents or minimizes the amount of torque the second motor/generator is able to transmit to output member 18). EX1004, ¶ 0042; Figs. 1-3.

254. At rest, the EVT is in Mode 3, and then “transitions to Mode 1” once the engine reaches operating speed. *Id.*, ¶ 0044. At relatively high rates of speed, the EVT may shift from Mode 1 to Mode 2 by releasing the brake C1 and applying the clutch C2, or alternately, the power of the first motor/generator may be supplied by the ESD, allowing the EVT to shift between Modes 1 and 2 without any torque being transmitted across slipping clutches. *Id.*, ¶ 0045; Figs. 2-3. The EVT can easily transition from either Mode 1 or Mode 2 to Mode 3 by a synchronous shift to the appropriate speed ratio, and then by engaging the appropriate brake C1 and/or clutch C2. *Id.*, ¶ 0047; Figs. 2-3. The shift between Mode 1 or Mode 2 to Mode 3 may also be achieved as an energy shift by engaging the appropriate brake C1 or clutch C2 to shift directly to Mode 3. *Id.*

255. Conlon necessarily teaches a control system for switching the EVT between these modes. A POSITA would have understood that a control system is

required to monitor operating conditions such as vehicle speed, motor speed, speed ratio, and power supplied from the ESD. In addition, a POSITA would have understood that a control system is required to engage and disengage clutches C1/D1 and C2/D2 as needed to shift the EVT between respective modes. *Id.*, ¶¶ 0006, 0017, 0033, 0043-0048, 0054-0058, Fig. 3. Accordingly, Conlon inherently discloses the claimed control system.

256. Therefore, limitation 9[g] is disclosed by Conlon.

257. To the extent Conlon does not disclose a control system, it would have been obvious to a POSITA to include a control system for switching the EVT between modes. A POSITA would have understood that a control system would be beneficial to monitor operating conditions such as vehicle speed, motor speed, speed ratio, and power supplied from the ESD, and to shift the EVT between respective modes as appropriate to maximize efficiency. Control systems for EV and HEV powertrains were well known in the industry before the January 2014 priority date of the '648 Patent. Indeed, Conlon discloses a control unit to control power distribution to or from the ESD, and “to balance input torque from the engine 12, from the motor/generator 80 (M/G A), and/or from the motor/generator 82 (M/G B) during braking in order to provide a desired rate of deceleration of the output member 18, and/or one or more individual braking units.” EX1004, ¶ 0037. A POSITA would have been motivated to incorporate a control system to selectively

operate M/G A and M/G B according to the modes disclosed by Conlon for better efficiency and enhanced performance of the EVT.

258. For at least these reasons, limitation 9[g] would have been obvious to a POSITA based on the teachings of Conlon.

*Limitation 9[g][i]: operate the first traction drive system and second traction drive system to drive the vehicle through the transmission device and gear assembly, respectively;*

259. As explained above, Conlon is capable of operating in Mode 3 (two-motor electric-only) in which both motors drive the output member 18 (which is operatively connected to final drive assembly 17) at a fixed ratio for electric-only propulsion when the engine is turned off. EX1004, ¶¶ 0028, 0035, 0042, Figs. 1-3. As shown in Figure 2, the first motor 80 (M/G A) drives output member 18 and final drive assembly 17 through the first planetary gear set 20 (transmission device), and the second motor 82 (M/G B) drives output member 18 and final drive assembly 17 through the second planetary gear set 22, as shown by the red arrows.

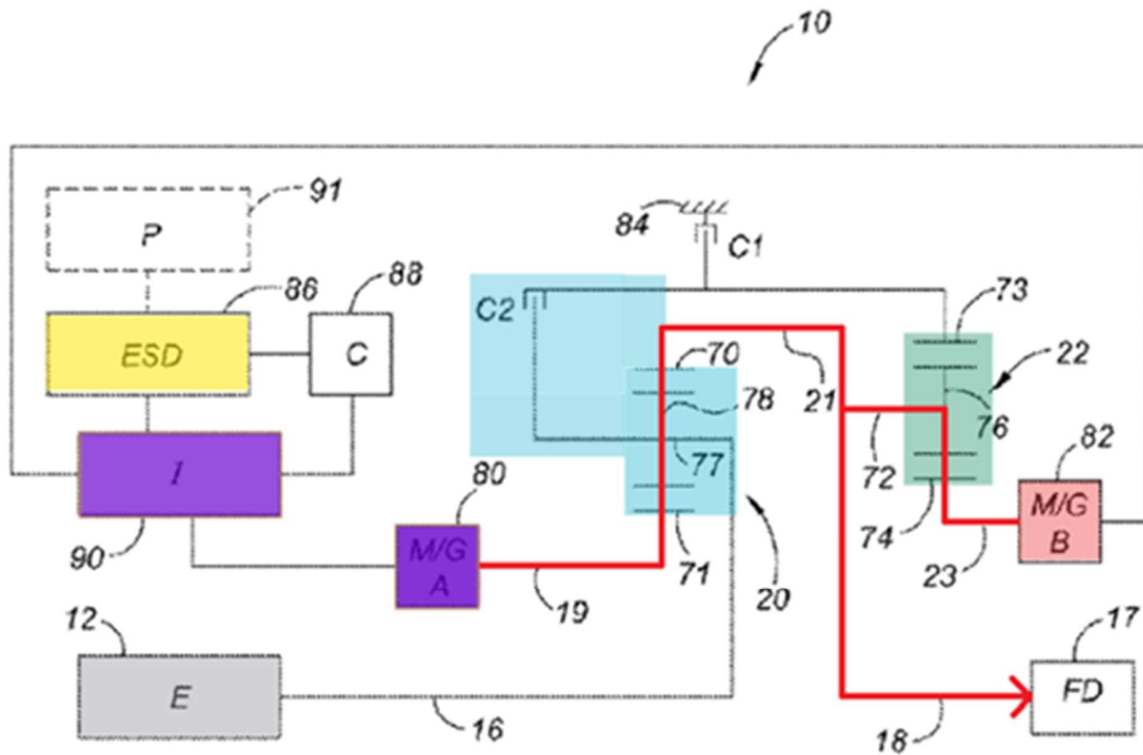


FIG. 2

260. Therefore, limitation 9[g][i] is disclosed by Conlon.

*Limitation 9[g][ii]: operate the first traction drive system to generate electrical power while operating the second traction drive system to drive the vehicle through the gear assembly; and*

261. As explained above, Conlon is capable of operating in Mode 1, which is an electrically variable mode normally used with the engine turned off. EX1004, ¶ 0042, Figs. 1-3. “When operating in Mode 1 (EVT 1/Input Split), the motor/generator 80 (M/G A) acts as a generator, and the motor/generator 82 (M/G B) acts as a motor.” *Id.*, ¶ 0044. The second motor 82 (M/G B) drives output member

18 (and final drive assembly 17) of the vehicle through the second planetary gear set 22. *See* Fig. 2.

262. Therefore, limitation 9[g][ii] is disclosed by Conlon.

*Limitation 9[g][iii]: operate the second traction drive system to generate electrical power.*

263. As explained above, Conlon is capable of operating in Mode 2 (compound-split), which is normally used when the engine is turned on. EX1004, ¶ 0042, Figs. 1-3. In this mode, “[t]he EVT 114 may then operate with the motor/generator 82 (M/G [B]) acting as a generator . . . .” *Id.*, ¶ 0051; *see also* ¶¶ 0046, 0052.

264. Therefore, limitation 9[g][iii] is disclosed by Conlon.

**F. Dependent Claim 10**

*10. The system of claim 9, further comprising a DC/DC converter coupled to the energy storage device.*

265. As explained above, Conlon in view of Reynolds discloses all the limitations of claim 9.

266. Reynolds discloses a DC/DC converter coupled to an energy storage device. “Electrical power stored in battery 46 is sent through a DC-DC voltage converter to modify the vehicle voltage level according to the devices being powered. The variable voltage control (VVC) 48 converts the DC voltage level

of battery 46 to the DC desired voltage level of high-voltage electrical bus 50.”  
EX1005, ¶ 0013; *see also* Fig. 1.

267. It would have been obvious to a POSITA to incorporate Reynolds’ DC/DC converter into Conlon. A DC-DC converter is a standard device for converting direct current from one voltage to another. For hybrid and electric vehicles, it was well known in January 2014 that a DC-DC converter could be used to manage power flow between a battery and other systems. For example, a DC-DC converter can step-down (buck) high voltage (*e.g.*, 250 V) from a battery to a lower voltage (*e.g.*, 12 V) for powering onboard devices such as lights, infotainment systems, or other accessories. A DC-DC converter can also step-up (boost) voltage, *e.g.*, from 250 V to 650 V to supply high power to electric motors via an inverter when it is necessary (*e.g.*, during heavy accelerations). This will allow an automotive manufacturer to use a smaller, lighter physical battery pack while still achieving high-performance motor output. A POSITA would have at least been motivated by Reynolds to include a DC-DC converter that has variable voltage control (VVC) function for use in the Conlon’s powertrain to buck or boost voltage to/from the vehicle battery as needed, as shown by Reynolds’ teaching that “battery 46 further includes a two-way electrical connection, such that it can also receive and store energy provided through regenerative braking, for example, and then supply the energy to an electric machine.” *Id.*, ¶ 0017. Accordingly, it would have been

obvious to a POSITA to include the DC-DC converter taught by Reynolds in the powertrain disclosed in Conlon to power onboard devices as well as turn braking energy back into electricity for charging the battery.

268. In addition, a POSITA would have recognized the drawback of Conlon's single inverter 90 powering motors and generators simultaneously (*i.e.*, simultaneous "push and pull"). Motors and generators have different electrical and control requirements. For example, motors are optimized for torque production and a wide range of speeds, while generators are optimized for voltage regulation and efficiently exporting electrical power. A single inverter cannot simultaneously support a motor and a generator as required in Mode 1 of operation in Conlon's powertrain due to such different electrical and control requirements. A POSITA incorporating Reynolds' DC-DC converter into Conlon's powertrain would have been motivated to replace inverter 90 with Reynolds' DC-DC converter 48 and two-inverter system 42 and 44. Separate inverters would be essential and would provide a stable and reliable system by allowing M/G A and M/G B to run under their own optimal voltage and current conditions, and by allowing independent regulation of power flow to/from each motor/generator.

269. For at least these reasons, claim 10 is obvious over Conlon in view of Reynolds.

**G. Dependent Claim 11**

*11. The system of claim 10, further comprising a second energy storage system coupled to the DC/DC converter.*

270. As explained above, Conlon in view of Reynolds discloses all the limitations of claim 10.

271. Conlon discloses that “ESD 86 may be, for example, one or more batteries or battery packs.” EX1004, ¶ 0036. Thus, a POSITA would have understood that Conlon teaches a second energy storage system, and further, that the second energy storage system could be coupled to Reynolds’ DC-DC converter for the same reasons discussed above for claim 2.

272. However, even if Conlon discloses only a single ESD with multiple batteries, it would have been obvious to a POSITA to further modify Conlon by including a second ESD coupled to the DC-DC converter taught by Reynolds. Use of two energy storage systems (*i.e.*, batteries) was common in HEVs and PHEVs before 2014. Some examples include model year (MY) 1997 Toyota Prius (Gen 1), MY 1999 Honda Insight (Gen 1), MY 2003 Honda Civic Hybrid (Gen 1), MY 2004 Toyota Prius (Gen 2), MY 2004 Ford Escape Hybrid, MY 2006 Saturn Vue Green Line, MY 2007 Nissan Altima Hybrid, and MY 2011 Chevrolet Volt (Gen 1). These vehicles include a high-voltage (HV) battery (*e.g.*, 200 V to 700 V), and a low-voltage (LV) battery (*e.g.*, 12 V to 14 V). The HV battery is used for vehicle

propulsion, while the LV battery is used to power the accessories in the vehicle. This dual-battery system is advantageous over a single-battery system, due to i) improved safety and isolation of functions, ii) component compatibility since many parts (headlights, wipers, airbag, power windows, door locks, etc.) are standardized to run on 12 V, and expecting them to run on high voltage (*e.g.*, 400 V) would require expensive and custom step-down converters for every single component, and iii) higher reliability to support “fail-safe” for critical non-propulsion systems. A DC-DC converter is also commonly used between these two batteries (*e.g.*, the HV battery charges the LV battery). A POSITA would have been motivated to include a second energy storage system coupled to the DC-DC converter to provide power for auxiliary applications such as heating, cooling, and cabin accessories that run on lower voltage and which were common in EV and HEV vehicles in 2014. Incorporating a second energy storage system in Conlon—and coupling the second energy storage system to the DC-DC converter taught by Reynolds—would yield predictable results, and a POSITA would have had a reasonable expectation of success in doing so.

273. For at least these reasons, claim 11 is obvious over Conlon in view of Reynolds.

**H. Dependent Claim 12**

*12. The system of claim 9, wherein the energy storage system comprises a battery.*

274. As explained above, Conlon in view of Reynolds discloses all the limitations of claim 9.

275. Conlon discloses that “ESD 86 may be, for example, one or more batteries or battery packs.” EX1004, ¶ 0036.

276. For at least these reasons, claim 12 is obvious over Conlon in view of Reynolds.

**I. Dependent Claim 13**

*13. The system of claim 9, further comprising a wheel/axle assembly coupled to the gear assembly.*

277. As explained above, Conlon in view of Reynolds discloses all the limitations of claim 9.

278. Conlon discloses a wheel/axle assembly coupled to the gear assembly. The second planetary gear set 22 is connected to and “operable for transmitting torque to the output member 18” (EX1004, ¶ 0035), which in turn is connected to final drive assembly 17 “for propelling the vehicle.” *Id.*, ¶ 0028. Figure 1 shows the output of final drive assembly 17 “to wheels.” The second planetary gear set 22 is thus coupled to a wheel/axle assembly, as shown by the red line.

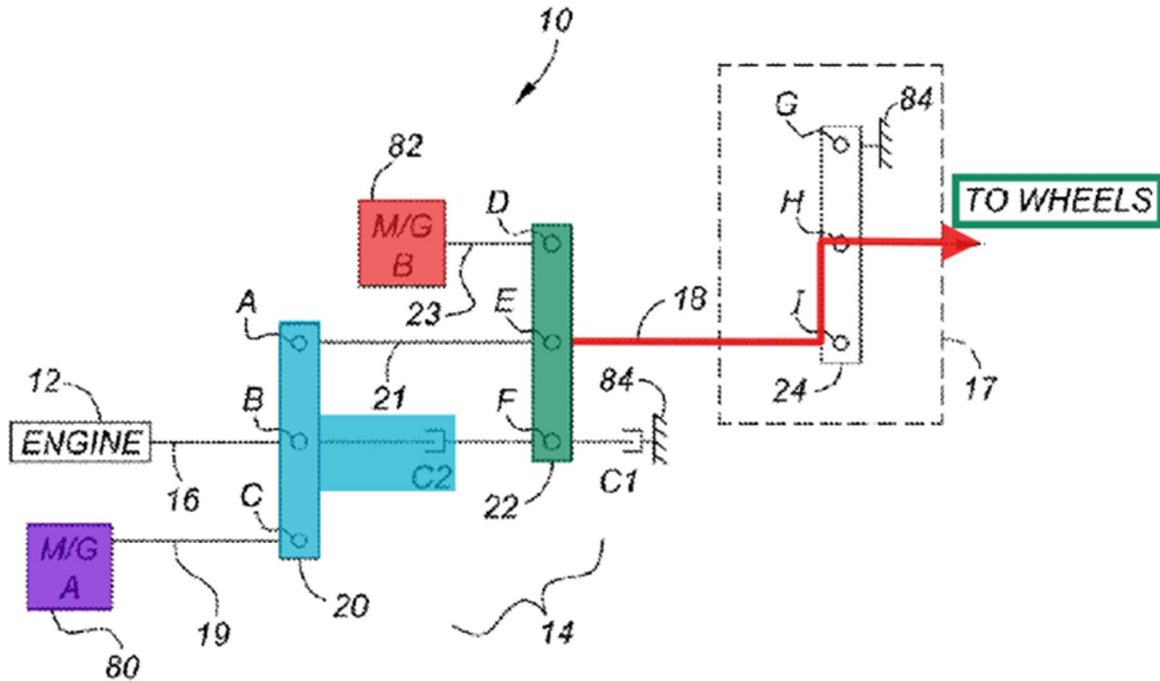


FIG. 1

279. For at least these reasons, claim 13 is obvious over Conlon in view of Reynolds.

#### J. Dependent Claim 14

*14. The system of claim 9, wherein the electrical power generated by the first traction drive system is provided to the second traction drive system.*

280. As explained above, Conlon in view of Reynolds discloses all the limitations of claim 9.

281. Conlon discloses that the electrical power generated by the first traction drive system is provided to the second traction drive system. In Mode 1 (input-split), “the motor/generator 80 (M/G A) acts as a generator, and the motor/generator 82

(M/G B) acts as a motor.” EX1004, ¶ 0044. “ESD 86 . . . is operatively connected to each of the respective motor/ generators 80, 82 such that motor/generators 80, 82 may selectively transfer power to or receive power from the ESD 86.” *Id.*, ¶ 0036. Further, as shown in Figure 2, motor/generators 80, 82 are operatively connected to each other through inverter 90. *Id.*, ¶ 0038. Thus, electrical power generated by motor/generator 80 (M/G A) can be supplied to motor/generator 82 (M/G B) through ESD 86 via inverter 90. The electrical power generated by M/G A is thus provided to M/G B.

282. For at least these reasons, claim 14 is obvious over Conlon in view of Reynolds.

**K. Dependent Claim 15**

*15. The system of claim 9, wherein the electrical power generated by the second traction drive system is provided to the energy storage system.*

283. As explained above, Conlon in view of Reynolds discloses all the limitations of claim 9.

284. Conlon discloses that the electrical power generated by the second traction drive system is provided to the energy storage system. EX1004, ¶ 0013 (“the EVT includes an energy storage device (ESD) that is connected to the first and second motor/generators for providing power thereto and **receiving power therefrom**”) (emphasis added); ¶ 0036 (“The powertrain 10 may be further

configured with an onboard energy storage device or ESD 86 that is operatively connected to each of the respective motor/generators 80, 82 such that motor/generators 80, 82 may selectively *transfer power to* or receive power from the ESD 86.”) (emphasis added).

285. For at least these reasons, claim 15 is obvious over Conlon in view of Reynolds.

**L. Dependent Claim 17**

*17. The system of claim 16, further comprising a DC/DC converter coupled to the energy storage device.*

286. As explained above, Conlon discloses or renders obvious all the limitations of claim 16.

287. Reynolds discloses a DC/DC converter coupled to an energy storage device. “Electrical power stored in battery 46 is sent through a DC-DC voltage converter to modify the vehicle voltage level according to the devices being powered. The variable voltage control (VVC) 48 converts the DC voltage level of battery 46 to the DC desired voltage level of high-voltage electrical bus 50.” EX1005, ¶ 0013; *see also* Fig. 1.

288. It would have been obvious to a POSITA to incorporate Reynolds’ DC/DC converter into Conlon. A DC-DC converter is a standard device for converting direct current from one voltage to another. For hybrid and electric

vehicles, it was well known in January 2014 that a DC-DC converter could be used to manage power flow between a battery and other systems. For example, a DC-DC converter can step-down (buck) high voltage (*e.g.*, 250 V) from a battery to a lower voltage (*e.g.*, 12 V) for powering onboard devices such as lights, infotainment systems, or other accessories. A DC-DC converter can also step-up (boost) voltage, *e.g.*, from 250 V to 650 V to supply high power to electric motors via an inverter when it is necessary (*e.g.*, during heavy accelerations). This will allow an automotive manufacturer to use a smaller, lighter physical battery pack while still achieving high-performance motor output. A POSITA would have at least been motivated by Reynolds to include a DC-DC converter that has variable voltage control (VVC) function for use in the Conlon's powertrain to buck or boost voltage to/from the vehicle battery as needed, as shown by Reynolds' teaching that "battery 46 further includes a two-way electrical connection, such that it can also receive and store energy provided through regenerative braking, for example, and then supply the energy to an electric machine." *Id.*, ¶ 0017. Accordingly, it would have been obvious to a POSITA to include the DC-DC converter taught by Reynolds in the powertrain disclosed in Conlon to power onboard devices as well as turn braking energy back into electricity for charging the battery.

289. In addition, a POSITA would have recognized the drawback of Conlon's single inverter 90 powering motors and generators simultaneously (*i.e.*,

simultaneous “push and pull”). Motors and generators have different electrical and control requirements. For example, motors are optimized for torque production and a wide range of speeds, while generators are optimized for voltage regulation and efficiently exporting electrical power. A single inverter cannot simultaneously support a motor and a generator as required in Mode 1 of operation in Conlon’s powertrain due to such different electrical and control requirements. A POSITA incorporating Reynolds’ DC-DC converter into Conlon’s powertrain would have been motivated to replace inverter 90 with Reynolds’ DC-DC converter 48 and two-inverter system 42 and 44. Separate inverters would be essential and would provide a stable and reliable system by allowing M/G A and M/G B to run under their own optimal voltage and current conditions, and by allowing independent regulation of power flow to/from each motor/generator.

290. For at least these reasons, claim 17 is obvious over Conlon in view of Reynolds.

**X. GROUND 4: CLAIMS 1, 2, 4-10, AND 12-20 ARE ANTICIPATED BY ORTMANN**

291. It is my opinion that the subject matter of claims 1, 2, 4-10, and 12-20 are anticipated by Ortmann.

### A. Independent Claim 1

*Limitation 1[p]: A system for a hybrid electric vehicle, comprising:*

292. Ortmann discloses a system for a hybrid electric vehicle. EX1008, ¶¶ 0002-0012. Figures 1 and 4 of Ortmann are schematic diagrams of an HEV powertrain and PHEV powertrain, respectively. *Id.*, ¶¶ 0014, 0017. In Figure 4, similar components of the powertrain 10 in Figure 1 are identified by the same reference numbers. *Id.*, ¶ 0026.

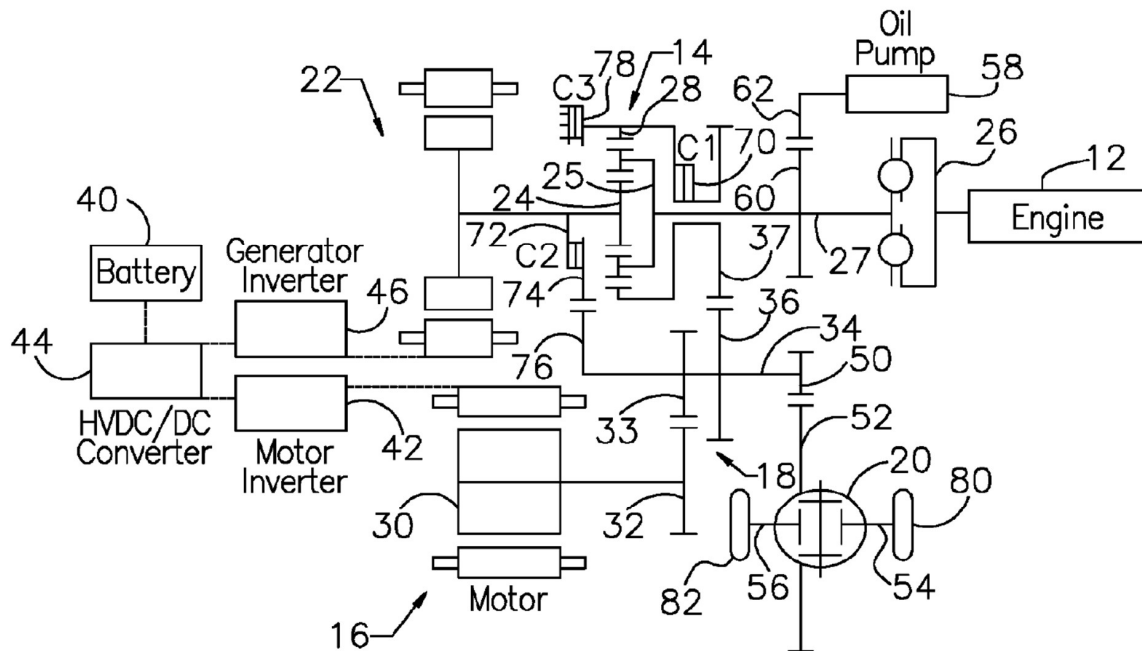


Fig. 4

293. Therefore, limitation 1[p] is disclosed by Ortmann.

*Limitation 1[a]: an energy storage system;*

294. Ortmann discloses an energy storage system. EX1008, ¶ 0021. Figure 4 of Ortmann shows that the powertrain includes traction battery 40 [shown in yellow]. *Id.*

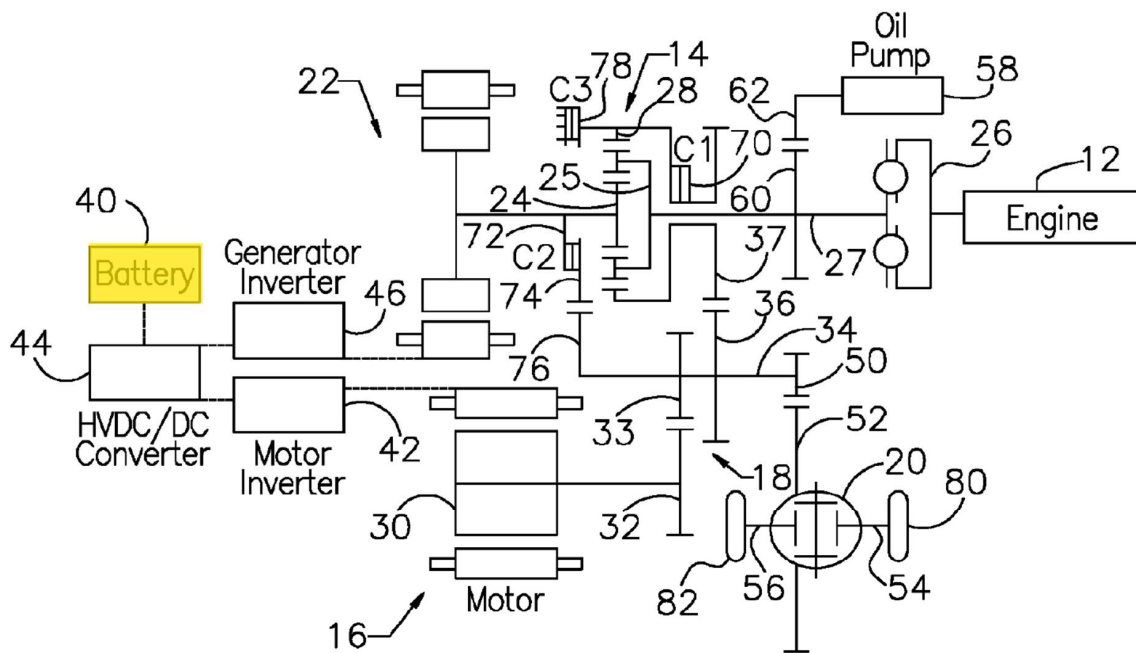


Fig. 4

295. Therefore, limitation 1[a] is disclosed by Ortmann.

*Limitation 1[b]: a first traction motor coupled to the energy storage system;*

296. Ortmann discloses a first traction motor coupled to the energy storage system. EX1008, ¶¶ 0019, 0021. Figure 4 of Ortmann shows that the first traction motor-generator 22 [shown in purple] “is electrically connected to battery 40 through an inverter 46 and converter 44.” *Id.*, ¶ 0021.

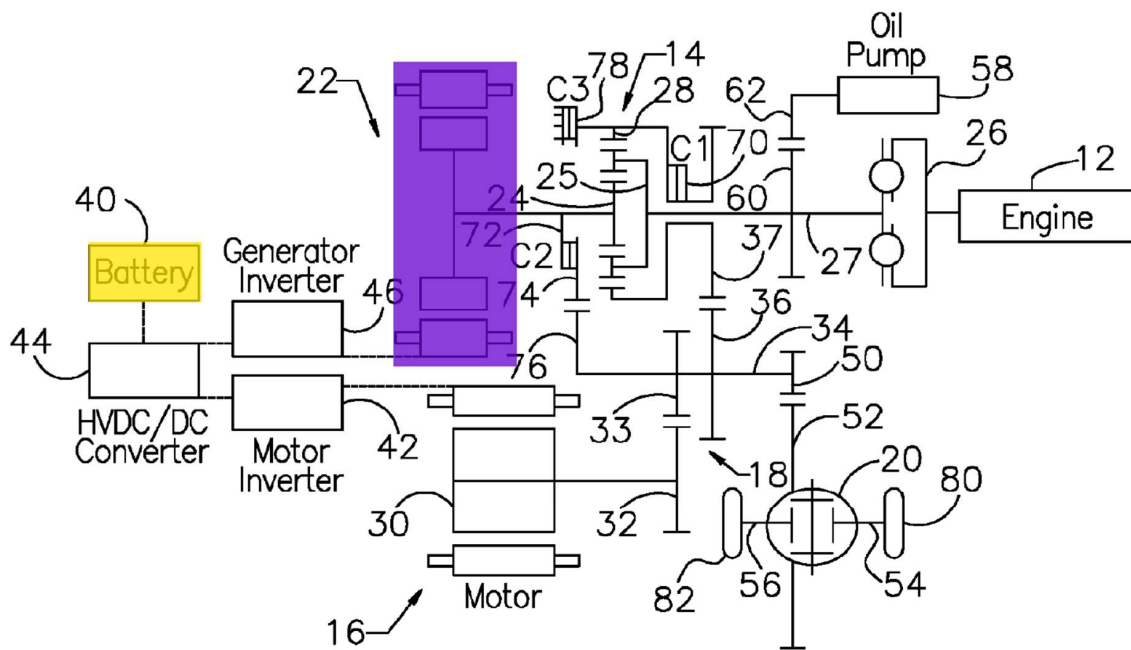


Fig. 4

297. Ortmann discloses that “[e]ach electric machine 16, 22 is a motor-generator, although conventionally electric machine 16 is referred to as a motor or traction motor, and electric machine 22 is referred to as a generator.” EX1008, ¶ 0019. Electric machine 22 acts as a traction motor in Mode 2 (two motor electric drive): “generator 22 is connected to the countershaft 34 and *drives* the vehicle wheels 80, 82 through clutch 72, layshaft gears 74-76, countershaft 34, layshaft gears 50-52, and differential 20.” *Id.*, ¶ 0030 (emphasis added).

298. Therefore, limitation 1[b] is disclosed by Ortmann.

*Limitation 1[c]: a second traction motor coupled to the energy storage system;*

299. Ortmann discloses a second traction motor coupled to the energy storage system. EX1008, ¶¶ 0019, 0021. Figure 4 of Ortmann shows that the second traction motor-generator 16 [shown in red] “is electrically connected to battery 40 through an inverter 42 and a high voltage DC/DC converter 44.” *Id.*, ¶ 0021. Motor-generator 16 drives the vehicle in at least Modes 1-3. *Id.*, ¶¶ 0029-0031.

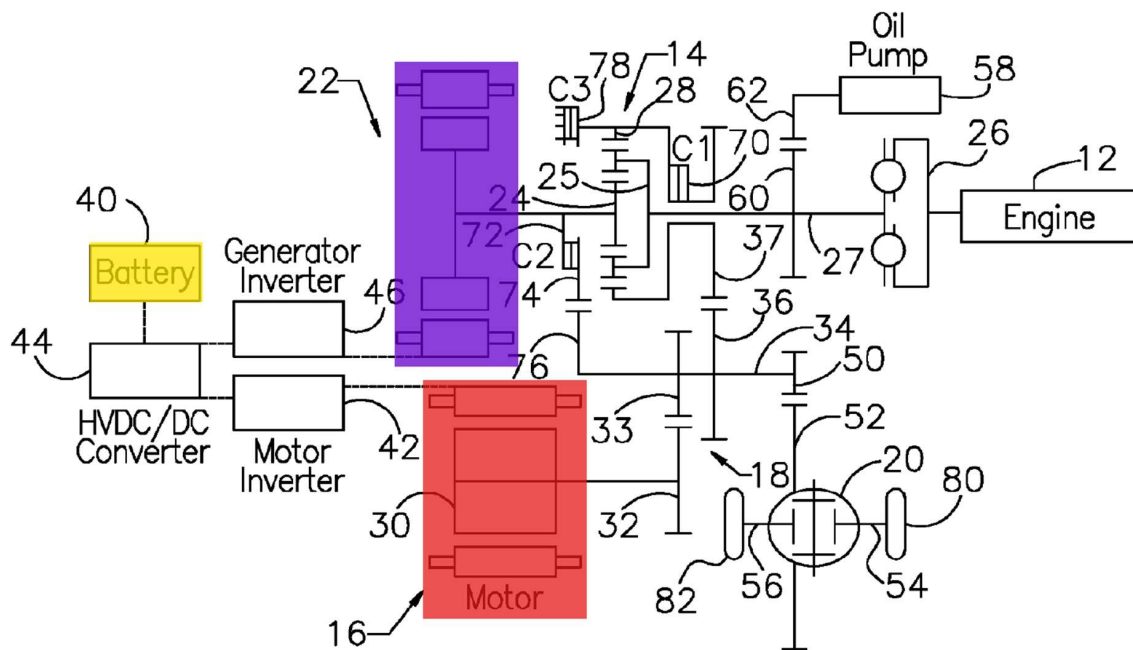


Fig. 4

300. Therefore, limitation 1[c] is disclosed by Ortmann.

*Limitation 1[d]: a transmission device coupled to the first traction motor, the transmission device comprising an arrangement of planetary gears;*

301. Ortmann discloses a transmission device coupled to the first traction motor where the transmission device comprises an arrangement of planetary gears. EX1008, ¶¶ 0019, 0020. In Figure 4, “planetary gearset 14 is connected to the [motor-]generator 22.” *Id.*, ¶ 0020. Planetary gear set 14 [shown in blue] is a transmission device comprising at least sun gear 24, ring gear 28, and carrier 25. *Id.* In addition, as explained above, the claimed “transmission device” of the ’648 Patent includes clutches, which connect and disconnect the flow of power from the motor. EX1001, 5:5-11, 5:21-25. Thus, the transmission device of Ortmann may also include, for example, clutch 72 (C2) shown in Figure 4.

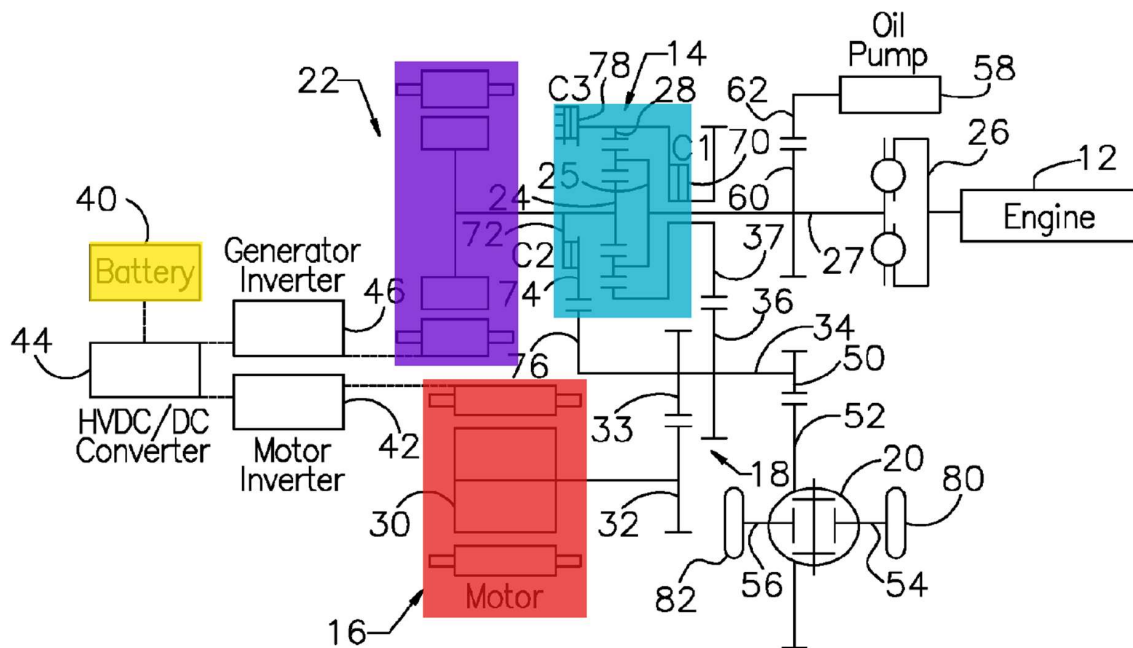


Fig. 4

302. Therefore, limitation 1[d] is disclosed by Ortmann.

*1[e]: a gear assembly coupled between the second traction motor and the transmission device such that the output of the second traction motor bypasses the transmission device;*

303. Ortmann discloses a gear assembly coupled between the second traction motor and the transmission device such that the output of the second traction motor bypasses the transmission device. The claimed gear assembly is a separate and distinct element from the transmission device recited in limitation 1[d]. First, the claim lists the transmission device and gear assembly as separate elements. Second, the claim recites that the gear assembly is positioned “between” the second motor and the transmission device, indicating three distinct components arranged in sequence. Third, the claim requires that the second motor’s output “bypasses the transmission device,” further indicating the transmission and gear assembly are separate because the output of the second motor cannot bypass the transmission device if the gear assembly to which the motor is coupled is part of the transmission device.

304. Ortmann’s layshaft gearing 18 includes countershaft 34 and layshaft gear pairs 32-33, 36-37, and 50-52. *Id.*, ¶¶ 0019, 0020, 0029, 0030, 0032. A layshaft gear is the gear mounted on the intermediate shaft that transfers power internally, rather than delivering it directly to the wheels. In Figure 1, motor 16 is “driveably connected to the vehicle wheels through layshaft gearing 18.” *Id.*, ¶ 0019. Ring gear 28 of the transmission device “is connected to countershaft 34 and layshaft gear

pair 36-37” and “rotor 30 of motor 16 is connected to countershaft 34 through the layshaft gear pair 32-33.” *Id.*, ¶ 0020. Layshaft gearing 18 [shown in green] is located between motor 16 [shown in red] and the planetary gear set 14 (transmission device) [shown in blue]. In Mode 1, where only motor 16 is active (*id.*, ¶ 0029), and in Mode 3, where motor 16 acts as a traction motor and motor-generator 22 acts as a generator when brake 78 is engaged (*id.*, ¶ 0031), the mechanical power of motor 16 is transmitted to differential mechanism 20 and axle shafts 54, 56 [shown in brown] without passing through (i.e., bypassing) planetary gear set 14 (transmission device), as shown by the red arrow.

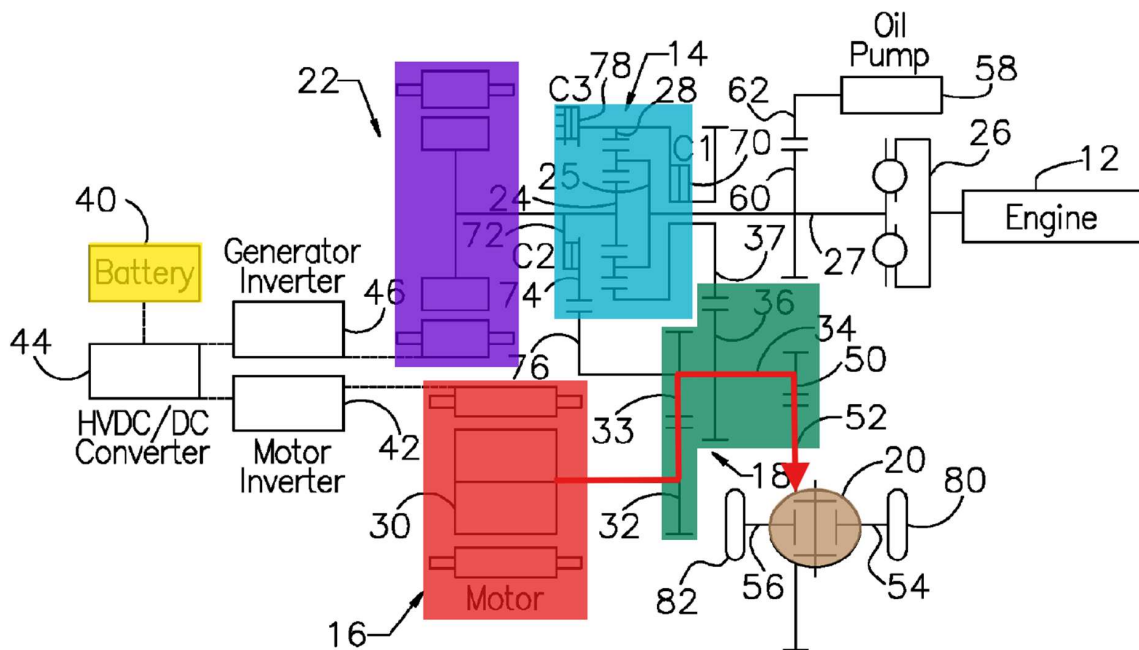


Fig. 4

305. Therefore, limitation 1[e] is disclosed by Ortmann.

*Limitation 1[f]: an internal combustion engine coupled to the transmission device via a path that does not include the first traction motor and second traction motor;*

306. Ortmann discloses an internal combustion engine coupled to the transmission device via a path that does not include the first traction motor and second traction motor. EX1008, ¶¶ 0019, 0020. In Figure 4, “[t]he carrier 25 of the planetary gearset 14 [transmission device] is connected to the engine 12 [shown in gray] through a torsion damper 26 and shaft 27” via a path that does not include motor 22 and motor 16, as shown by the red arrow. *Id.*, ¶ 0020.

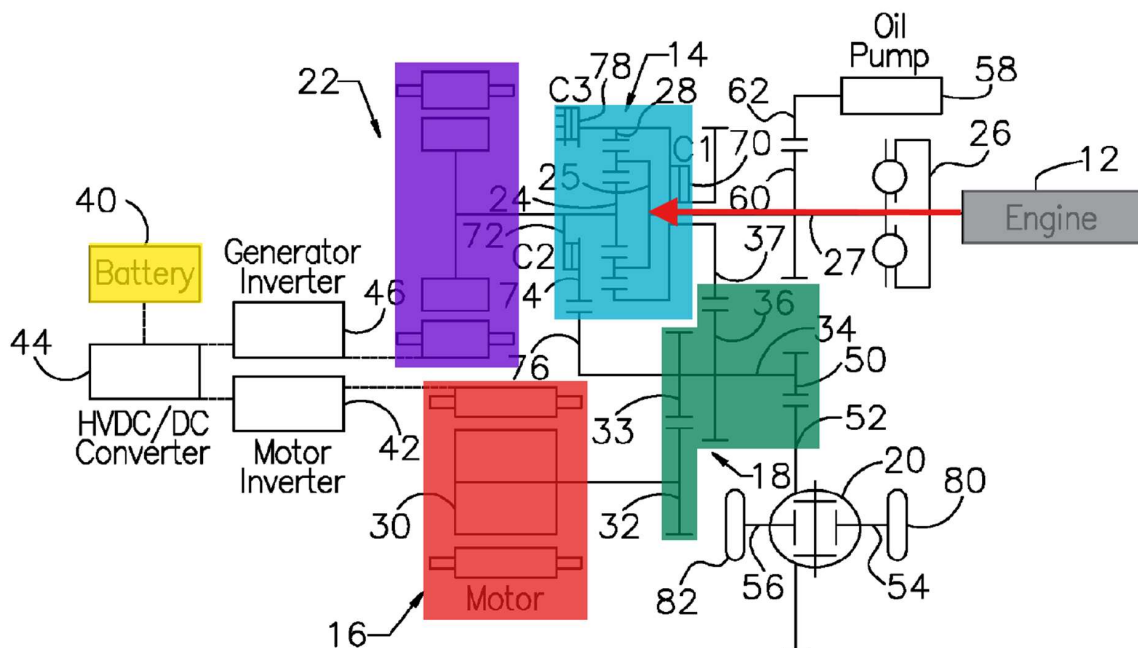


Fig. 4

307. Therefore, limitation 1[f] is disclosed by Ortmann.

*Limitation 1[g]: a control system configured to selectively:*

308. Ortmann's powertrain is capable of operating in several modes: Mode 1 (one motor electric drive), Mode 2 (two motor electric drive), Mode 3 (series), Mode 4 (powersplit), and Modes 5 and 6 (direct drive). EX1008, ¶¶ 0029-0035. Ortmann necessarily teaches a control system for switching the powertrain among these modes. A POSITA would have understood that a control system is required to monitor operating conditions such as vehicle speed, motor speed, speed ratio, and power supplied from the battery. In addition, a POSITA would have understood that a control system is required to engage and disengage clutches C1, C2, and C3 as needed to shift the powertrain between respective modes (Fig. 5). Accordingly, Ortmann inherently discloses the claimed control system.

309. Therefore, limitation 1[g] is disclosed by Ortmann.

*Limitation 1[g][i]: operate the first traction motor and second traction motor to drive the vehicle through the transmission device and gear assembly, respectively;*

310. Mode 2 of Ortmann is two motor electric drive. EX1008, ¶ 0030. "When clutch 72 is engaged, and both clutch 72 and brake 78 are disengaged, generator 22 is connected to the countershaft 34 and drives the vehicle wheels 80, 82 through clutch 72, layshaft gears 74-76, countershaft 34, layshaft gears 50-52, and differential 20." *Id.* "Mode 2 is used during electric drive (sometimes called charge depletion) to provide extra power and torque under conditions of high torque

demand.” *Id.* As explained above, clutch 72 (C2) connects and disconnects the flow of power from the motor and is part of the transmission device. Thus, in this mode, when the power from first motor-generator 22 is transmitted to clutch 72, it is transmitted through the transmission device. *Id.*, ¶ 0026, Figs. 4-5. Therefore, motor-generator 22 drives the vehicle through (clutch 72 of) the transmission device, and motor-generator 16 drives the vehicle through layshaft gearing 18 (gear assembly), as shown by the red arrows in annotated Figure 4.

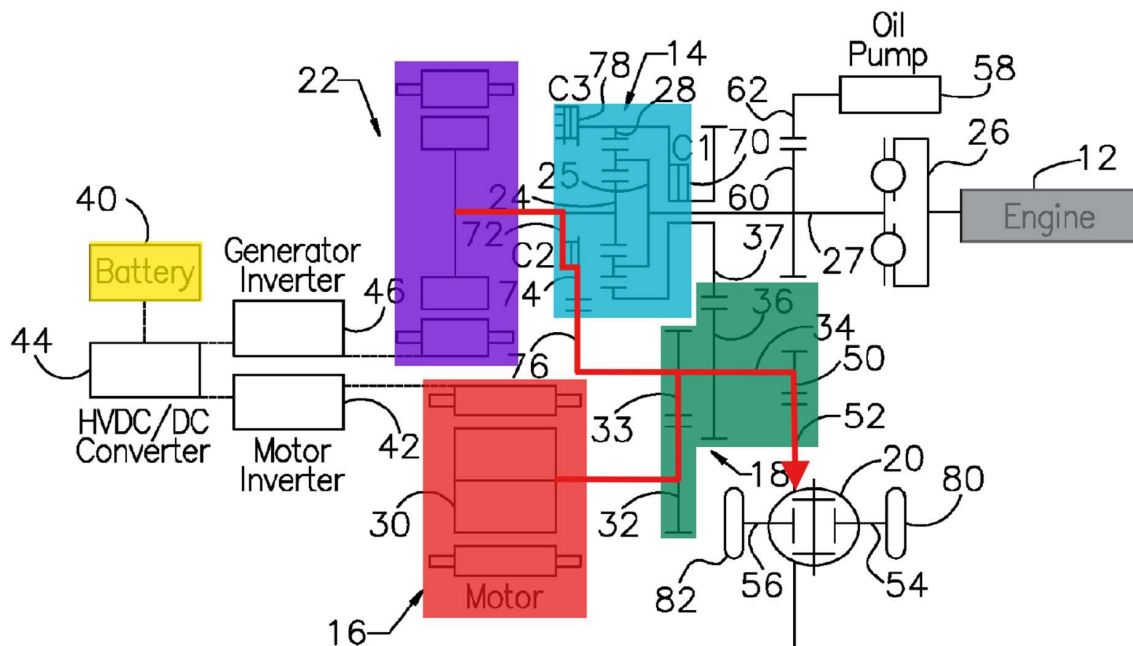


Fig. 4

311. Alternatively, Ortmann discloses Mode 5 as one of the two modes of direct drive. *Id.*, ¶¶ 0034-0036. “In mode 5, clutches 70, 72 are engaged and brake 78 is disengaged.” *Id.*, ¶ 0034. Ortmann discloses two states for Mode 5. The **first**

*state* refers to vehicle driving during **towing conditions**: “In modes 5 and 6, both generator 22 and traction motor 16 can be turned off so that no traction power is transferred into the electrical domain. . . . The direct drive modes provide a benefit in that they produce less heat while towing a load. These modes improve the tow/payload capability of the powersplit powertrain 70.” *Id.*, ¶ 0035. The **second state** refers to vehicle **launch condition** where high torque is required: “If the torque capacity of clutch 72 is sufficient to transmit vehicle launch torque, the engine 12 can be used to aid in the launch of the vehicle **along with the two motors 16, 22**, so that under wheel high torque demand, full engine and battery power are used to drive the wheels during a launch condition.” *Id.*, ¶ 0036 (emphasis added). The launch condition refers to the transition of a vehicle from a stationary position to forward motion (0 mph to a low-speed threshold). This is a demanding operating state for a powertrain because it must overcome the vehicle’s static inertia and rolling resistance.

312. According to Ortmann, in this second state, the engine (12) and both electric motors (16, 22) can be turned on and provide power to support the required high torque demand for the launch condition. In other words, in this second state, when high torque is required to drive the wheels, both electric motors (16, 22) can operate in motoring mode rather than as generators. This configuration maximizes available wheel torque, which can be critical during high-load launch conditions

(e.g., launch scenarios, including uphill gradients and trailer towing). I refer to this specific operating state as Three-Torque Source-Launch (“3TL”).

313. The 3TL state can occur during Ortmann’s Mode 5 (*i.e.*, Direct Drive 1). In this mode, both clutch 70 (C1) and clutch 72 (C2) are engaged and brake C3 is disengaged. *Id.*, Fig. 5. To this end, in Mode 5 during the 3TL state, the engine power is transmitted to planet carrier 25, power from electric machine 22 is transmitted to the sun gear 24, and power from electric machine 16 is transmitted to layshaft gear 32. During the 3TL state, planetary gear set 14 has two inputs and one output, as shown in the following annotated Figure 4. The input power ports to the transmission device (shown with red arrows) are from engine 12 and electric motor 22, and the output power port (shown with a yellow arrow) is the ring gear 28 that transfers the power from the sun gear (*i.e.*, motor 22) and planet carrier (*i.e.*, engine 12) to the wheels via clutch 70 and layshaft gears 36, 37. The output from second motor 16 driving the wheels through layshaft gearing 18 (gear assembly) is also shown with a red arrow.

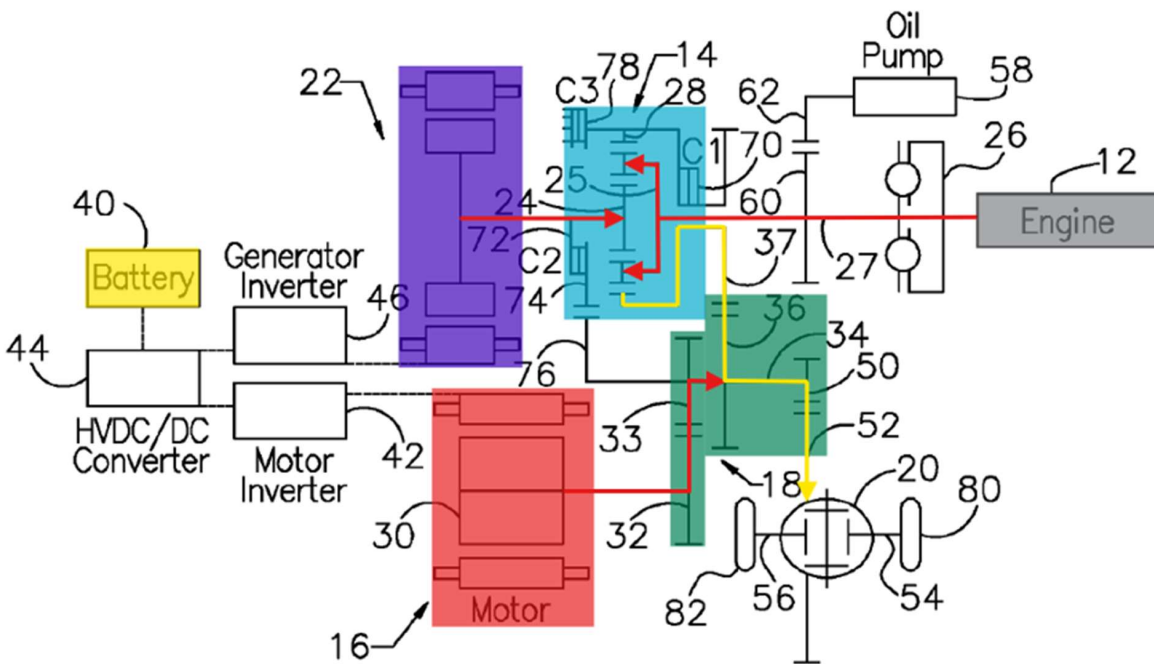


Fig. 4

314. The power flow that may be required to support high torque demands during vehicle launch is further detailed below. As illustrated in the following figure, power from electric motor 22 is transmitted via two distinct paths originating from the (unenumerated) shaft connecting motor 22 to sun gear 24:

- Path I (shown in yellow): Power is transmitted through the planetary gear set 14 and clutch 70 (C1) to the 37/36 gear pair, which then drives countershaft 34.
- Path II (shown in blue): Power is routed through clutch 72 (C2) to pinion 74, which meshes with gear 76 (secured to countershaft 34).

Both paths converge at countershaft 34 to provide maximum torque during the launch sequence.

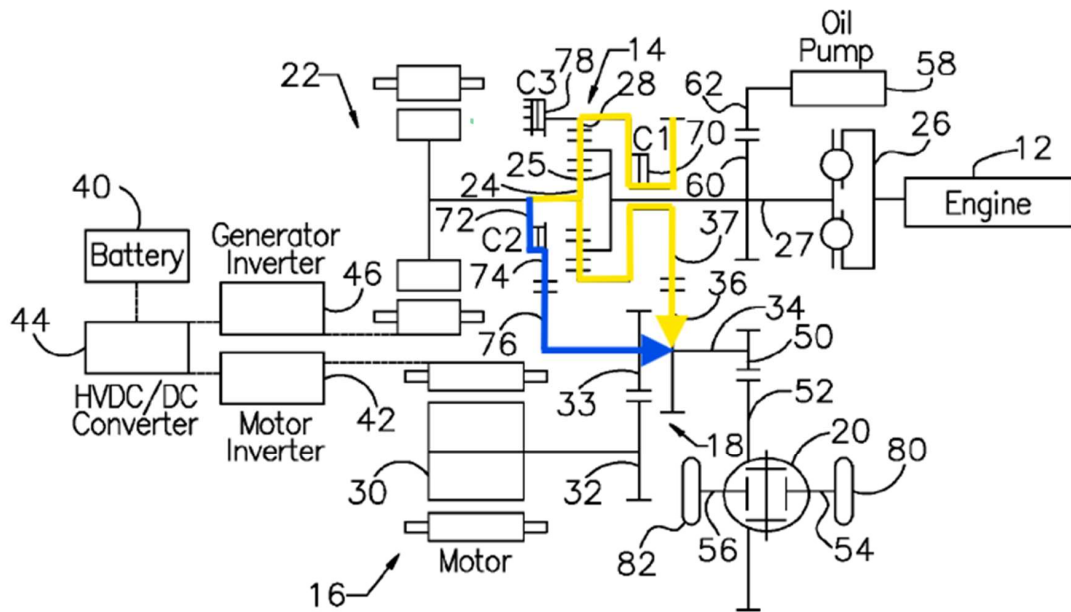


Fig. 4

315. The power flow from electric motor 16 is separately illustrated in red below. Collectively, engine 12 and electric motors 16, 22 drive countershaft 34. This shaft powers layshaft gears 50, 52 connected to the differential 20, ultimately transmitting high torque to the wheels 80, 82 via the axle shafts 54, 56.

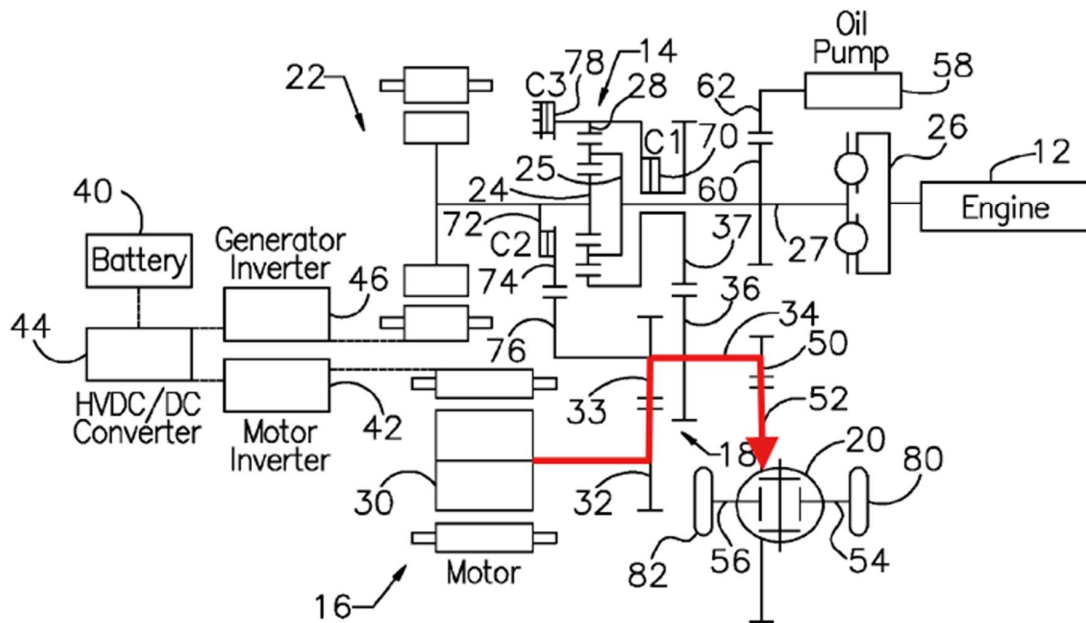


Fig. 4

316. Accordingly, the first motor/generator 22 can also drive the vehicle through the transmission device in Mode 5.

317. Therefore, limitation 1[g][i] is disclosed by Ortmann.

*Limitation 1[g][ii]: operate the first traction motor as a generator to generate electrical power while operating the second traction motor to drive the vehicle through the gear assembly;*

318. Ortmann is capable of operating in Mode 3 (series). EX1008, ¶ 0031.

“When brake 78 is engaged and clutches 70, 72 are disengaged; generator 22 is driven through the planetary gearset 14 at about two to three times engine speed with brake 78 due to brake 78 grounding the ring gear 28 and providing a torque reaction.” *Id.* “The traction motor 16 is connected directly to the wheels 80, 82 to

provide propulsion.” *Id.* Thus, motor-generator 22 generates electrical power and motor-generator 16 drives the vehicle through layshaft gearing 18 (gear assembly).

319. Therefore, limitation 1[g][ii] is disclosed by Ortmann.

*Limitation 1[g][iii]: operate the second traction motor as a generator to generate electrical power.*

320. Ortmann discloses that “[e]ach electric machine 16, 22 is a motor-generator, although conventionally electric machine 16 is referred to as a motor or traction motor, and electric machine 22 is referred to as a generator.” EX1008, ¶¶ 0019. Thus, the electric machine 22 can act as a traction motor or a generator. For instance, in Mode 1 (one motor electric drive) or Mode 2 (two motor electric drive), the electric machine 16 acts as a traction motor. *Id.*, ¶¶ 0029-0030. But during braking, ***the electric machine 16 acts as a generator***, and in fact it is the “main” electric machine to capture regenerative braking energy. This is because the electric machine 16 is connected directly to the wheels (final drive). *Id.*, ¶¶ 0019, 0029, 0031. In braking mode, electric machine 16 functions as the primary load (braking force). The engine is disconnected and deactivated to prevent parasitic loss, allowing for maximum capture of regenerative braking energy. The electric machine 16 produces AC electricity that is sent to the motor inverter 42, which converts it to DC and pushes it to the high-voltage battery 40 after passing through DC/DC converter 44.

321. Therefore, limitation 1[g][iii] is disclosed by Ortmann.

**B. Dependent Claim 2**

*2. The system of claim 1, further comprising a DC/DC converter coupled to the energy storage device.*

322. As explained above, Ortmann discloses all the limitations of claim 1.

323. Ortmann also discloses DC/DC converter 44 coupled to battery 40.

EX1008, ¶ 0021, Figs. 1, 4.

324. Therefore, the limitations of claim 2 are disclosed by Ortmann.

**C. Dependent Claim 4**

*4. The system of claim 1, wherein the energy storage system comprises a battery.*

325. As explained above, Ortmann discloses all the limitations of claim 1.

326. Ortmann discloses traction battery 40. EX1008, ¶ 0021, Figs. 1, 4.

327. Therefore, the limitations of claim 4 are disclosed by Ortmann.

**D. Dependent Claim 5**

*5. The system of claim 1, further comprising a wheel/axle assembly coupled to the gear assembly.*

328. As explained above, Ortmann discloses all the limitations of claim 1.

329. Ortmann also discloses wheels 80, 82 and axle shafts 54, 56 coupled to layshaft gearing 18 (gear assembly) through countershaft 34, pinion 50, ring gear 52, and differential mechanism 20. EX1008, ¶¶ 0019, 0022, 0029-0031, Fig. 4.

330. Therefore, the limitations of claim 5 are disclosed by Ortmann.

**E. Dependent Claim 6**

*6. The system of claim 1, further comprising: a first inverter coupled between the energy storage device and first traction motor; and a second inverter coupled between the energy storage device and second traction motor.*

331. As explained above, Ortmann discloses all the limitations of claim 1.

332. Ortmann also discloses inverters 42 and 46 coupled between battery 40 and motor-generators 16 and 22, respectively. EX1008, ¶ 0021, Figs. 1, 4.

333. Therefore, the limitations of claim 6 are disclosed by Ortmann.

**F. Dependent Claim 7**

*7. The system of claim 1, wherein the electrical power generated by the first traction motor is provided to the second traction motor.*

334. As explained above, Ortmann discloses all the limitations of claim 1.

335. Ortmann discloses Mode 3 (series): “When brake 78 is engaged and clutches 70, 72 are disengaged; generator 22 is driven through the planetary gearset 14 at about two to three times engine speed with brake 78 due to brake 78 grounding the ring gear 28 and providing a torque reaction. The traction motor 16 is connected directly to the wheels 80, 82 to provide propulsion.” EX1008, ¶ 0031. “Mode 3 allows full torque to the wheels from the traction motor 16 . . . .” *Id.* Thus, in Mode 3, engine 12 is not connected to the wheels (because clutch 70 (C2) is disengaged) and instead the engine powers motor-generator 22, which charges battery 40, and then electric power from the battery is transmitted to traction motor

16 to propel the vehicle. All this occurs simultaneously, and electric power generated by motor-generator 22 is provided to motor-generator 16.

336. Therefore, the limitations of claim 7 are disclosed by Ortmann.

**G. Dependent Claim 8**

*8. The system of claim 1, wherein the electrical power generated by the second traction motor is provided to the energy storage system.*

337. Ortmann discloses that “[e]ach electric machine 16, 22 is a motor-generator, although conventionally electric machine 16 is referred to as a motor or traction motor, and electric machine 22 is referred to as a generator.” EX1008, ¶¶ 0019. Thus, the electric machine 22 can act as a traction motor or a generator. For instance, in Mode 1 (one motor electric drive) or Mode 2 (two motor electric drive), the electric machine 16 acts as a traction motor. *Id.*, ¶¶ 0029-0030. But during braking, the electric machine 16 acts as a generator, and in fact it is the “main” electric machine to capture regenerative braking energy. This is because the electric machine 16 is connected directly to the wheels (final drive). *Id.*, ¶¶ 0019, 0029, 0031. In braking mode, electric machine 16 functions as the primary load (braking force). The engine is disconnected and deactivated to prevent parasitic loss, allowing for maximum capture of regenerative braking energy. The electric machine 16 produces AC electricity that is sent to the motor inverter 42, which converts it to DC and pushes it to the high-voltage battery 40 after passing through DC/DC converter 44.



*Limitation 9[a]: an energy storage system;*

341. Ortmann discloses an energy storage system. EX1008, ¶ 0021.

342. Figure 4 of Ortmann shows that the powertrain includes traction battery  
40 [shown in yellow]. *Id.*

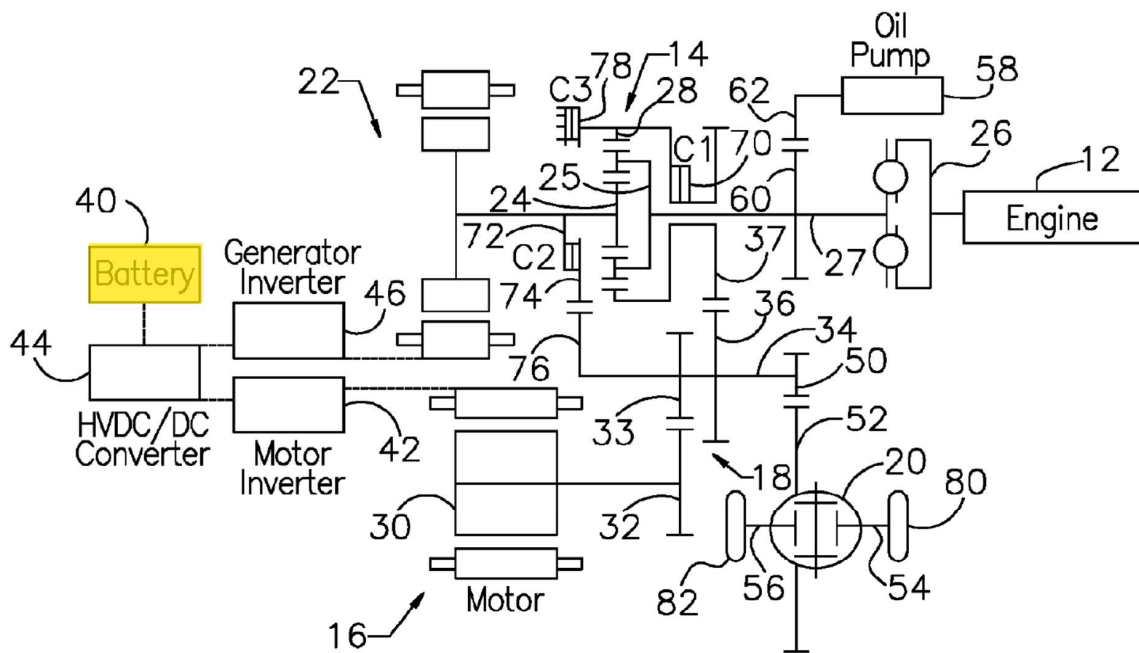


Fig. 4

343. Therefore, limitation 9[a] is disclosed by Ortmann.

*Limitation 9[b]: a first traction drive system coupled to the energy storage system, the first traction drive system comprising a first inverter coupled to a first AC motor;*

344. Ortmann discloses a first traction drive system coupled to the energy storage system where the first traction drive system comprises a first inverter coupled to a first AC motor. EX1008, ¶¶ 0019, 0021. Figure 4 of Ortmann shows

that the first traction motor-generator 22 [shown in purple] “is electrically connected to battery 40 through an inverter 46 [also shown in purple] and converter 44.” *Id.*, ¶ 0021. The inverter converts DC from the battery to AC for the electric motor—thus, motor-generator 22 is an AC motor.

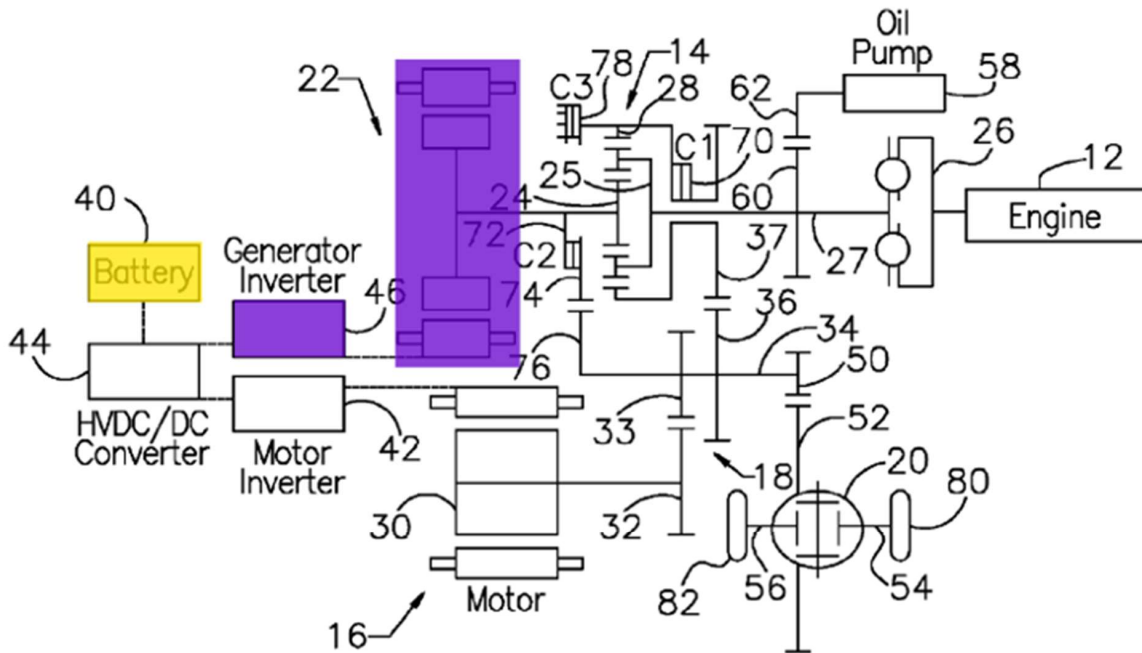


Fig. 4

345. Ortmann discloses that “[e]ach electric machine 16, 22 is a motor-generator, although conventionally electric machine 16 is referred to as a motor or traction motor, and electric machine 22 is referred to as a generator.” EX1008, ¶ 0019. Electric machine 22 acts as a traction motor in Mode 2 (two motor electric drive): “generator 22 is connected to the countershaft 34 and *drives* the vehicle

wheels 80, 82 through clutch 72, layshaft gears 74-76, countershaft 34, layshaft gears 50-52, and differential 20.” *Id.*, ¶ 0030 (emphasis added).

346. Therefore, limitation 9[b] is disclosed by Ortmann.

*Limitation 9[c]: a second traction drive system coupled to the energy storage system, the second traction drive system comprising a second inverter coupled to a second AC motor;*

347. Ortmann discloses a second traction drive system coupled to the energy storage system where the second traction drive system comprises a second inverter coupled to a second AC motor. EX1008, ¶¶ 0019, 0021. Figure 1 of Ortmann shows that the second traction motor-generator 16 [shown in red] “is electrically connected to battery 40 through an inverter 42 [also shown in red] and a high voltage DC/DC converter 44.” *Id.*, ¶ 0021. The inverter converts DC from the battery to AC for the electric motor—thus, motor-generator 16 is an AC motor. Motor-generator 16 drives the vehicle in at least Modes 1-3. *Id.*, ¶¶ 0029-0031.

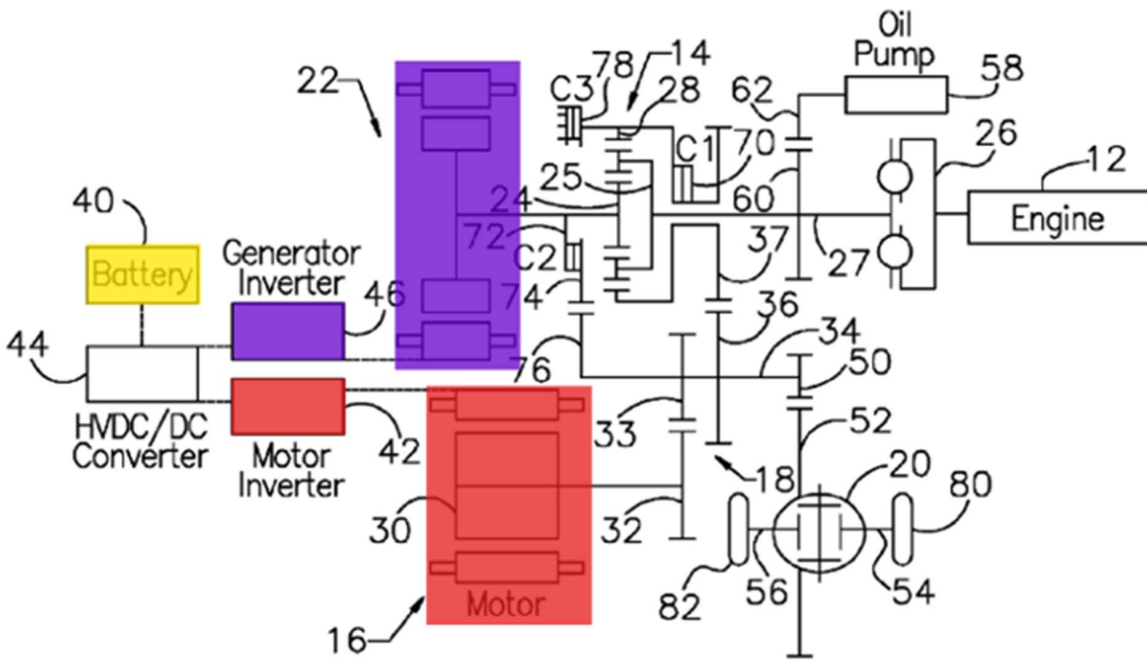


Fig. 4

348. Therefore, limitation 9[c] is disclosed by Ortmann.

*Limitation 9[d]: a transmission device coupled to the first traction drive system, the transmission device comprising an arrangement of planetary gears;*

349. Ortmann discloses a transmission device coupled to the first traction drive system where the transmission device comprises an arrangement of planetary gears. EX1008, ¶¶ 0019, 0020. In Figure 4, “planetary gearset 14 is connected to the [motor-]generator 22.” *Id.*, ¶ 0020. Planetary gear set 14 [shown in blue] is a transmission device comprising sun gear 24, ring gear 28, and carrier 25. *Id.* In addition, as explained above, the claimed “transmission device” of the ’648 Patent includes clutches, which connect and disconnect the flow of power from the motor.

EX1001, 5:5-11, 5:21-25. Thus, the transmission device of Ortmann may also include, for example, clutch 72 (C2) shown in Figure 4.

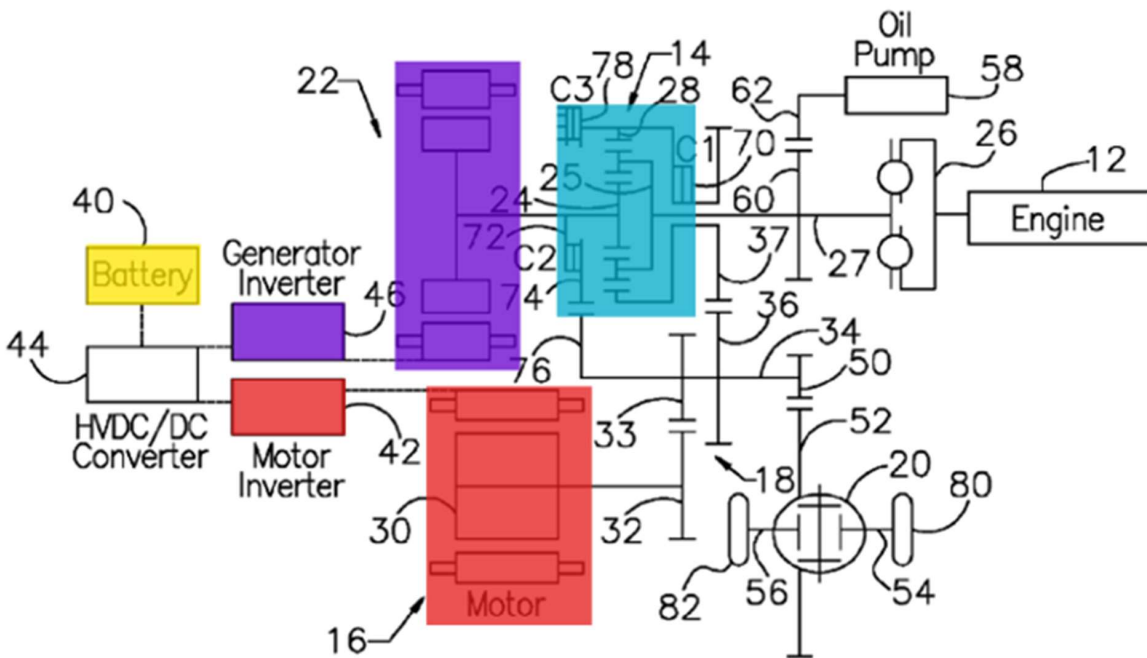


Fig. 4

350. Therefore, limitation 9[d] is disclosed by Ortmann.

*Limitation 9[e]: a gear assembly coupled between the second traction drive system and the transmission device such that the output of the second traction motor bypasses the transmission device;*

351. Ortmann discloses a gear assembly coupled between the second traction drive system and the transmission device such that the output of the second traction drive system bypasses the transmission device. EX1008, ¶¶ 0019, 0020. The claimed gear assembly is a separate and distinct element from the transmission device recited in limitation 9[d]. Ortmann's layshaft gearing 18 includes

countershaft 34 and layshaft gear pairs 32-33, 36-37, and 50-52. *Id.*, ¶¶ 0019, 0020, 0029, 0030, 0032. In Figure 1, motor 16 is “driveably connected to the vehicle wheels through layshaft gearing 18.” *Id.*, ¶ 0019. Ring gear 28 of the transmission device “is connected to countershaft 34 and layshaft gear pair 36-37” and “rotor 30 of motor 16 is connected to countershaft 34 through the layshaft gear pair 32-33.” *Id.*, ¶ 0020. Layshaft gearing 18 [shown in green] is located between motor 16 [shown in red] and the planetary gear set 14 (transmission device) [shown in blue]. In Mode 1, where only motor 16 is active (*id.*, ¶ 0029), and in Mode 3, where motor 16 acts as a traction motor and motor-generator 22 acts as a generator when brake 78 is engaged (*id.*, ¶ 0031), the mechanical power of motor 16 is transmitted to differential mechanism 20 and axle shafts 54, 56 [shown in brown] without passing through (*i.e.*, bypassing) planetary gear set 14 (transmission device), as shown by the red arrow.

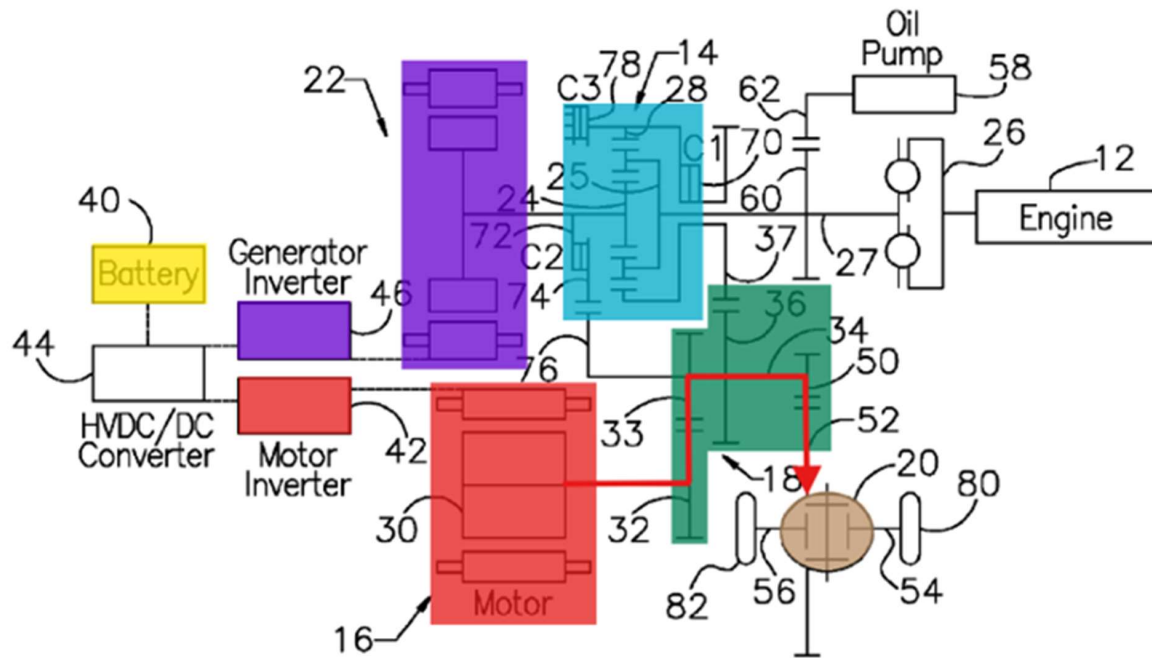


Fig. 4

352. Therefore, limitation 9[e] is disclosed by Ortmann.

*Limitation 9[f]: an internal combustion engine coupled to the transmission device via a path that does not include the first AC motor and second AC motor;*

353. Ortmann discloses an internal combustion engine coupled to the transmission device via a path that does not include the first and second AC motors. EX1008, ¶¶ 0019, 0020. In Figure 4, “[t]he carrier 25 of the planetary gearset 14 [transmission device] is connected to the engine 12 [shown in gray] through a torsion damper 26 and shaft 27” via a path that does not include motor 22 and motor 16, as shown by the red arrow. *Id.*, ¶ 0020.

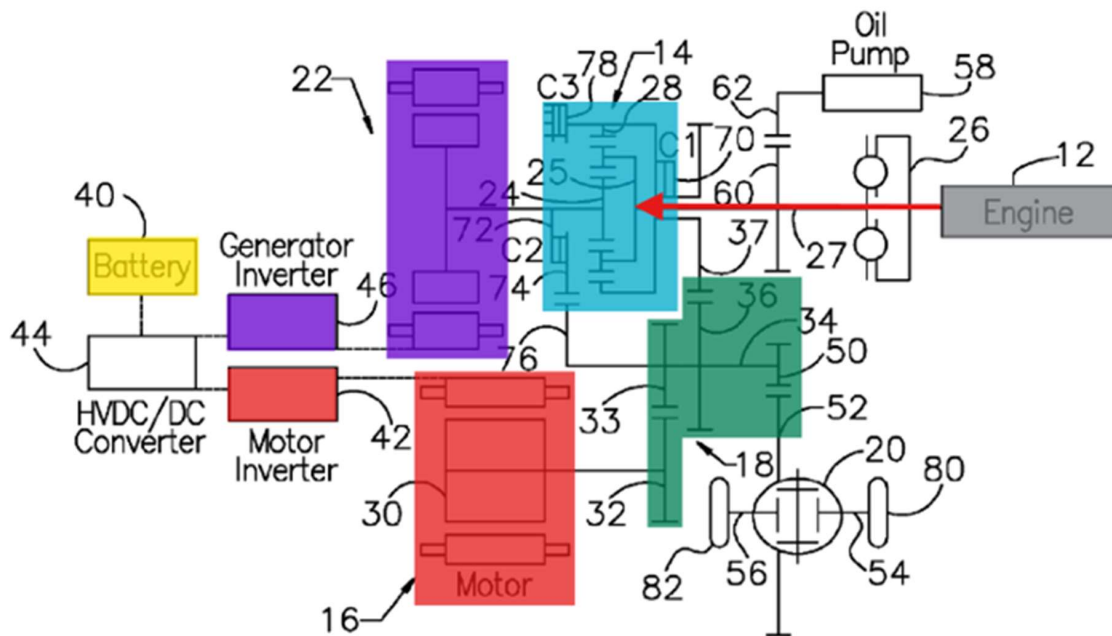


Fig. 4

354. Therefore, limitation 9[f] is disclosed by Ortmann.

*Limitation 9[g]: a control system configured to selectively:*

355. Ortmann's powertrain is capable of operating in several modes: Mode 1 (one motor electric drive), Mode 2 (two motor electric drive), Mode 3 (series), Mode 4 (powersplit), and Modes 5 and 6 (direct drive). EX1008, ¶¶ 0029-0035. Ortmann necessarily teaches a control system for switching the powertrain among these modes. A POSITA would have understood that a control system is required to monitor operating conditions such as vehicle speed, motor speed, speed ratio, and power supplied from the battery. In addition, a POSITA would have understood that a control system is required to engage and disengage clutches C1, C2, and C3 as

needed to shift the powertrain between respective modes (Fig. 5). Accordingly, Ortmann inherently discloses the claimed control system.

356. Therefore, limitation 9[g] is disclosed by Ortmann.

*Limitation 9[g][i]: operate the first traction drive system and second traction drive system to drive the vehicle through the transmission device and gear assembly, respectively;*

357. Mode 2 of Ortmann is two motor electric drive. EX1008, ¶ 0030. “When clutch 72 is engaged, and both clutch 72 and brake 78 are disengaged, generator 22 is connected to the countershaft 34 and drives the vehicle wheels 80, 82 through clutch 72, layshaft gears 74-76, countershaft 34, layshaft gears 50-52, and differential 20.” *Id.* “Mode 2 is used during electric drive (sometimes called charge depletion) to provide extra power and torque under conditions of high torque demand.” *Id.* As explained above, clutch 72 (C2) connects and disconnects the flow of power from the motor and is part of the transmission device. Thus, in this mode, when the power from first motor-generator 22 is transmitted to clutch 72, it is transmitted through the transmission device. *Id.*, ¶ 0026, Figs. 4-5. Therefore, motor-generator 22 drives the vehicle through (clutch 72 of) the transmission device, and motor-generator 16 drives the vehicle through layshaft gearing 18 (gear assembly), as shown by the red arrows in annotated Figure 4.

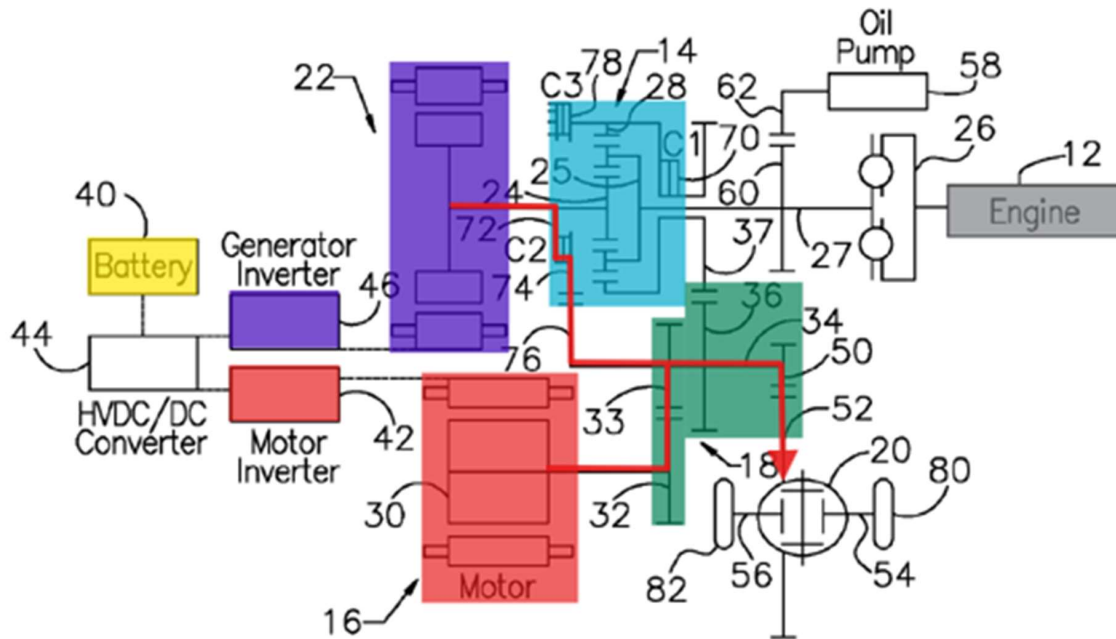


Fig. 4

358. Alternatively, Ortmann discloses Mode 5 as one of the two modes of direct drive. *Id.*, ¶¶ 0034-0036. “In mode 5, clutches 70, 72 are engaged and brake 78 is disengaged.” *Id.*, ¶ 0034. Ortmann discloses two states for Mode 5. The **first state** refers to vehicle driving during **towing conditions**: “In modes 5 and 6, both generator 22 and traction motor 16 can be turned off so that no traction power is transferred into the electrical domain. . . . The direct drive modes provide a benefit in that they produce less heat while towing a load. These modes improve the tow/payload capability of the powersplit powertrain 70.” *Id.*, ¶ 0035. The **second state** refers to vehicle **launch condition** where high torque is required: “If the torque capacity of clutch 72 is sufficient to transmit vehicle launch torque, the engine 12

can be used to aid in the launch of the vehicle *along with the two motors 16, 22*, so that under wheel high torque demand, full engine and battery power are used to drive the wheels during a launch condition.” *Id.*, ¶ 0036 (emphasis added). The launch condition refers to the transition of a vehicle from a stationary position to forward motion (0 mph to a low-speed threshold). This is a demanding operating state for a powertrain because it must overcome the vehicle’s static inertia and rolling resistance.

359. According to Ortmann, in this second state, the engine (12) and both electric motors (16, 22) can be turned on and provide power to support the required high torque demand for the launch condition. In other words, in this second state, when high torque is required to drive the wheels, both electric motors (16, 22) can operate in motoring mode rather than as generators. This Three-Torque Source Launch (3TL) configuration maximizes available wheel torque, which can be critical during high-load launch conditions (*e.g.*, launch scenarios, including uphill gradients and trailer towing).

360. The 3TL state can occur during Ortmann’s Mode 5 (*i.e.*, Direct Drive 1). In this mode, both clutch 70 (C1) and clutch 72 (C2) are engaged and brake C3 is disengaged. *Id.*, Fig. 5. To this end, in Mode 5 during the 3TL state, the engine power is transmitted to planet carrier 25, power from electric machine 22 is transmitted to the sun gear 24, and power from electric machine 16 is transmitted to

layshaft gear 32. During the 3TL state, planetary gear set 14 has two inputs and one output, as shown in the following annotated Figure 4. The input power ports to the transmission device (shown with red arrows) are from engine 12 and electric motor 22, and the output power port (shown with a yellow arrow) is the ring gear 28 that transfers the power from the sun gear (*i.e.*, motor 22) and planet carrier (*i.e.*, engine 12) to the wheels via clutch 70 and layshaft gears 36, 37. The output from second motor 16 driving the wheels through layshaft gearing 18 (gear assembly) is also shown with a red arrow.

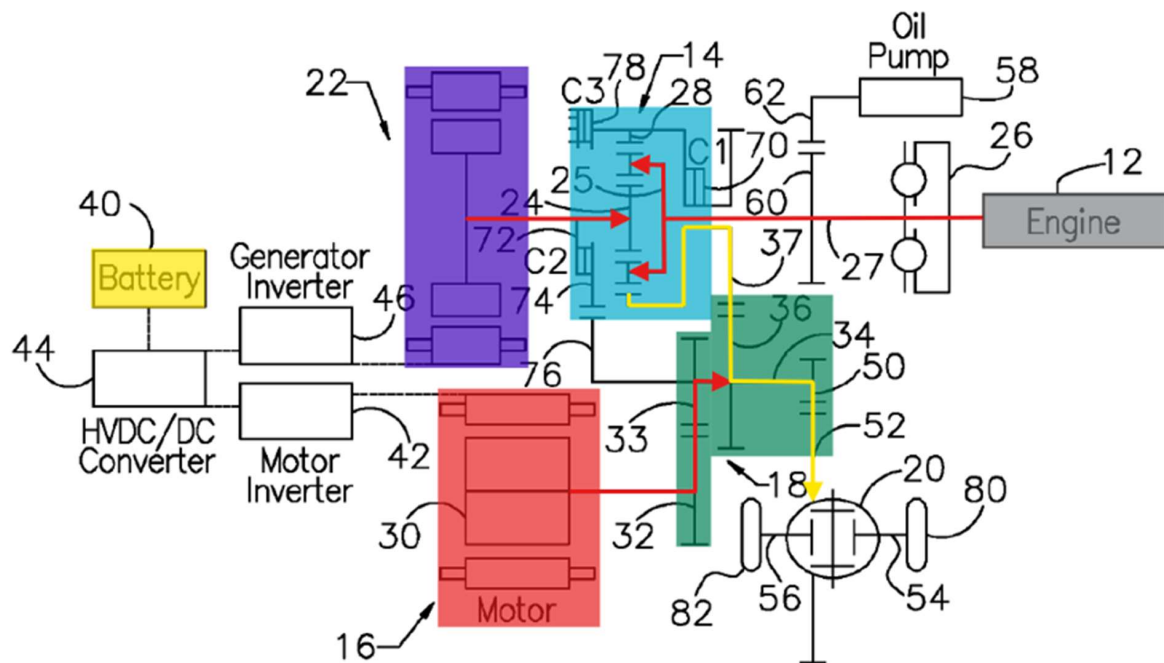


Fig. 4

361. The power flow that may be required to support high torque demands during vehicle launch is further detailed below. As illustrated in the following figure,

power from electric motor 22 is transmitted via two distinct paths originating from the (unenumerated) shaft connecting motor 22 to sun gear 24:

- Path I (shown in yellow): Power is transmitted through the planetary gear set 14 and clutch 70 (C1) to the 37/36 gear pair, which then drives countershaft 34.
- Path II (shown in blue): Power is routed through clutch 72 (C2) to pinion 74, which meshes with gear 76 (secured to countershaft 34).

Both paths converge at countershaft 34 to provide maximum torque during the launch sequence.

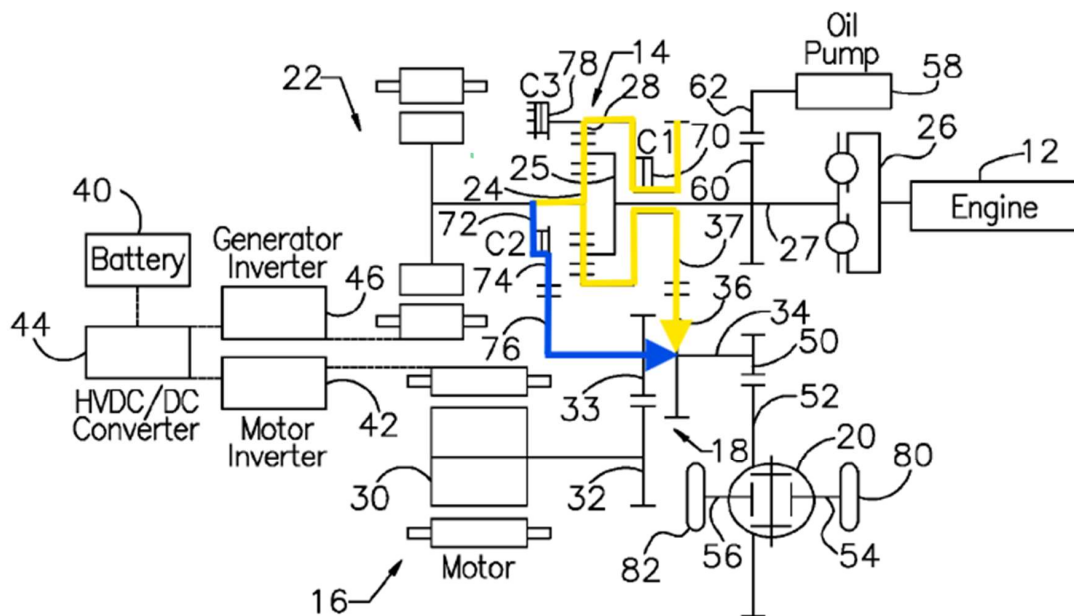


Fig. 4

362. The power flow from electric motor 16 is separately illustrated in red below. Collectively, engine 12 and electric motors 16, 22 drive countershaft 34. This shaft powers layshaft gears 50, 52 connected to the differential 20, ultimately transmitting high torque to the wheels 80, 82 via the axle shafts 54, 56.

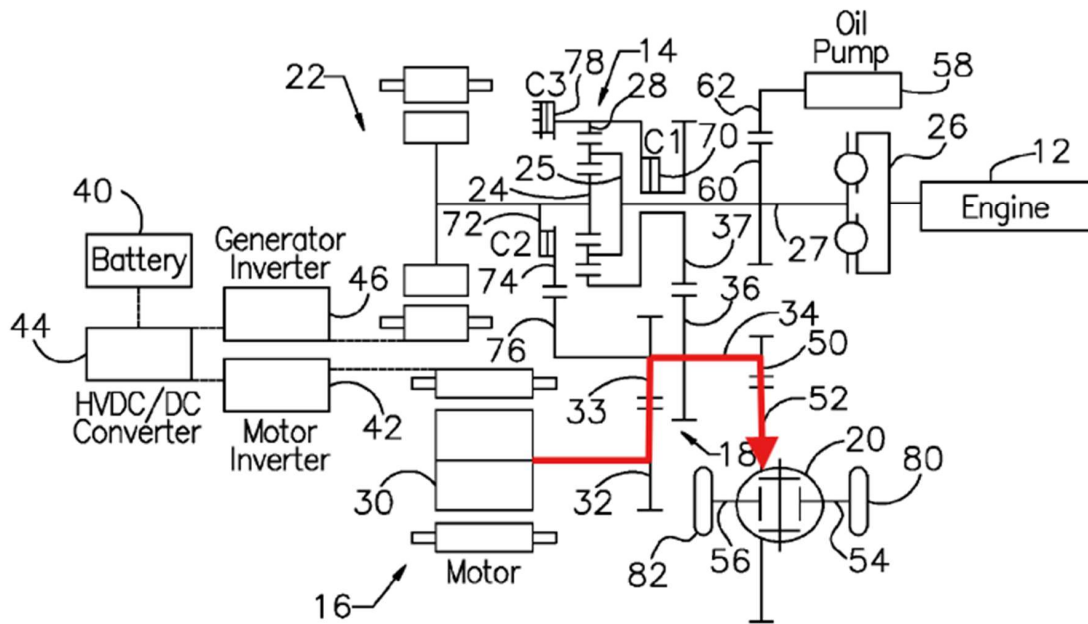


Fig. 4

363. Accordingly, the first motor/generator 22 can also drive the vehicle through the transmission device in Mode 5.

364. Therefore, limitation 9[g][i] is disclosed by Ortmann.

*Limitation 9[g][ii]: operate the first traction drive system to generate electrical power while operating the second traction drive system to drive the vehicle through the gear assembly;*

365. Ortmann is capable of operating in Mode 3 (series). EX1008, ¶ 0031.

“When brake 78 is engaged and clutches 70, 72 are disengaged; generator 22 is driven through the planetary gearset 14 at about two to three times engine speed with brake 78 due to brake 78 grounding the ring gear 28 and providing a torque reaction.” *Id.* “The traction motor 16 is connected directly to the wheels 80, 82 to provide propulsion.” *Id.* Thus, motor-generator 22 generates electrical power and motor-generator 16 drives the vehicle through layshaft gearing 18 (gear assembly).

366. Therefore, limitation 9[g][i][ii] is disclosed by Ortmann.

*Limitation 9[g][iii]: operate the second traction drive system to generate electrical power.*

367. Ortmann discloses that “[e]ach electric machine 16, 22 is a motor-generator, although conventionally electric machine 16 is referred to as a motor or traction motor, and electric machine 22 is referred to as a generator.” EX1008, ¶¶ 0019. Thus, the electric machine 22 can act as a traction motor or a generator. For instance, in Mode 1 (one motor electric drive) or Mode 2 (two motor electric drive), the electric machine 16 acts as a traction motor. *Id.*, ¶¶ 0029-0030. But during braking, ***the electric machine 16 acts as a generator***, and in fact it is the “main” electric machine to capture regenerative braking energy. This is because the electric

machine 16 is connected directly to the wheels (final drive). *Id.*, ¶¶ 0019, 0029, 0031. In braking mode, electric machine 16 functions as the primary load (braking force). The engine is disconnected and deactivated to prevent parasitic loss, allowing for maximum capture of regenerative braking energy. The electric machine 16 produces AC electricity that is sent to the motor inverter 42, which converts it to DC and pushes it to the high-voltage battery 40 after passing through DC/DC converter 44.

368. Therefore, limitation 9[g][i][iii] is disclosed by Ortmann.

**I. Dependent Claim 10**

*10. The system of claim 9, further comprising a DC/DC converter coupled to the energy storage device.*

369. As explained above, Ortmann discloses all the limitations of claim 9.

370. Ortmann also discloses DC/DC converter 44 coupled to battery 40.

EX1008, ¶ 0021, Figs. 1, 4.

371. Therefore, the limitations of claim 10 are disclosed by Ortmann.

**J. Dependent Claim 12**

*12. The system of claim 9, wherein the energy storage system comprises a battery.*

372. As explained above, Ortmann discloses all the limitations of claim 9.

373. In particular, Ortmann discloses traction battery 40. EX1008, ¶ 0021,

Figs. 1, 4.

374. Therefore, the limitations of claim 12 are disclosed by Ortmann.

**K. Dependent Claim 13**

*13. The system of claim 9, further comprising a wheel/axle assembly coupled to the gear assembly.*

375. As explained above, Ortmann discloses all the limitations of claim 9.

376. Ortmann also discloses wheels 80, 82 and axle shafts 54, 56 coupled to layshaft gearing 18 (gear assembly) through countershaft 34, pinion 50, ring gear 52, and differential mechanism 20. EX1008, ¶¶ 0019, 0022, 0029-0031, Fig. 4.

377. Therefore, the limitations of claim 13 are disclosed by Ortmann.

**L. Dependent Claim 14**

*14. The system of claim 9, wherein the electrical power generated by the first traction drive system is provided to the second traction drive system.*

378. As explained above, Ortmann discloses all the limitations of claim 9.

379. Ortmann discloses Mode 3 (series): “When brake 78 is engaged and clutches 70, 72 are disengaged; generator 22 is driven through the planetary gearset 14 at about two to three times engine speed with brake 78 due to brake 78 grounding the ring gear 28 and providing a torque reaction. The traction motor 16 is connected directly to the wheels 80, 82 to provide propulsion.” EX1008, ¶ 0031. “Mode 3 allows full torque to the wheels from the traction motor 16 . . . .” *Id.* Thus, in Mode 3, engine 12 is not connected to the wheels (because clutch 70 (C2) is disengaged) and instead the engine powers motor-generator 22, which charges battery 40, and then electric power from the battery is transmitted to traction motor

16 to propel the vehicle. All this occurs simultaneously, and electric power generated by motor-generator 22 of the first traction drive system is provided to motor-generator 16 of the second traction drive system.

380. Therefore, the limitations of claim 14 are disclosed by Ortmann.

**M. Dependent Claim 15**

*15. The system of claim 9, wherein the electrical power generated by the second traction drive system is provided to the energy storage system.*

381. Ortmann discloses that “[e]ach electric machine 16, 22 is a motor-generator, although conventionally electric machine 16 is referred to as a motor or traction motor, and electric machine 22 is referred to as a generator.” EX1008, ¶¶ 0019. Thus, the electric machine 22 can act as a traction motor or a generator. For instance, in Mode 1 (one motor electric drive) or Mode 2 (two motor electric drive), the electric machine 16 acts as a traction motor. *Id.*, ¶¶ 0029-0030. But during braking, the electric machine 16 acts as a generator, and in fact it is the “main” electric machine to capture regenerative braking energy. This is because the electric machine 16 is connected directly to the wheels (final drive). *Id.*, ¶¶ 0019, 0029, 0031. In braking mode, electric machine 16 functions as the primary load (braking force). The engine is disconnected and deactivated to prevent parasitic loss, allowing for maximum capture of regenerative braking energy. The electric machine 16 of the second traction drive system produces AC electricity that is sent to the motor inverter



384. Therefore, limitation 16[p] is disclosed by Ortmann.

*Limitation 16[a]: an energy storage system;*

385. Ortmann discloses an energy storage system. EX1008, ¶ 0021. Figure 4 of Ortmann shows that the powertrain includes traction battery 40 [shown in yellow]. *Id.*

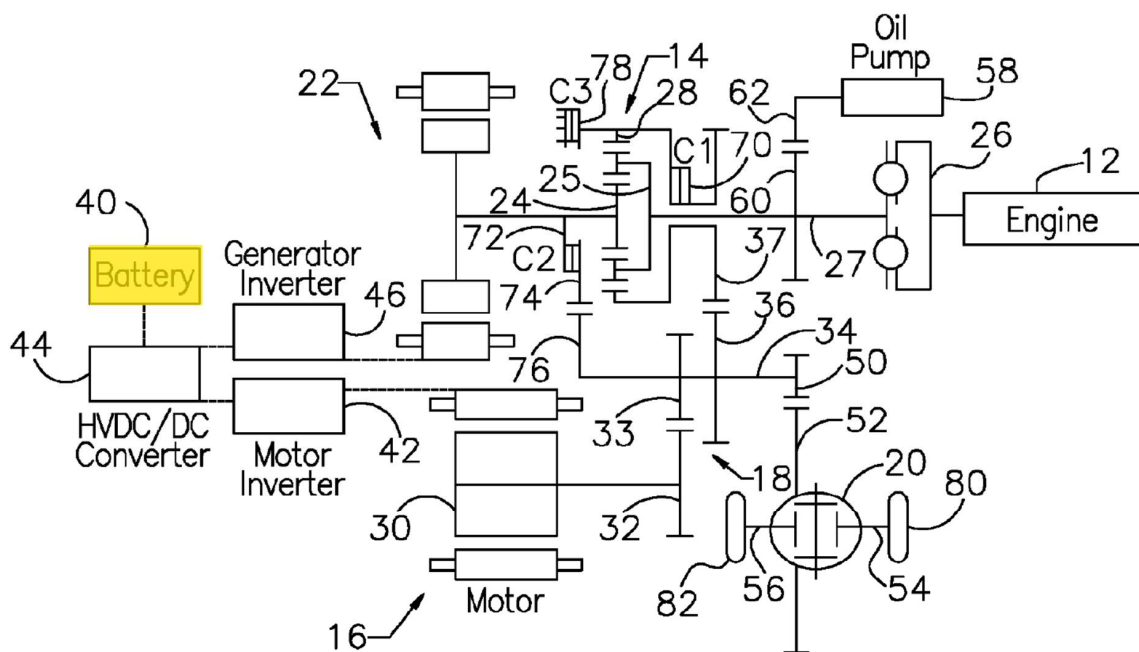


Fig. 4

386. Therefore, limitation 16[a] is disclosed by Ortmann.

*Limitation 16[b]: a first electric motor coupled to the energy storage system;*

387. Ortmann discloses a first electric motor coupled to the energy storage system. EX1008, ¶¶ 0019, 0021. Figure 4 of Ortmann shows that the first traction

motor-generator 22 [shown in purple] “is electrically connected to battery 40 through an inverter 46 and converter 44.” *Id.*, ¶ 0021.

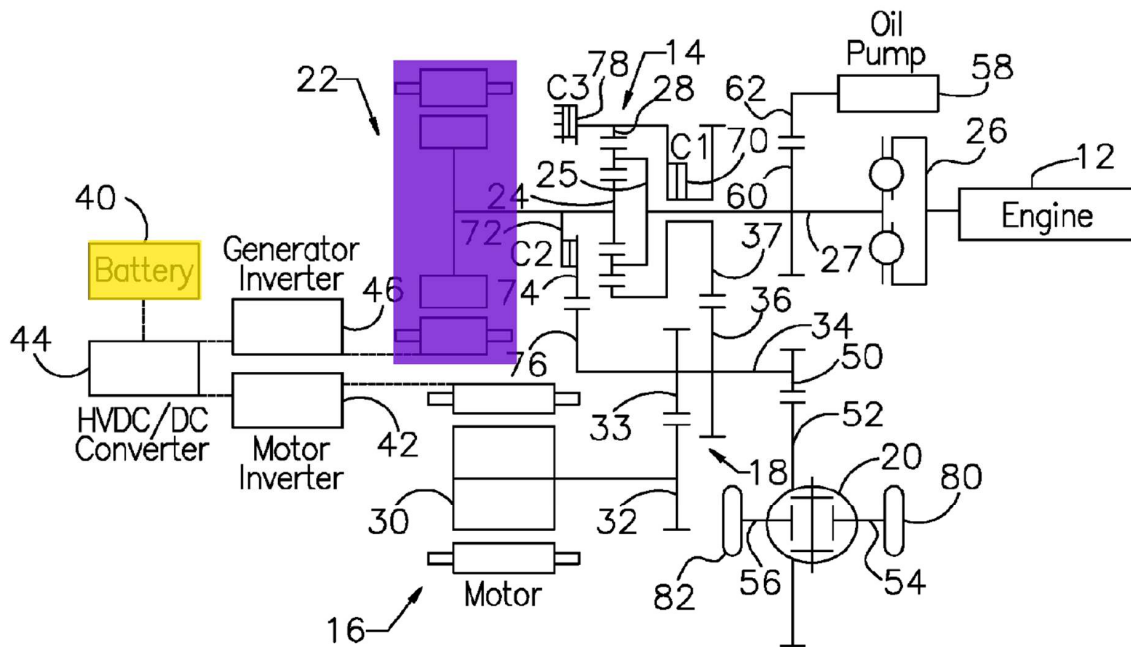


Fig. 4

388. Therefore, limitation 16[b] is disclosed by Ortmann.

*Limitation 16[c]: a second electric motor coupled to the energy storage system;*

389. Ortmann discloses a second electric motor coupled to the energy storage system. EX1008, ¶¶ 0019, 0021. Figure 1 of Ortmann shows that the second traction motor-generator 16 [shown in red] “is electrically connected to battery 40 through an inverter 42 and a high voltage DC/DC converter 44.” *Id.*, ¶ 0021.

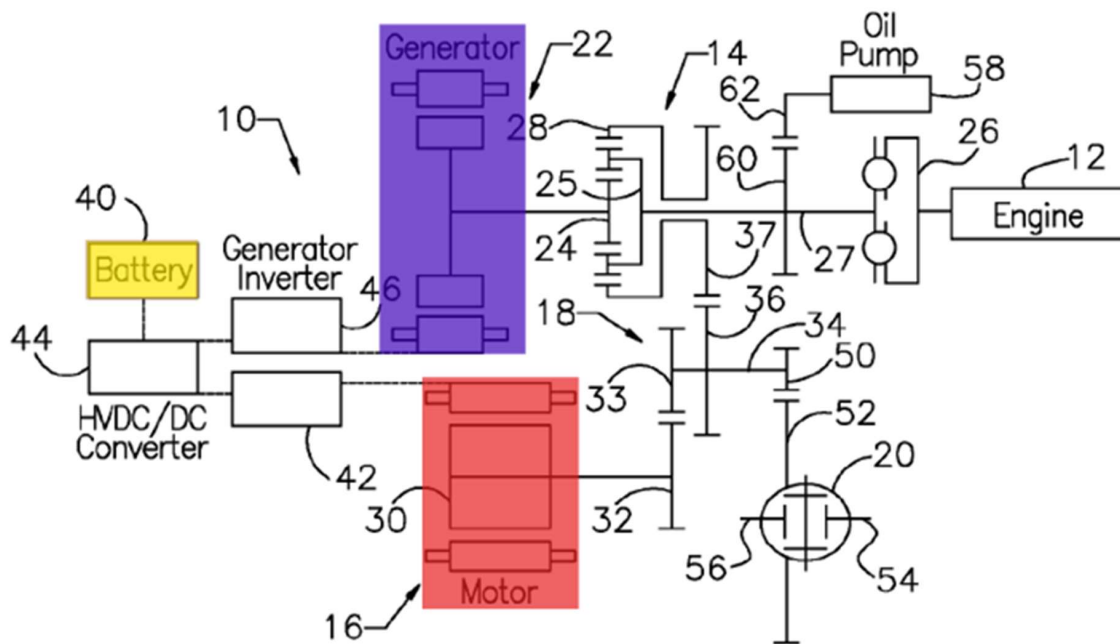


Fig. 1

390. Therefore, limitation 16[c] is disclosed by Ortmann.

*Limitation 16[d]: a transmission device coupled to the first electric motor, the transmission device comprising an arrangement of planetary gears;*

391. Ortmann discloses a transmission device coupled to the first electric motor where the transmission device comprises an arrangement of planetary gears. EX1008, ¶¶ 0019, 0020. In Figure 1, “planetary gearset 14 is connected to the [motor-]generator 22.” *Id.*, ¶ 0020. Planetary gear set 14 [shown in blue] is a transmission device comprising sun gear 24, ring gear 28, and carrier 25. *Id.* In addition, as explained above, the claimed “transmission device” of the ’648 Patent includes clutches, which connect and disconnect the flow of power from the motor.

EX1001, 5:5-11, 5:21-25. Thus, the transmission device of Ortmann may also include, for example, clutch 72 (C2) shown in Figure 4.

392.

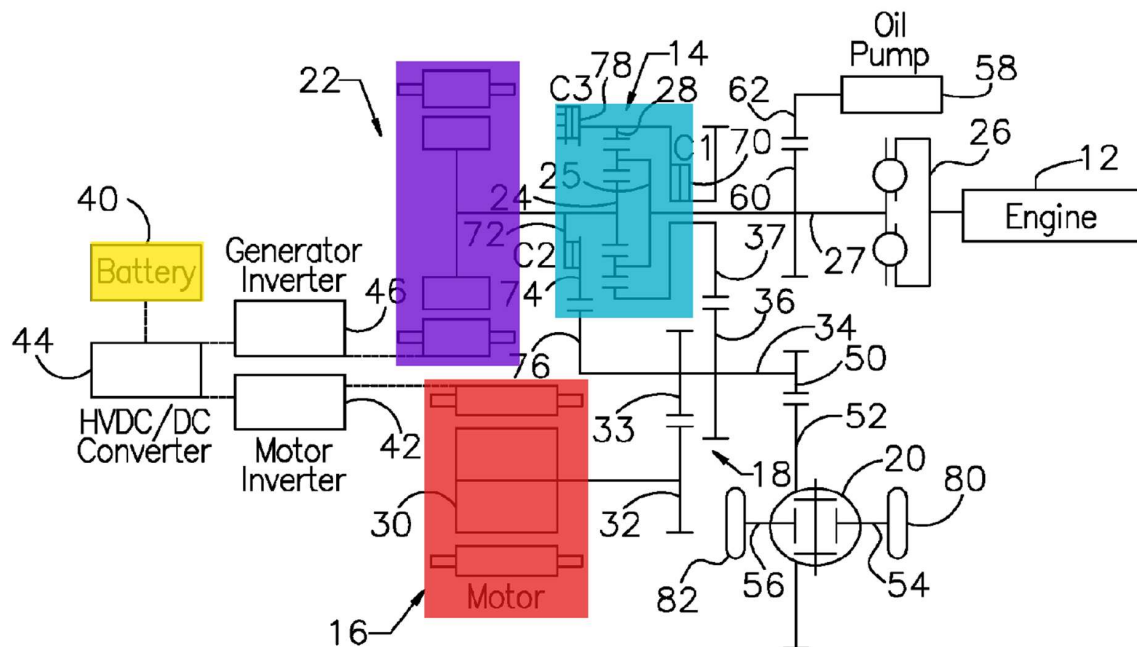


Fig. 4

393. Therefore, limitation 16[d] is disclosed by Ortmann.

*Limitation 16[e]: a gear assembly coupled between the second electric motor and the transmission device such that the output of the second electric motor bypasses the transmission device;*

394. The claimed gear assembly is a separate and distinct element from the transmission device in limitation 16[d] for reasons explained in Section VII(A)(1). Ortmann discloses a gear assembly coupled between the second electric motor and the transmission device such that the output of the second electric motor bypasses

the transmission device. EX1008, ¶¶ 0019, 0020. Ortmann's layshaft gearing 18 includes countershaft 34 and layshaft gear pairs 32-33, 36-37, and 50-52. *Id.*, ¶¶ 0019, 0020, 0029, 0030, 0032. In Figure 1, motor 16 is "driveably connected to the vehicle wheels through layshaft gearing 18." *Id.*, ¶ 0019. Ring gear 28 of the transmission device "is connected to countershaft 34 and layshaft gear pair 36-37" and "rotor 30 of motor 16 is connected to countershaft 34 through the layshaft gear pair 32-33." *Id.*, ¶ 0020. Layshaft gearing 18 [shown in green] is located between motor 16 [shown in red] and the planetary gear set 14 (transmission device) [shown in blue]. In Mode 1, where only motor 16 is active (*id.*, ¶ 0029), and in Mode 3, where motor 16 acts as a traction motor and motor-generator 22 acts as a generator when brake 78 is engaged (*id.*, ¶ 0031), the mechanical power of motor 16 is transmitted to differential mechanism 20 and axle shafts 54, 56 [shown in brown] without passing through (*i.e.*, bypassing) planetary gear set 14 (transmission device), as shown by the red arrow.

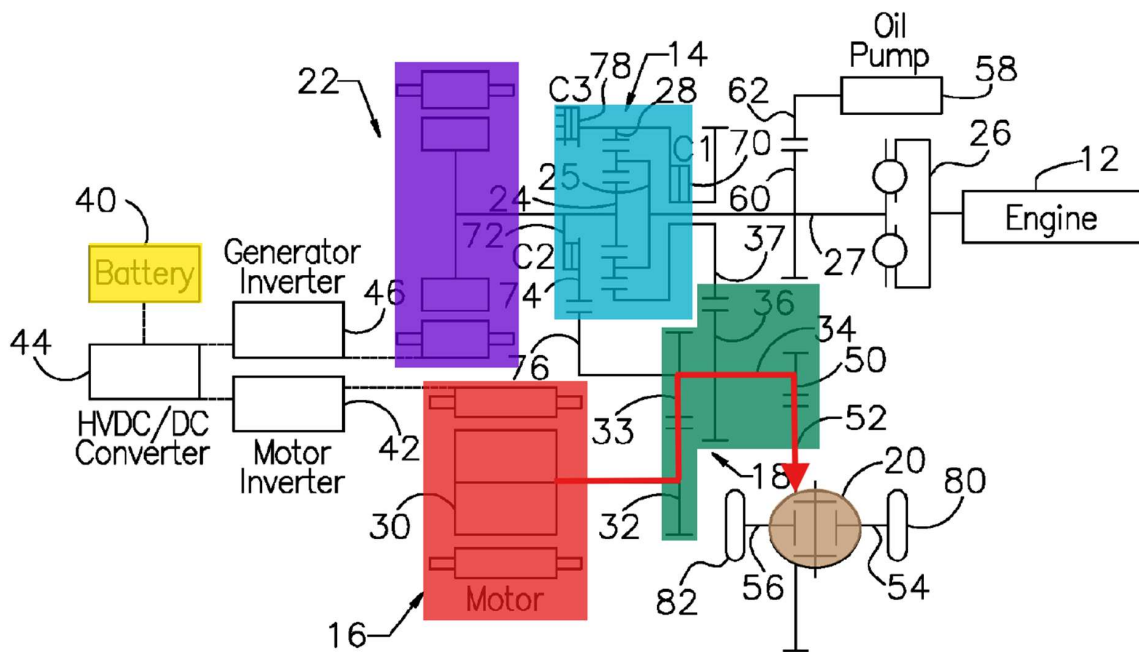


Fig. 4

395. Therefore, limitation 16[e] is disclosed by Ortmann.

*Limitation 16[f]: an internal combustion engine coupled to the transmission device;*

396. Ortmann discloses an internal combustion engine coupled to the transmission device. EX1008, ¶¶ 0019, 0020. In Figure 1, “[t]he carrier 25 of the planetary gearset 14 [transmission device] is connected to the engine 12 [shown in gray] through a torsion damper 26 and shaft 27.” *Id.*, ¶ 0020.

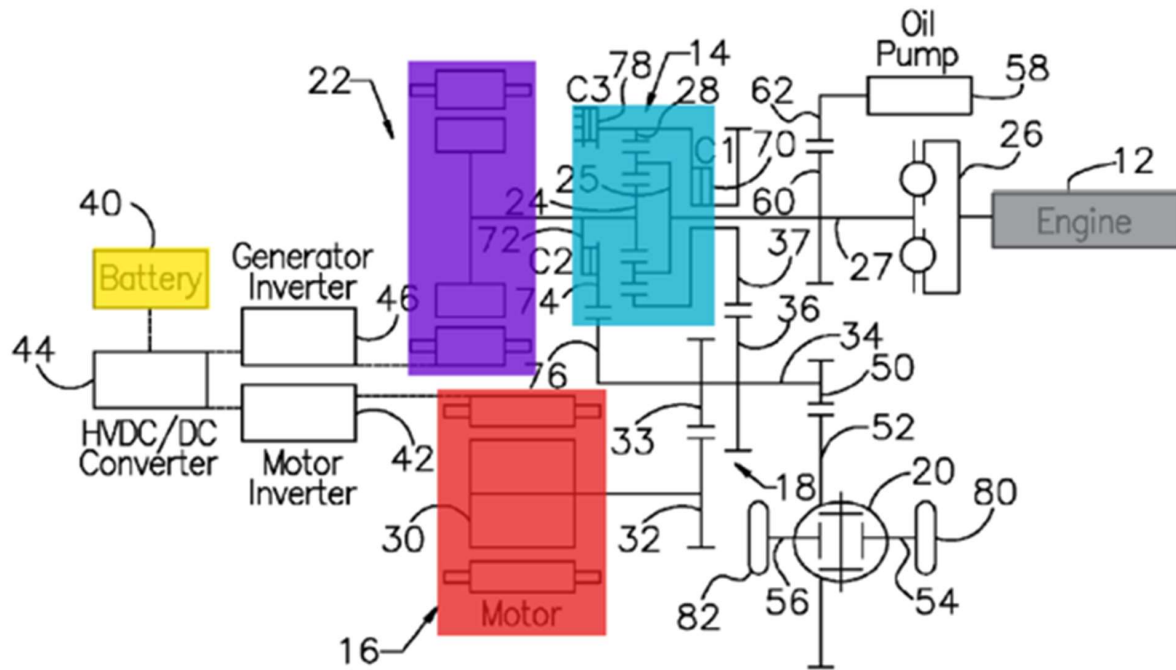


Fig. 4

397. Therefore, limitation 16[f] is disclosed by Ortmann.

*Limitation 16[g]: a control system configured to selectively:*

398. Ortmann's powertrain is capable of operating in several modes: Mode 1 (one motor electric drive), Mode 2 (two motor electric drive), Mode 3 (series), Mode 4 (powersplit), and Modes 5 and 6 (direct drive). EX1008, ¶¶ 0029-0035. Ortmann necessarily teaches a control system for switching the powertrain among these modes. A POSITA would have understood that a control system is required to monitor operating conditions such as vehicle speed, motor speed, speed ratio, and power supplied from the battery. In addition, a POSITA would have understood that

a control system is required to engage and disengage clutches C1, C2, and C3 as needed to shift the powertrain between respective modes (Fig. 5). Accordingly, Ortmann inherently discloses the claimed control system.

399. Therefore, limitation 16[g] is disclosed by Ortmann.

*Limitation 16[g][i]: operate the first electric motor and second electric motor to drive the vehicle through the transmission device and gear assembly, respectively;*

400. Mode 2 of Ortmann is two motor electric drive. EX1008, ¶ 0030. “When clutch 72 is engaged, and both clutch 72 and brake 78 are disengaged, generator 22 is connected to the countershaft 34 and drives the vehicle wheels 80, 82 through clutch 72, layshaft gears 74-76, countershaft 34, layshaft gears 50-52, and differential 20.” *Id.* “Mode 2 is used during electric drive (sometimes called charge depletion) to provide extra power and torque under conditions of high torque demand.” *Id.* As explained above, clutch 72 (C2) connects and disconnects the flow of power from the motor and is part of the transmission device. Thus, in this mode, when the power from first motor-generator 22 is transmitted to clutch 72, it is transmitted through the transmission device. *Id.*, ¶ 0026, Figs. 4-5. Therefore, motor-generator 22 drives the vehicle through (clutch 72 of) the transmission device, and motor-generator 16 drives the vehicle through layshaft gearing 18 (gear assembly), as shown by the red arrows in annotated Figure 4.

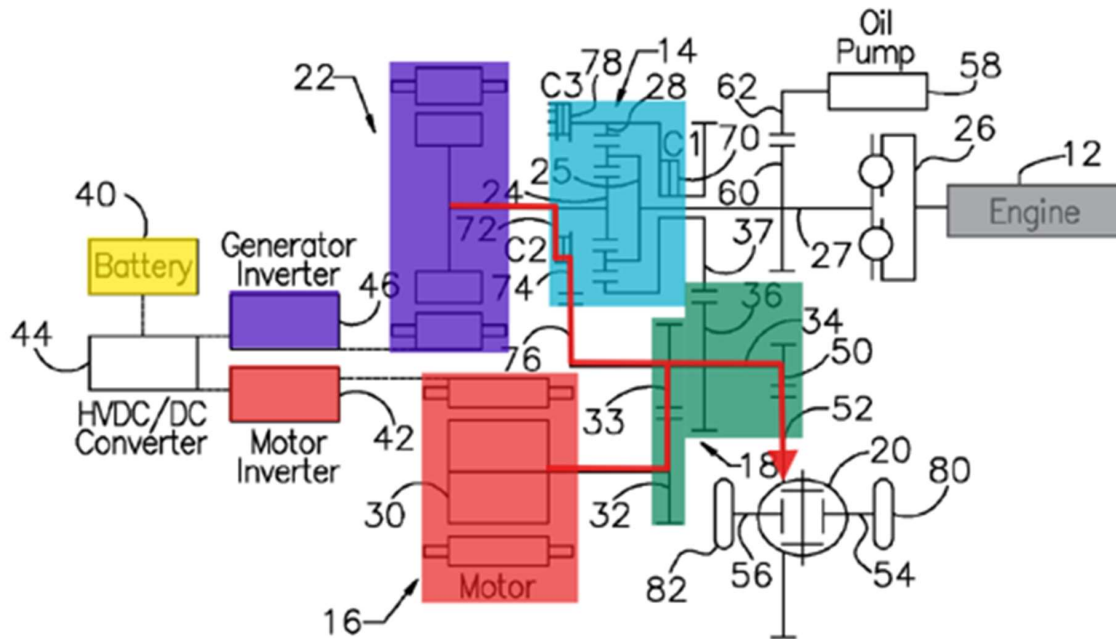


Fig. 4

401. Alternatively, Ortmann discloses Mode 5 as one of the two modes of direct drive. *Id.*, ¶¶ 0034-0036. “In mode 5, clutches 70, 72 are engaged and brake 78 is disengaged.” *Id.*, ¶ 0034. Ortmann discloses two states for Mode 5. The **first state** refers to vehicle driving during **towing conditions**: “In modes 5 and 6, both generator 22 and traction motor 16 can be turned off so that no traction power is transferred into the electrical domain. . . . The direct drive modes provide a benefit in that they produce less heat while towing a load. These modes improve the tow/payload capability of the powersplit powertrain 70.” *Id.*, ¶ 0035. The **second state** refers to vehicle **launch condition** where high torque is required: “If the torque capacity of clutch 72 is sufficient to transmit vehicle launch torque, the engine 12

can be used to aid in the launch of the vehicle *along with the two motors 16, 22*, so that under wheel high torque demand, full engine and battery power are used to drive the wheels during a launch condition.” *Id.*, ¶ 0036 (emphasis added). The launch condition refers to the transition of a vehicle from a stationary position to forward motion (0 mph to a low-speed threshold). This is a demanding operating state for a powertrain because it must overcome the vehicle’s static inertia and rolling resistance.

402. According to Ortmann, in this second state, the engine (12) and both electric motors (16, 22) can be turned on and provide power to support the required high torque demand for the launch condition. In other words, in this second state, when high torque is required to drive the wheels, both electric motors (16, 22) can operate in motoring mode rather than as generators. This Three-Torque Source-Launch (3TL) configuration maximizes available wheel torque, which can be critical during high-load launch conditions (*e.g.*, launch scenarios, including uphill gradients and trailer towing).

403. The 3TL state can occur during Ortmann’s Mode 5 (*i.e.*, Direct Drive 1). In this mode, both clutch 70 (C1) and clutch 72 (C2) are engaged and brake C3 is disengaged. *Id.*, Fig. 5. To this end, in Mode 5 during the 3TL state, the engine power is transmitted to planet carrier 25, power from electric machine 22 is transmitted to the sun gear 24, and power from electric machine 16 is transmitted to

layshaft gear 32. During the 3TL state, planetary gear set 14 has two inputs and one output, as shown in the following annotated Figure 4. The input power ports to the transmission device (shown with red arrows) are from engine 12 and electric motor 22, and the output power port (shown with a yellow arrow) is the ring gear 28 that transfers the power from the sun gear (*i.e.*, motor 22) and planet carrier (*i.e.*, engine 12) to the wheels via clutch 70 and layshaft gears 36, 37. The output from second motor 16 driving the wheels through layshaft gearing 18 (gear assembly) is also shown with a red arrow.

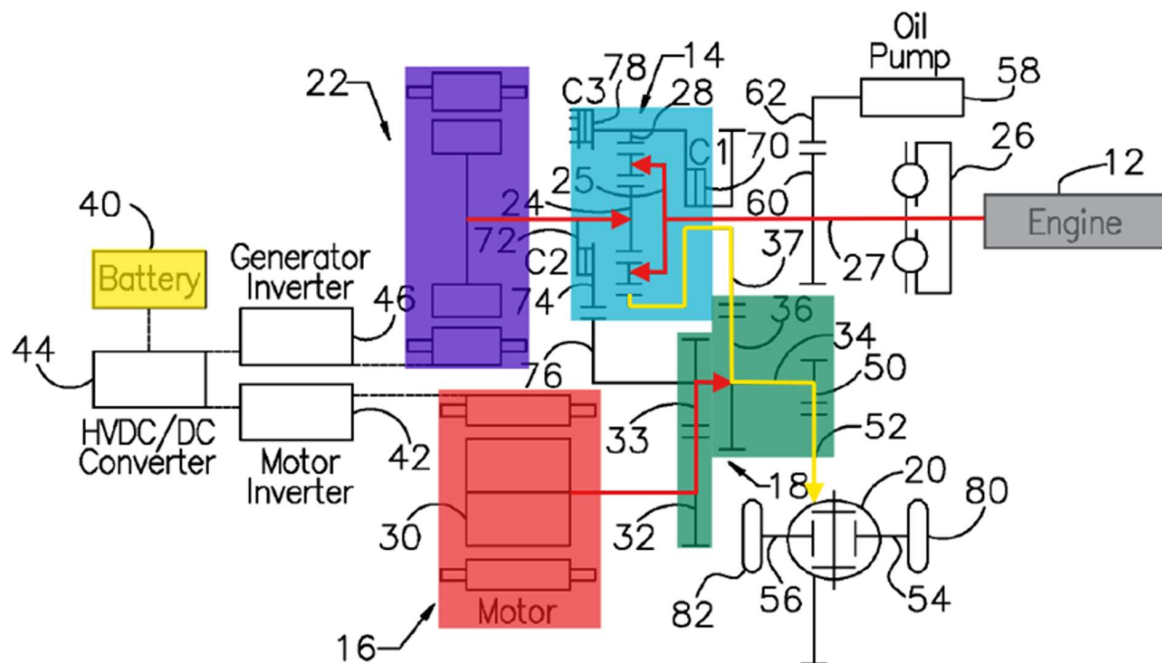


Fig. 4

404. The power flow that may be required to support high torque demands during vehicle launch is further detailed below. As illustrated in the following figure,

power from electric motor 22 is transmitted via two distinct paths originating from the (unenumerated) shaft connecting motor 22 to sun gear 24:

- Path I (shown in yellow): Power is transmitted through the planetary gear set 14 and clutch 70 (C1) to the 37/36 gear pair, which then drives countershaft 34.
- Path II (shown in blue): Power is routed through clutch 72 (C2) to pinion 74, which meshes with gear 76 (secured to countershaft 34).

Both paths converge at countershaft 34 to provide maximum torque during the launch sequence.

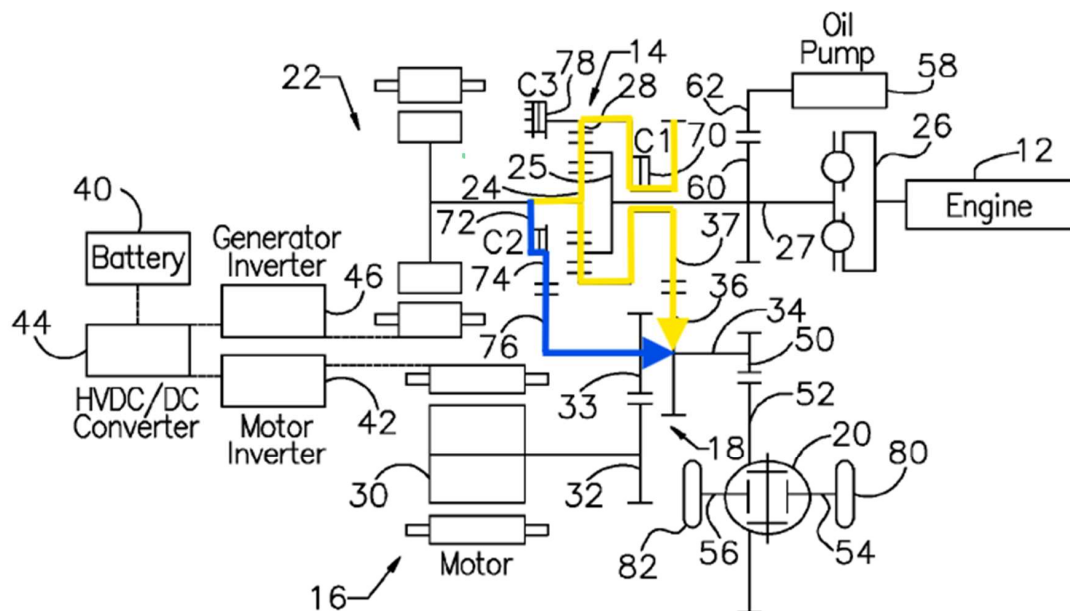


Fig. 4

405. The power flow from electric motor 16 is separately illustrated in red below. Collectively, engine 12 and electric motors 16, 22 drive countershaft 34. This shaft powers layshaft gears 50, 52 connected to the differential 20, ultimately transmitting high torque to the wheels 80, 82 via the axle shafts 54, 56.

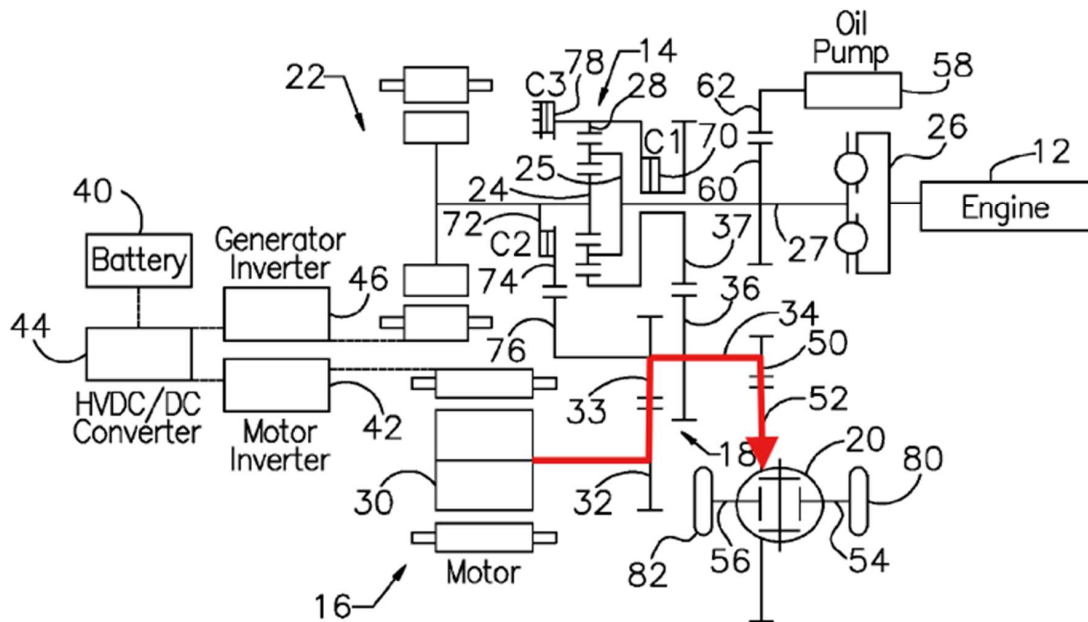


Fig. 4

406. Accordingly, the first motor/generator 22 can also drive the vehicle through the transmission device in Mode 5.

407. Therefore, limitation 16[g][i] is disclosed by Ortmann.

*Limitation 16[g][ii]: operate the first electric motor as a generator to generate electrical power while operating the second electric motor to drive the vehicle through the gear assembly;*

408. Ortmann is capable of operating in Mode 3 (series). EX1008, ¶ 0031.

“When brake 78 is engaged and clutches 70, 72 are disengaged; generator 22 is driven through the planetary gearset 14 at about two to three times engine speed with brake 78 due to brake 78 grounding the ring gear 28 and providing a torque reaction.” *Id.* “The traction motor 16 is connected directly to the wheels 80, 82 to provide propulsion.” *Id.* Thus, motor-generator 22 generates electrical power and motor-generator 16 drives the vehicle through layshaft gearing 18 (gear assembly).

409. Therefore, limitation 16[g][ii] is disclosed by Ortmann.

*Limitation 16[g][iii]: operate the second electric motor as a generator to generate electrical power.*

410. Ortmann discloses that “[e]ach electric machine 16, 22 is a motor-generator, although conventionally electric machine 16 is referred to as a motor or traction motor, and electric machine 22 is referred to as a generator.” EX1008, ¶¶ 0019. Thus, the electric machine 22 can act as a traction motor or a generator. For instance, in Mode 1 (one motor electric drive) or Mode 2 (two motor electric drive), the electric machine 16 acts as a traction motor. *Id.*, ¶¶ 0029-0030. But during braking, ***the electric machine 16 acts as a generator***, and in fact it is the “main” electric machine to capture regenerative braking energy. This is because the electric

machine 16 is connected directly to the wheels (final drive). *Id.*, ¶¶ 0019, 0029, 0031. In braking mode, electric machine 16 functions as the primary load (braking force). The engine is disconnected and deactivated to prevent parasitic loss, allowing for maximum capture of regenerative braking energy. The electric machine 16 produces AC electricity that is sent to the motor inverter 42, which converts it to DC and pushes it to the high-voltage battery 40 after passing through DC/DC converter 44.

411. Therefore, limitation 16[g][iii] is disclosed by Ortmann.

**O. Dependent Claim 17**

*17. The system of claim 16, further comprising a DC/DC converter coupled to the energy storage device.*

412. As explained above, Ortmann discloses all the limitations of claim 16.

413. Ortmann also discloses DC/DC converter 44 coupled to battery 40.

EX1008, ¶ 0021, Figs. 1, 4.

414. Therefore, the limitations of claim 17 are disclosed by Ortmann.

**P. Dependent Claim 18**

*18. The system of claim 16, further comprising a wheel/axle assembly coupled to the gear assembly.*

415. As explained above, Ortmann discloses all the limitations of claim 16.

416. Ortmann also discloses wheels 80, 82 and axle shafts 54, 56 coupled to layshaft gearing 18 (gear assembly) through countershaft 34, pinion 50, ring gear 52, and differential mechanism 20. EX1008, ¶¶ 0019, 0022, 0029-0031, Fig. 4.

417. Therefore, the limitations of claim 18 are disclosed by Ortmann.

**Q. Dependent Claim 19**

*19. The system of claim 16, wherein the electrical power generated by the first electric motor is provided to the second electric motor.*

418. As explained above, Ortmann discloses all the limitations of claim 16.

419. Ortmann discloses Mode 3 (series): “When brake 78 is engaged and clutches 70, 72 are disengaged; generator 22 is driven through the planetary gearset 14 at about two to three times engine speed with brake 78 due to brake 78 grounding the ring gear 28 and providing a torque reaction. The traction motor 16 is connected directly to the wheels 80, 82 to provide propulsion.” EX1008, ¶ 0031. “Mode 3 allows full torque to the wheels from the traction motor 16 . . . .” *Id.* Thus, in Mode 3, engine 12 is not connected to the wheels (because clutch 70 (C2) is disengaged) and instead the engine powers motor-generator 22, which charges battery 40, and then electric power from the battery is transmitted to traction motor 16 to propel the vehicle. All this occurs simultaneously, and electric power generated by motor-generator 22 is provided to motor-generator 16.

420. Therefore, the limitations of claim 19 are disclosed by Ortmann.

**R. Dependent Claim 20**

*20. The system of claim 16, wherein the electrical power generated by the second electric motor is provided to the energy storage system.*

421. Ortmann discloses that “[e]ach electric machine 16, 22 is a motor-generator, although conventionally electric machine 16 is referred to as a motor or traction motor, and electric machine 22 is referred to as a generator.” EX1008, ¶¶ 0019. Thus, the electric machine 22 can act as a traction motor or a generator. For instance, in Mode 1 (one motor electric drive) or Mode 2 (two motor electric drive), the electric machine 16 acts as a traction motor. *Id.*, ¶¶ 0029-0030. But during braking, the electric machine 16 acts as a generator, and in fact it is the “main” electric machine to capture regenerative braking energy. This is because the electric machine 16 is connected directly to the wheels (final drive). *Id.*, ¶¶ 0019, 0029, 0031. In braking mode, electric machine 16 functions as the primary load (braking force). The engine is disconnected and deactivated to prevent parasitic loss, allowing for maximum capture of regenerative braking energy. The electric machine 16 produces AC electricity that is sent to the motor inverter 42, which converts it to DC and pushes it to the high-voltage battery 40 after passing through DC/DC converter 44.

422. Therefore, the limitations of claim 20 are disclosed by Ortmann.

**XI. GROUND 5: CLAIMS 3 AND 11 ARE OBVIOUS OVER ORTMANN**

423. The subject matter of claims 3 and 11 would have been obvious to a POSITA based on the teachings of Ortmann.

**A. Dependent Claim 3**

*3. The system of claim 2, further comprising a second energy storage system coupled to the DC/DC converter.*

424. As explained above in Ground 4, Ortmann discloses all the limitations of claim 2.

425. It would have been obvious to a POSITA to modify Ortmann by including a second battery coupled to the DC-DC converter. Use of two energy storage systems (*i.e.*, batteries) was common in HEVs and PHEVs before 2014. Some examples include model year (MY) 1997 Toyota Prius (Gen 1), MY 1999 Honda Insight (Gen 1), MY 2003 Honda Civic Hybrid (Gen 1), MY 2004 Toyota Prius (Gen 2), MY 2004 Ford Escape Hybrid, MY 2006 Saturn Vue Green Line, MY 2007 Nissan Altima Hybrid, and MY 2011 Chevrolet Volt (Gen 1). These vehicles include a high-voltage (HV) battery (*e.g.*, 200 V to 700 V), and a low-voltage (LV) battery (*e.g.*, 12 V to 14 V). The HV battery is used for vehicle propulsion, while the LV battery is used to power the accessories in the vehicle. This dual-battery system is advantageous over a single-battery system, due to i) improved safety and isolation of functions, ii) component compatibility since many parts (headlights, wipers, airbag, power windows, door locks, etc.) are standardized to run on 12 V, and expecting them to run on high voltage (*e.g.*, 400 V) would require expensive and custom step-down converters for every single component, and iii) higher reliability to support “fail-safe” for critical non-propulsion systems. A DC-DC converter is also

commonly used between these two batteries (*e.g.*, the HV battery charges the LV battery). A POSITA would have been motivated to include a second energy storage system coupled to the DC-DC converter to provide power for auxiliary applications such as heating, cooling, and cabin accessories that run on lower voltage and which were common in EV and HEV vehicles in 2014. Incorporating a second energy storage system in Ortmann would yield predictable results, and a POSITA would have had a reasonable expectation of success in doing so.

426. For at least these reasons, claim 3 is obvious over Ortmann.

**B. Dependent Claim 11**

*11. The system of claim 10, further comprising a second energy storage system coupled to the DC/DC converter.*

427. As explained above in Ground 4, Ortmann discloses all the limitations of claim 10.

428. It would have been obvious to a POSITA to modify Ortmann by including a second battery coupled to the DC-DC converter. Use of two energy storage systems (*i.e.*, batteries) was common in HEVs and PHEVs before 2014. Some examples include model year (MY) 1997 Toyota Prius (Gen 1), MY 1999 Honda Insight (Gen 1), MY 2003 Honda Civic Hybrid (Gen 1), MY 2004 Toyota Prius (Gen 2), MY 2004 Ford Escape Hybrid, MY 2006 Saturn Vue Green Line, MY 2007 Nissan Altima Hybrid, and MY 2011 Chevrolet Volt (Gen 1). These vehicles

include a high-voltage (HV) battery (*e.g.*, 200 V to 700 V), and a low-voltage (LV) battery (*e.g.*, 12 V to 14 V). The HV battery is used for vehicle propulsion, while the LV battery is used to power the accessories in the vehicle. This dual-battery system is advantageous over a single-battery system, due to i) improved safety and isolation of functions, ii) component compatibility since many parts (headlights, wipers, airbag, power windows, door locks, etc.) are standardized to run on 12 V, and expecting them to run on high voltage (*e.g.*, 400 V) would require expensive and custom step-down converters for every single component, and iii) higher reliability to support “fail-safe” for critical non-propulsion systems. A DC-DC converter is also commonly used between these two batteries (*e.g.*, the HV battery charges the LV battery). A POSITA would have been motivated to include a second energy storage system coupled to the DC-DC converter to provide power for auxiliary applications such as heating, cooling, and cabin accessories that run on lower voltage and which were common in EV and HEV vehicles in 2014. Incorporating a second energy storage system in Ortmann would yield predictable results, and a POSITA would have had a reasonable expectation of success in doing so.

429. For at least these reasons, claim 11 is obvious over Ortmann.

## **XII. CONCLUSION**

430. For the reasons set forth above, claims 1-20 of the '648 Patent are unpatentable in view of the prior art.

431. In signing this declaration, I recognize that it will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the USPTO. I also recognize that I may be subject to cross-examination in the case. If cross-examination is required of me, I will appear at the allotted time.

432. I reserve the right to supplement my opinions in the future to respond to any arguments that the Patent Owner raises and to consider new information as it becomes available to me.

433. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Date: February 3, 2026



---

Mahdi Shahbakhti, Ph.D.