

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re *Inter Partes* Review of:)
U.S. Patent No. 8,466,654)
Issued: Jun. 18, 2013)
Application No.: 12/498,159)
Filing Date: Jul. 6, 2009)

For: **Wireless High Power Transfer Under Regulatory Constraints**

**DECLARATION OF DR. MARK ALLEN IN SUPPORT OF
PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 8,466,654**

Table of Contents

I.	Introduction	4
II.	Background and Qualifications.....	5
III.	Summary Of Materials Reviewed And Considered	9
IV.	Summary of Opinions	11
V.	Understanding of Legal Principles.....	11
A.	Understanding of Legal Principles Relevant to Anticipation and Obviousness	11
B.	Person of Ordinary Skill in the Art.....	15
VI.	Overview Of The '654 Patent And Background	17
A.	The '654 Patent (Ex. 1001).....	17
B.	The Challenged Claims.....	23
C.	Prosecution History	25
VII.	Claim Construction	26
VIII.	Overview of the Prior Art	26
A.	Odachi (Ex. 1005).....	26
B.	Wang (Ex. 1008).....	34
C.	Partovi (Ex. 1006).....	38
D.	Ross (Ex. 1007).....	39
IX.	Ground 1a: Claims 13 and 15 Would Have Been Unpatentable Over Odachi	44
A.	Independent Claim 13	44
1.	Claim Element 13[pre]: Preamble.....	44
2.	Claim Element 13[a]: Guiding a Receiving Antenna into a First Alignment Position	44
3.	Claim Element 13[b]: Moving the antenna to improve alignment	48
B.	Claim 15: Moving Transmitting Antenna Laterally	58

X.	Ground 1b: Claims 1, 7, and 18 are Unpatentable Over Odachi and Wang	59
A.	Claim 1	59
1.	Claim Element 1[pre]: Preamble	60
2.	Claim Element 1[a]: Transmitting Antenna	65
3.	Claim Element 1[b]: Charging Control System	75
4.	Claim Element 1[c]: Alignment Controller	79
B.	Claim 7: Transmitting Power	82
C.	Claim 18: Measuring Power	83
XI.	Ground 1c: Claims 4-6 Are Unpatentable Over Odachi, Wang and Partovi	85
A.	Claim 4: Antenna Array	85
B.	Claims 5-6: Antenna Selection and Switch	94
XII.	Ground 2: Claims 8-10, 12-14, 16 and 19 are unpatentable over Ross, alone or in view of Wang	97
A.	Independent Claim 13	98
1.	Claim Element 13[pre]: Preamble	98
2.	Claim Element 13[a]: Guiding a Receiving Antenna into a First Alignment Position	98
3.	Claim Element 13[b]: Moving antenna to improve alignment	102
B.	Claim 14: Moving Receiving Antenna Laterally	106
C.	Claim 16: Moving Receiving Antenna Perpendicularly	107
D.	Independent Claim 8	109
1.	Claim Element 8[pre]: Preamble	109
2.	Claim Element 8[a]: Receiving Antenna	110
3.	Claim Element 8[b]: Guidance Control System	118
4.	Claim Element 8[c]: Lifting Device	119
5.	Claim Element 8[d]: Alignment Controller	120
E.	Claim 9: X-Y Axis Alignment Control	123
F.	Claim 10: Magnetically Induced Signal Circuitry	129
G.	Claim 12: Battery Operated Vehicle	131
H.	Claim 19: Measurement of Power	132
XIII.	Conclusion	133

I. Introduction

1. I have been retained as an expert witness on behalf of InductEV, Inc. (“InductEV” or “Petitioner”) in the above-captioned *inter partes* review (“IPR”) relating to U.S. Patent No. 8,466,654 (Ex. 1001). The ’654 patent relates to systems that transfer energy from a transmitting antenna to a receiving antenna, and move one or both antennas to “align[]” them for better “coupling.” *See, e.g.*, ’654 patent, claims 1, 8, 13.

2. I understand that InductEV is petitioning for IPR of claims 1, 4-10, 12-16, and 18-19 of the ’654 patent and requests that the United States Patent and Trademark Office (“PTO”) cancel those claims.

3. In preparing this Declaration, I have reviewed the ’654 patent and considered the documents identified in Section III in light of the general knowledge in the relevant art. In forming my opinions, I relied on my education, knowledge, and experience (including my extensive research and development experience with wireless power transfer) and considered the level of ordinary skill in the art as discussed below.

4. I am being compensated for my time in connection with this IPR at my standard consulting rate, which is \$625.00 per hour, plus actual expenses. My compensation is not dependent in any way upon the outcome of this matter.

II. Background and Qualifications

5. I received a B.A. degree in Chemistry, a B.S.E. degree in Chemical Engineering, and a B.S.E. degree in Electrical Engineering from the University of Pennsylvania, and a S.M. and Ph.D. in Chemical Engineering/Microelectronics (1989) from the Massachusetts Institute of Technology. From 1989 to 2013, I was a member of the faculty of the School of Electrical and Computer Engineering of the Georgia Institute of Technology, ultimately holding the rank of Regents' Professor and the J.M. Pettit Professorship in Microelectronics. In 2013, I joined the University of Pennsylvania faculty as the Alfred Fitler Moore Professor of Electrical and Systems Engineering, and was named the founding director of the Singh Center for Nanotechnology at Penn.

6. As discussed below, my technical expertise is in microelectromechanical systems (MEMS), microfabrication technologies for MEMS, and the application of MEMS in multiple fields. A particular research interest area of mine is the application of microfabrication technologies to magnetics, including magnetoquasistatic problems such as those inherent in near-field wireless power transfer based on magnetic field coupling.

7. At the beginning of my academic career in 1989, I founded my research group, the Microsensors and Microactuators Group. This group, consisting of graduate students and postdoctoral associates of both the Georgia

Institute of Technology and the University of Pennsylvania, has been in continuous existence since that time. Although the composition as well as the specific research topics of the group have changed over time, the group has maintained a focus since its founding on the development of new microfabrication technologies and their application to MEMS.

8. In 1990 I began a project on integrated magnetics with my first Ph.D. student. Our group has continuously worked on magnetics projects since then, with applications including magnetic energy storage and conversion, inductors and transformers, magnetically driven relays, magnetic generators, permanent magnets, magnetic sensors, and wireless power transfer based on magnetic coupling.

9. In 1994 my student and I gave a plenary address to the IEEE Applied Power Electronics Conference and Exposition on the topic of micromachined inductors.

10. Over the past three decades, our group has published its work on magnetics in multiple IEEE journals, including the IEEE Journal of Microelectromechanical Systems, IEEE Transactions on Magnetics, IEEE Magnetics Letters, and IEEE Transactions on Power Electronics.

11. I am co-founder of multiple MEMS-related companies, including CardioMEMS, Axion Biosystems, and EnaChip.

12. CardioMEMS was founded in 2001 and has commercialized wireless implantable microsensors for treatment of aneurysms and congestive heart failure – ultimately becoming the first MEMS-based medical device transducer FDA-approved for permanent human implantation. CardioMEMS received the 2006 Company of the Year award from Small Times magazine and the 2006 Frost and Sullivan Patient Monitoring Product Innovation of the Year Award, and its wireless aneurysm pressure monitor was highlighted by the FDA in its 2005 ODE annual report as a cleared medical device likely to have a significant impact on patient care. CardioMEMS completed a 550-patient clinical trial for its second product, a MEMS-based wireless implantable hemodynamic monitor for patients with congestive heart failure. After receiving FDA approval for its hemodynamic monitor, CardioMEMS was acquired by St. Jude Medical (now Abbott) in 2014.

13. The CardioMEMS wireless pressure sensor relies on near-field magnetic coupling between a source coil and a sensor coil, as detailed in U.S. Patents 6,111,520 and 7,245,117, among others, of which I am a co-author.

14. EnaChip was launched in 2017 and is focused on exploiting electroplatable, nanoengineered materials for the realization of ultracompact power supplies. In particular, Enachip is using these nanoengineered materials as the magnetic core of integrated inductors to produce multiwatt power supplies on a chip.

15. I have graduated approximately 50 PhD students and approximately 24 postdoctoral associates from the MSMA Group in the field of MEMS. Together with this group, I have published approximately 400 technical articles in the field of MEMS. I hold approximately sixty U.S. patents in the MEMS area.

16. The work of my research group has been cited approximately 31,000 times as estimated by Google Scholar.

17. In addition to the above, I have maintained my leadership position within the MEMS community. I was co-chair of the 2012 Power MEMS Conference, and chair of the 2016 Solid State Sensors, Actuators, and Microsystems Conference ('Hilton Head'). In 2021 I chaired the IEEE PwrSoC ('Power Supply on a Chip') conference, sponsored in part by the IEEE Power Electronics Society.

18. I am a Fellow of the IEEE, with the citation "for contributions to micro and nanofabrication technologies for microelectromechanical systems."

19. I received the 2016 IEEE Daniel P. Noble award in emerging technologies, with the citation "For contributions to research and development, clinical translation, and commercialization of biomedical microsystems."

20. I was elected to the U.S. National Academy of Inventors in 2017.

21. I was elected to the U.S. National Academy of Engineering in 2023.

22. Additional details are provided in my CV, attached as Ex. 1004.

III. Summary Of Materials Reviewed And Considered

23. In addition to the information identified above (e.g., ¶ 3) and elsewhere in this Declaration, in forming my opinions, I have considered these documents:

Ex.	Description
1001	U.S. Patent No. 8,466,654 B2 (“’654 patent”)
1002	File History for U.S. Patent No. 8,466,654 B2 (“’654 FH”)
1005	U.S. Patent No. 5,617,003 (“Odachi”)
1006	U.S. Patent No. 7,952,322 B2 (“Partovi”)
1007	U.S. Patent No. 5,669,470 (“Ross”)
1008	Chwei-Sen Wang, <i>Design Considerations for Inductively Coupled Power Transfer Systems</i> (2004) (Ph.D. dissertation, University of Auckland) (“Wang”)
1009	U.S. Patent No. 5,821,638 (“Boys-638”)
1012	U.S. Patent No. 9,774,086 B2 (“Cook-086”)
1013	U.S. Patent Application Publication No. 2010/0231163 A1 (“Mashinsky”)
1014	Malik Elsammany Elbuluk, <i>Resonant Converters: Topologies, Dynamic Modeling and Control</i> (Sept. 22, 1986) (D.Sc. dissertation, Massachusetts Institute of Technology) (“Elbuluk”)
1015	U.S. Patent No. 8,159,183 B2 (“Choi”)
1016	U.S. Patent Application Publication No. 2007/0182367 A1 (“Partovi App.”)
1017	O.H. Stielau & G.A. Covic, <i>Design of Loosely Coupled Inductive Power Transfer Systems</i> , Proceedings of the PowerCon 2000 International Conference on Power System Technology, vol. 1 (Dec. 2000), 85-90 (“Stielau”)

Declaration for *Inter Partes* Review of USP 8,466,654

Ex.	Description
1018	RESERVED
1019	A.W. Green & J.T. Boys, <i>10kHz Inductively Coupled Power Transfer – Concept and Control</i> , Power Electronics and Variable-Speed Drives, Conf. Pub. No. 399 (IEE, Oct. 26-28, 1994), 694-699 (“Green”)
1020	Aiguo Patrick Hu, <i>Selected Resonant Converters for IPT Power Supplies</i> (Oct. 2001) (Ph.D. dissertation, University of Auckland) (“Hu”)
1021	Byung-Song Lee & Kyung-Hee Han, <i>Modeling and Analysis of IPT System Used for PRT</i> , Proceedings of the Eighth International Conference on Electrical Machines and Systems – ICEMS 2005, vol. 1 (ICEMS, Sept. 27-29, 2005), 839-842 (“Lee”)
1022	RESERVED
1023	RESERVED
1024	Excerpts from James W. Nilsson & Susan A. Riedel, <i>Electrical Circuits</i> (8th ed. 2008) (“Nilsson”)
1025	Chwei-Sen Wang, et al., <i>Investigating an LCL Load Resonant Inverter for Inductive Power Transfer Applications</i> , IEEE Transactions on Power Electronics, vol. 19, no. 4 (IEEE, July 2004), 995-1002 (“Wang-IEEE”)
1026	<i>Horizontal</i> , Collins English Dictionary, https://www.collinsdictionary.com/us/dictionary/english/horizontal (last visited Nov. 3, 2023)
1027	<i>Horizontal</i> , Cambridge English Dictionary, https://dictionary.cambridge.org/us/dictionary/english/horizontal (last visited Nov. 3, 2023)
1028	<i>Horizontal</i> , The Britannica Dictionary, https://www.britannica.com/dictionary/horizontal (last visited Nov. 3, 2023)

24. My opinions are also guided by my appreciation of how a person of ordinary skill in the art would have understood the claims of the '654 patent at the time of the alleged invention, which I have been asked to assume is July 8, 2008, as I explain in Section V(B) below.

IV. Summary of Opinions

25. As further detailed below, my opinions is that the prior art teaches or renders obvious every element of claims 1, 4-10, 12-16, and 18-19 of the '654 patent, as arranged in the claims, as follows:

- 1a.** Odachi teaches claims 13 and 15
- 1b.** Odachi in combination with Wang renders obvious claims 1, 7 and 18
- 1c.** Odachi in combination with Wang and Partovi renders obvious claims 4-6.
- 2.** Ross in combination with Wang renders obvious claims 8-10, 12-14, 16, and 19.

V. Understanding of Legal Principles

A. Understanding of Legal Principles Relevant to Anticipation and Obviousness

26. I understand that a prior art reference can anticipate a patent claim when the prior art's disclosure renders the recited claim elements not novel. I understand that in order to anticipate a patent claim, a prior art reference must teach

each and every element of the claim, expressly or inherently, with the same arrangement as in the claims.

27. In analyzing anticipation, I understand that it is important to consider the scope of the claims, the level of skill in the relevant art, and the scope and content of the prior art.

28. I understand that a prior art reference or combination of prior art references can render a patent claim obvious to one of ordinary skill in the art if the differences between the subject matter set forth in the patent claim and the prior art are such that the subject matter of the claim would have been obvious at the time the claimed invention was made.

29. I understand that the obviousness inquiry typically requires an analysis of whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue. I understand that there should be some kind of motivation so that one would understand why a person of ordinary skill would have thought of either combining two or more references or modifying one to achieve the patented invention.

30. I understand that when a POSA would be motivated to combine two references, the test for obviousness does not require that the features of a secondary reference be bodily incorporated into the structure of the primary reference. Put another way, I understand that a determination of obviousness based on teachings

from multiple references does not require an actual, physical substitution of elements. Rather, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art.

31. In addition, there is no requirement that a combination only unite old elements without changing their respective functions. Rather, I understand that the obviousness framework permits, for example, modifying one reference and combining it with a second reference.

32. I understand that obviousness does not require absolute predictability of success when modifying or combining prior art elements. Rather, all that is required is a reasonable expectation of success.

33. I further understand that in an obviousness analysis, a reference is considered prior art whether or not it is enabled. Prior art patents and publications are presumed enabled, however, and a party challenging enablement of the prior art may only overcome that presumption with evidence that the practice of the invention would have required undue experimentation. The presumption of enablement in prior art patents applies to both the claimed and unclaimed disclosures.

34. In analyzing obviousness, I understand that it is important to consider the scope of the claims, the level of skill in the relevant art, the scope, and content

of the prior art, the differences between the prior art and the claims, and any secondary considerations.

35. I understand that when the claimed subject matter involves combining pre-existing elements to yield no more than one would expect from such an arrangement, the combination is obvious. I also understand that in assessing whether a claim is obvious one must consider whether the claimed improvement is more than the predictable use of prior art elements according to their established functions. I understand that there need not be a precise teaching in the prior art directed to the specific subject matter of a claim because one can consider the inferences and creative steps that a person of skill in the art would employ. I further understand that a person of ordinary skill is a person of ordinary creativity, not an automaton.

36. I understand that obviousness cannot be based on the hindsight combination of components selectively culled from the prior art. I understand that in an obviousness analysis, neither the motivation nor the avowed purpose of the inventors controls the inquiry. Any need or problem known in the field at the time of the invention and addressed by the patent can provide a reason for combining elements, even if that reason is different from the reason(s) that subjectively led the inventor to make its claimed combination. For example, I understand that it is important to consider whether there existed at the time of the invention a known

problem for which there was an obvious solution encompassed by the patent's claims. I understand that known techniques can have obvious uses beyond their primary purposes, and that in many cases a person of ordinary skill can fit the teachings of multiple pieces of prior art together like pieces of a puzzle.

37. I understand that, when there is a reason to solve a problem and there is a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue the known options within his or her technical grasp. I further understand that, if this leads to the anticipated success, it is likely the product not of innovation but of ordinary skill and common sense, which bears on whether the claim would have been obvious.

38. I understand that secondary considerations can include, for example, evidence of commercial success of the invention, evidence of a long-felt need that was solved by an invention, evidence that others copied an invention, or evidence that an invention achieved a surprising or unexpected result. I further understand that such evidence must have a nexus, or causal relationship to the elements of a claim, in order to be relevant. I am unaware of any such secondary considerations for the '654 patent. To the extent that Patent Owner puts forth any secondary considerations in these IPRs, I reserve the right to rebut those considerations with rebuttal evidence.

B. Person of Ordinary Skill in the Art

39. I understand that a person of ordinary skill in the art (“POSA”) is a hypothetical person who is presumed to be aware of all pertinent art, possesses conventional wisdom in the art, is a person of ordinary creativity, and has common sense. I understand that this hypothetical person is considered to have the normal skills and knowledge of a person in a certain technical field (including knowledge of known problems and desired features in the field).

40. I have been asked to analyze the claims of the ’654 patent, and related prior art, from the perspective of such a person at the time of the alleged inventions. I understand that the ’654 patent was filed on July 6, 2009 and claims priority to a provisional applications filed on July 8, 2008.

41. It is my opinion that a person of ordinary skill in the art in the 2008 timeframe would have had at least a bachelor’s degree in electrical engineering, microelectronics (or equivalent) and at least two to three years of industry experience or equivalent research in the field of wireless energy transfer. This description is approximate, and a higher level of education or skill might make up for less experience, and vice-versa.

42. As of July 8, 2008, I would have qualified as at least a POSA, and my opinions are informed by my own knowledge based on my personal experiences and observing others of various skill levels (including those at, above and below the level of a POSA).

43. In this declaration, my opinions are informed by how a POSA would have understood the '654 patent and the prior art in the relevant time frame, which I have been asked to assume is July 2008. My opinions in this declaration apply that assumption, and reflect how a POSA would have viewed the '654 patent and the prior art in approximately July 2008, even where written in the present tense.

44. My opinions below are not restricted to the precise definition of a POSA above. The claims of the '654 patent are directed to antenna coupling and alignment systems that were well-known in the art and taught by numerous prior art references, including the references discussed below. Thus, my opinions below would apply under any reasonable definition of a POSA.

VI. Overview Of The '654 Patent And Background

A. The '654 Patent (Ex. 1001)

45. The '654 patent is titled “wireless high power transfer under regulatory constraints.” The patent describes a wireless power transfer system using a “transmitter” and a “receiver” that “couples to the radiated field” generated by the transmitter. '654 patent 2:10-25. The transmitter and receiver can be in “a mutual resonant relationship,” and can have the same “resonant frequency.” *Id.*

46. The '654 patent does not claim to have invented a new type of resonator or antenna. Instead, it states that the “antennas may be capacitively loaded wire loops or multi-turn coils.” '654 patent 1:15-30. Such a “loop antenna”

has “inductance created by the loop,” and “capacitance is generally added to the loop antenna’s inductance to create a resonant structure at a desired resonant frequency.” ’654 patent 3:24-42.

47. The ’654 patent also does not claim to have invented resonant power transfer. It explains, as a POSA would have known, that “magnetically resonant transfer of power between antennas” was already well known, such that “a resonant antenna ... effectively coupled energy from a primary structure (a transmitter) to a distal positioned secondary structure (a receiver) via a magnetic field.” ’654 patent 1:15-30.

48. The ’654 patent explains that its invention can be implemented with known components, such as “any conventional processor,” as shown below:

The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general purpose processor, a Digital Signal Processor (DSP), an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

'654 patent 7:9-24.

49. The '654 patent states that “efficient transfer of energy between the transmitter 104 and receiver 108 occurs during matched or nearly matched resonance” between the two, although “energy may be transferred at a lower efficiency” even when “not matched.” '654 patent 3:14-23. Energy is transferred from the transmitter to the receiver “by coupling energy from the near-field of the transmitting antenna to the receiving antenna residing in the neighborhood where this near-field is established.” '654 patent 3:14-23. The transmitter, also known as a “primary,” has a coil that transfers energy to the “receive coil,” also known as a “secondary.” '654 patent 5:20-34. Either coil can be made “resonan[t] at the operating frequency ... by adding an appropriate value high-Q capacitor.” '654 patent 5:40-45.

50. One embodiment of the '654 patent describes using this antenna arrangement to charge a “battery electric vehicle.” '654 patent 5:20-34. As shown below, a “primary coil 310 that delivers ... charging power to the vehicle may be completely buried into the soil of a parking lot at a position corresponding to whether the secondary coil 360 is likely to be on a vehicle.” '654 patent 5:46-56.

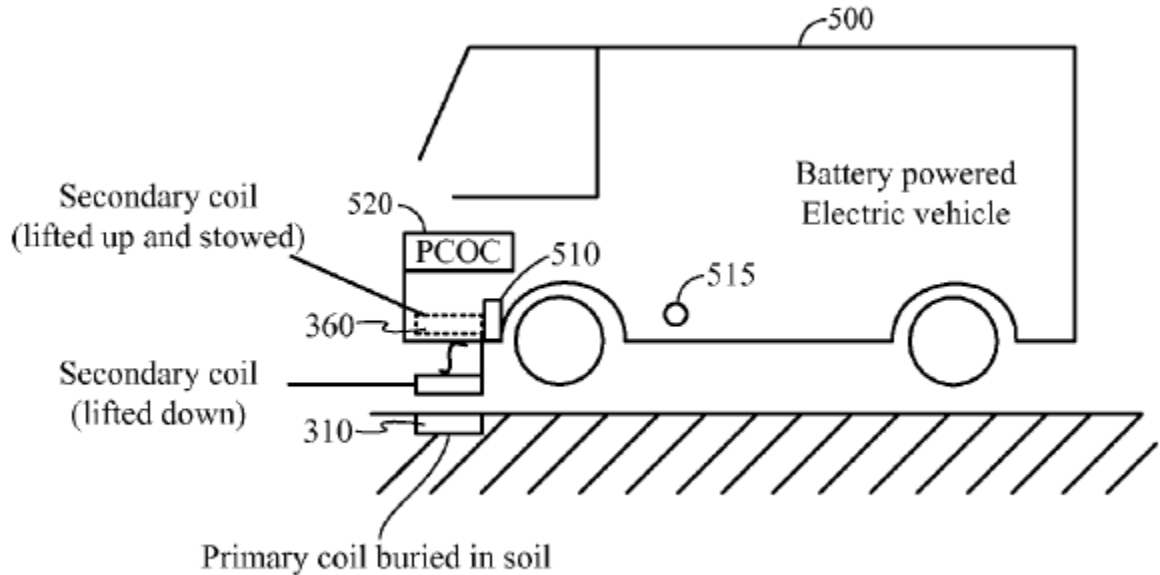


FIG. 5

'654 patent Fig. 5. The secondary coil can be “mounted on a lifting mechanism 510 that controls lifting and lowering the coil.” '654 patent 5:45-56. The patent states that the primary and secondary coils should be “coaxially aligned,” after which the secondary coil “is lowered down to achieve close proximity coupling to the primary.” '654 patent 5:57-65. Then “the processor may control initial tests to check coupling and efficiency of the power transfer between primary and secondary.” '654 patent 5:57-65.

51. In one embodiment, the '654 patent uses a two-stage process for aligning the primary coil with the secondary coil. First, a “guidance system” “assist[s] the driver (or an autopilot in case of an automatically driven vehicle) to accurately position the vehicle.” '654 patent 6:5-8. The guidance system can use “radio positioning” or “may sense a degree of coupling between the primary 410

and secondary 460.” ’654 patent 6:8-14. For example, “the amount of coupling can be detected ... by the vehicle receiving power from the primary.” ’654 patent 6:8-14. The claims of the ’654 patent confirm the same thing: a “coupling test” can comprise “measurement of the amount of power that is transferred to the receiving antenna.” ’654 patent cls. 18-19. The guidance system provides “coarse positioning” of the vehicle-mounted receiving antenna over the transmitting antenna embedded in the road. ’654 patent 6:15-20.

52. Second, after “coarse positioning” by moving the vehicle, “fine alignment” can be achieved by using “an x-y offset control ... to allow better coupling between the coils.” ’654 patent 6:15-24. This fine alignment uses a “vehicle-mounted subsystem” that moves the vehicle-mounted secondary coil in the x- or y- directions in order to be better aligned with the transmitting coil, as Figure 8 shows.

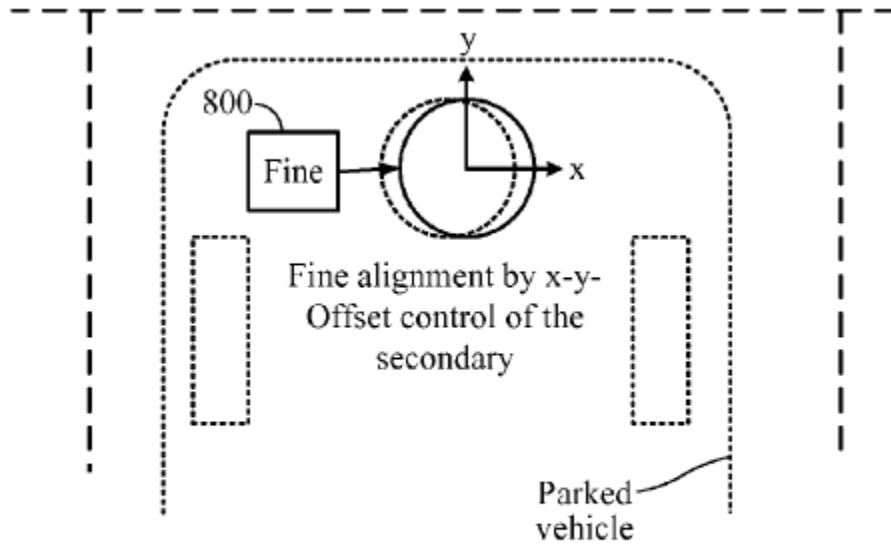


FIG. 8

'654 patent Fig. 8, 6:15-20. Alternatively, the secondary coil can be stationary, while the primary coil is moved, as shown in Figure 9.

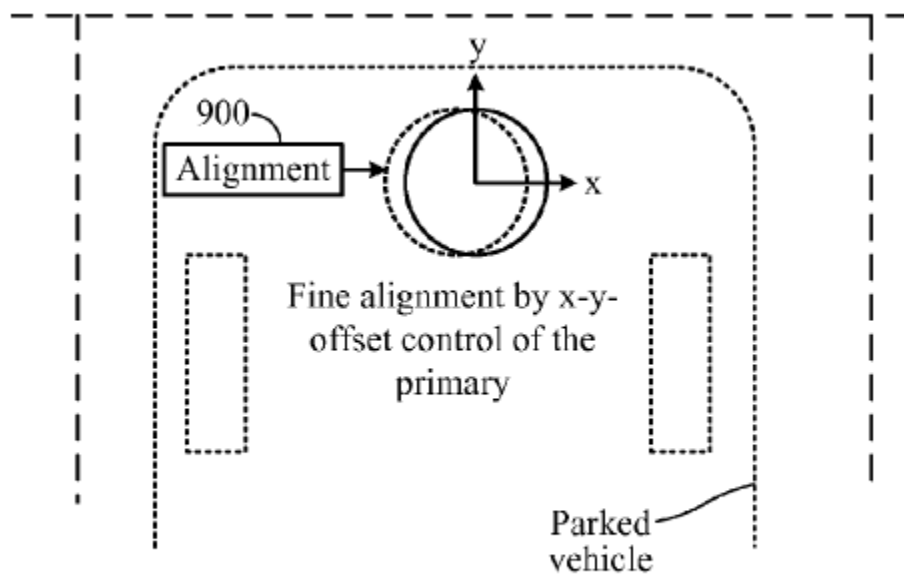


FIG. 9

'654 patent Fig. 9, 6:21-24.

53. The '654 patent does not appear to claim to have invented any new type of alignment, or any new manner of increasing coupling between coils. It only states that the vehicle should be parked so that the “primary and secondary are coaxially aligned” with “fine alignment,” meaning that they are in “close proximity” to each other, as was well known in the art. '654 patent 5:50-62, 6:15-42. This was not new. A POSA would have been familiar with the fact that placing a transmitting and receiving antenna closer to each other, with better alignment, could improve power transfer in a wireless charging system. The Wang thesis, for example, explains that an inductively-coupled power transfer system “is essentially a transformer with the additional flexibility of relative movement between the primary and secondary.” Wang 78. The “coupling parameters” are determined, in part, by “the relative position between the primary and secondary,” which thus has a “strong” impact on “the power transfer capability” of the system. Wang 83.

B. The Challenged Claims

54. The '654 patent recites three independent claims. Claim 1 is a “transmitter system,” claims 8 is a “receiver system,” and claim 13 is a “method.”

55. For reference, I reproduce the independent claims below, with designations I have added in brackets for reference to different parts of the claim:

1[pre]. A transmitter system for wireless power, comprising:

1[a] a transmitting antenna including an inductive element and a capacitor, said transmitting antenna being resonant at a first frequency, said transmitting antenna being configured to generate a wireless field for charging a device including a receiving antenna;

1[b] a charging control system coupled to said transmitting antenna and configured to generate a signal at said first frequency and provide said signal to said transmitting antenna; and

1[c] an alignment controller configured to test coupling of said transmitting antenna to the receiving antenna in the first alignment position and based on a degree of the coupling, the alignment controller further configured to adjust an x-y alignment of the transmitting antenna relative to the receiving antenna from the first alignment position to a second alignment position having a finer alignment between the receiving antenna and the transmitting antenna than the first alignment position to improve said coupling.

8[pre]. A receiver system for wireless power, comprising:

8[a] a receiving antenna coupled to a device, the receiving antenna including a coil and capacitor that are resonant at a first frequency;

8[b] a guidance controller configured to guide the receiving antenna of the device to a first alignment position relative to a transmitting antenna that is not physically connected to said device coupled to the receiving antenna;

8[c] a lifting device for said receiving antenna configured to lift and lower said receiving antenna; and

8[d] an alignment controller configured to sense a degree of coupling of said receiving antenna and the transmitting antenna based on a detection of the coupling that is measured at the receiving antenna, the alignment controller being further configured to move said receiving antenna from the first alignment position to a second alignment position to better align the receiving antenna with the transmitting antenna.

13[pre]. A method, comprising:

13[a] guiding a receiving antenna of a vehicle to a first alignment position relative to a transmitting antenna;

13[b] responsive to detecting a degree of coupling in the first alignment position between the receiving antenna and the transmitting antenna that is measured at the receiving antenna, moving one of the receiving antenna and the transmitting antenna from the first alignment position to a second alignment position to improve alignment of the receiving antenna with the transmitting antenna and improve the degree of coupling.

C. Prosecution History

56. I understand from counsel that none of Odachi, Wang, Partovi, or Ross were discussed by the Patent Applicant or Examiner.

57. I further understand from counsel that references similar to Partovi and Ross were discussed by the Examiner, but that does not change the opinions I provide in this declaration.

VII. Claim Construction

58. In my analysis, I have applied the plain meaning of every term that appears in the Challenged Claims. The plain meaning is the meaning that a POSA would have understood the term to have at the relevant time, in the context of the '654 patent.

59. My analysis does not depend on any particular or precise construction. Rather, the prior art that I discuss in this declaration disclosed the subject matter of the claims of the '654 patent under any reasonable construction of the claim terms.

VIII. Overview of the Prior Art

60. I have been informed that the documents described in this section constitute prior art to the '654 Patent. I am not a lawyer and do not purport to be an expert in determining whether a document constitutes prior art.

A. Odachi (Ex. 1005)

61. U.S. Patent No. 5,617,003 to Odachi ("Odachi") was filed on March 22, 1996 and issued on April 1, 1997.

62. Odachi is titled "Method and apparatus for charging a battery of an electric vehicle." Odachi describes a "method and apparatus of charging a battery of an electric vehicle through inductive coupling." Odachi Abstract.

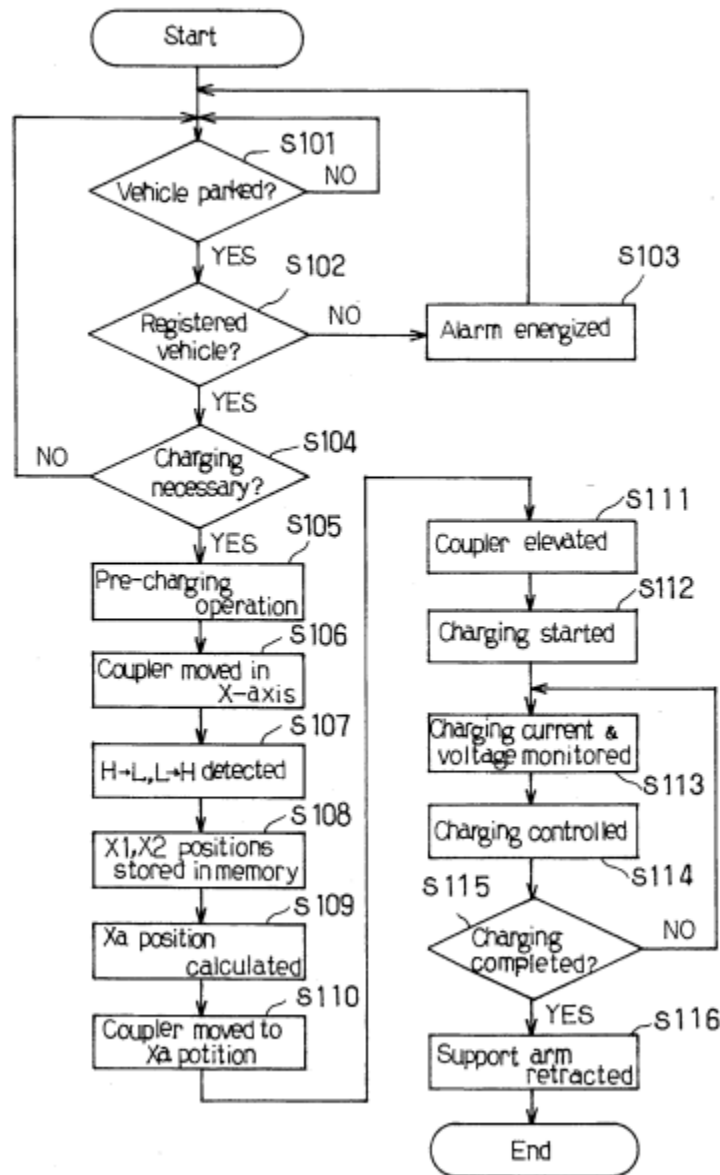
63. To charge the vehicle, a "primary inductive device" that includes a "primary coil connected to a power source" delivers power to a "secondary

inductive device ... mounted on the bottom of the vehicle.” Odachi Abstract, 2:23-65, 8:1-62. The primary inductive device is “comprised of a core 31 and a coil 32.” Odachi 8:16-19. The secondary inductive device is “comprised of a core 3 and a coil 4 connected to the battery of the vehicle.” Odachi 8:1-15.

64. The primary and secondary inductive devices form a “magnetic circuit” so that “an electric current flows in the primary coil 14 to induce a secondary current in the secondary coil,” charging the vehicle battery via inductive coupling. Odachi 4:34-47, 7:20-38; 8:40-54.

65. As shown below, Odachi’s Figure 14 provides a “flow chart” illustrating the positioning and parking operations of its charging system. Odachi 4:1-2, 10:31-12:42, Fig. 14.

Fig. 14

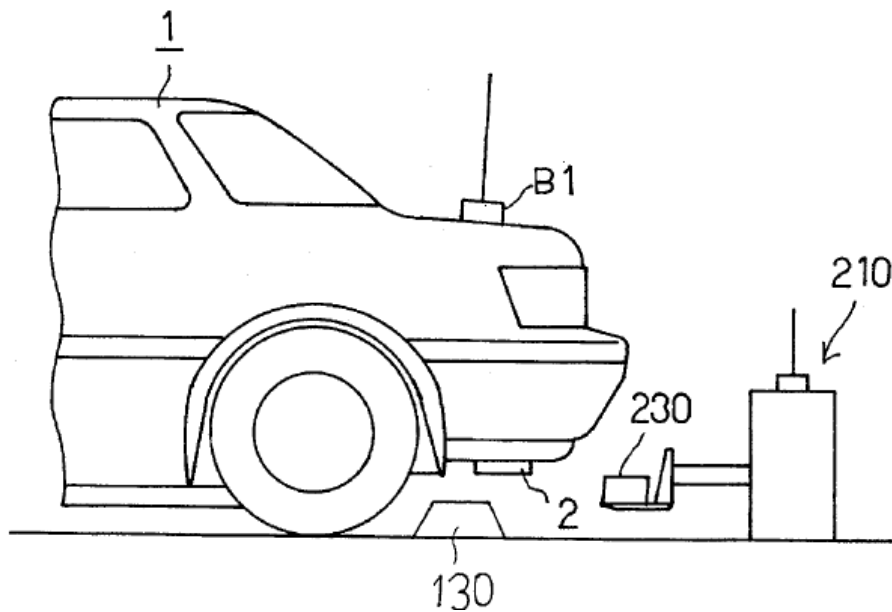


Odachi Fig. 14.

66. First, at Step 101, the vehicle is parked near “wheel stops 130,” for charging, as shown in the figure below. Odachi 8:1-15; *see* Odachi 1:28-40 (wheels stops provide “predetermined position”), 9:52-65 (wheel stops ensure that “when the vehicle is parked against the stops, the secondary inductive receptacle 2

carried by the vehicle is placed within the stroke range ... of the primary coupler 230”), 10:36-42.

Fig. 6



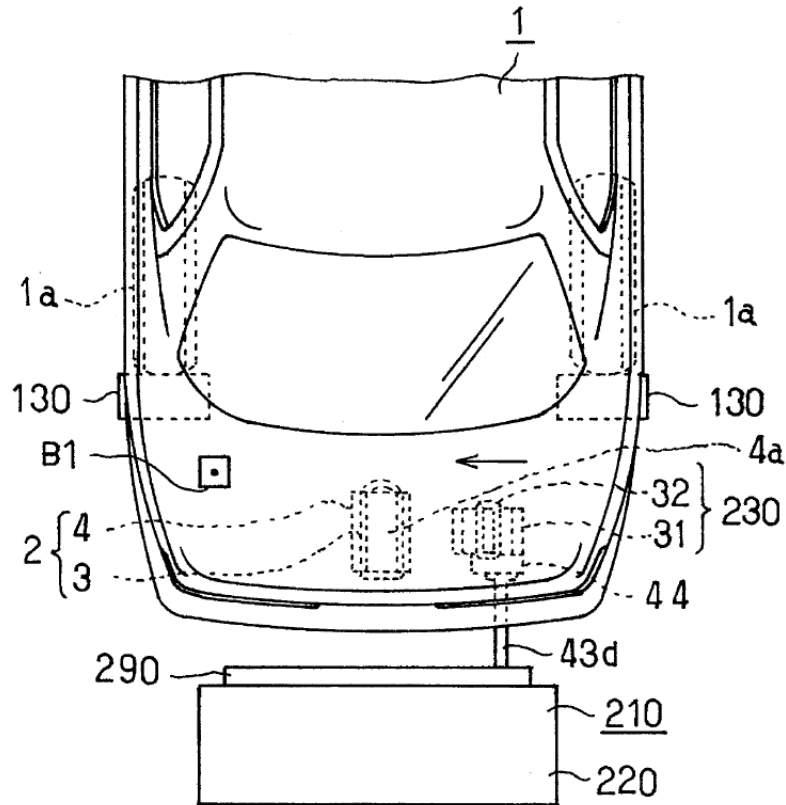
Odachi Fig. 6; *see* Fig. 7 (alternative view of same). Odachi’s receiving antenna (the “secondary inductive device 2”) is mounted on the bottom of the vehicle near the transmitting antenna (the “primary inductive device or coupler 230”). Odachi 8:40-54. The primary inductive coupler is mounted on a “support arm” of “ground battery charger 210.” Odachi 8:16-54; *see* 4:16-28, 7:27-38, Figs. 6-7.

67. Next, at Steps S102-104, the vehicle uses “wireless transmitter B1” to send a signal to the controller of the ground charger, indicating that 1) the vehicle

is parked, 2) the vehicle is registered to be charged, and 3) the vehicle's battery needs to be charged. Odachi 10:43-63.

68. Once the vehicle is parked, a “positioning apparatus” extends the support arm to a home position, and then repositions the support arm to better align the primary inductive device with the secondary inductive device, for improved coupling during charging. Odachi 8:55-62, 10:64-12:7. This operation is described in Steps S105 through S111 in Fig. 14.

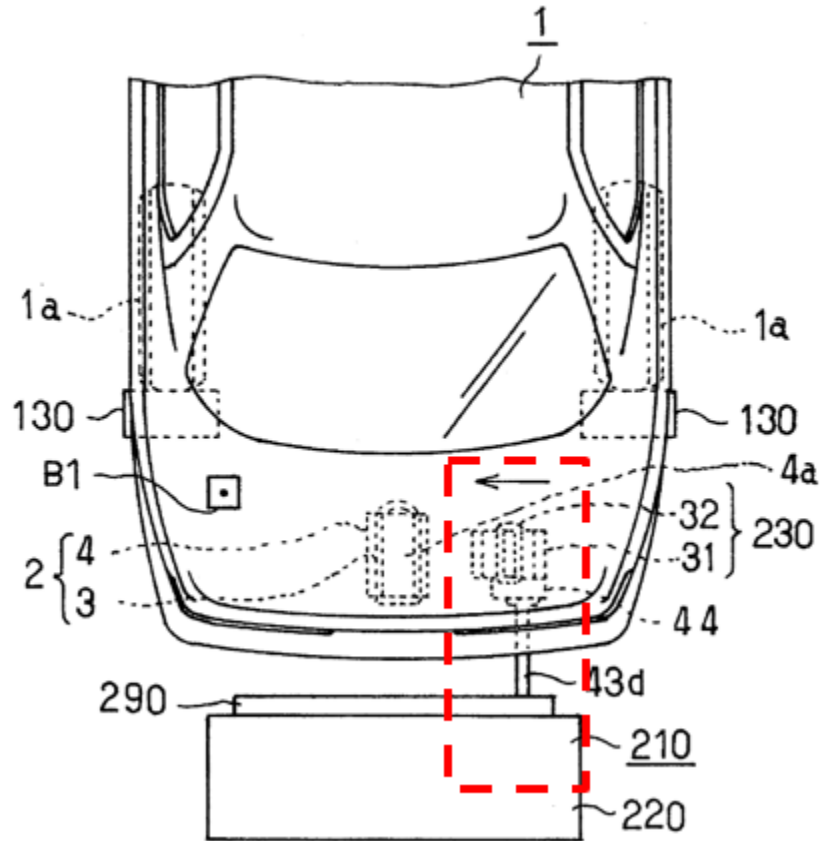
69. At Step S105, “pre-charging operations” occur, including the door of the charging unit opening. Odachi 10:64-11:17. The support arm 43d on which the primary inductively coupler is mounted swings outward to its “rightmost, operative home position at E1 along the X-axis below the vehicle bottom,” as shown below in Fig. 11



Odachi Fig. 11, Odachi 10:64-11:17 (arm is in “projecting operative position”). Also as part of pre-charging operations, the controller enters “positioning mode,” causing the “power circuit ... to supply a check current I_{RMS} to the primary coil.” Odachi 1:6-17; 10:64-11:17; Fig. 14. Alternatively, the check can be a “voltage V_{RMS} which is induced across the secondary coil on the vehicle.” Odachi 13:39-64.

70. At step S106, the controller “starts the X-axis motor” to “move the support arm 43d [on which the primary coil is mounted] leftward from its operative home position E1 at a constant speed,” as shown by the arrow in Fig. 11 below. I

have annotated Fig. 11 to highlight the support arm in its home position and Odachi's arrow indicating leftward movement. Odachi 11:6-59; Figs. 11, 14.



As the support arm moves from the right to the left, the primary inductive coupler will come closer to, and then further away from, the secondary coupler. Odachi 11:6-59; Figs. 11. As that happens, monitoring circuits measure I_{RMS} and V_{RMS} , and output a high (H) signal if the check “is greater than a predetermined reference value” and a low (L) signal if not. Odachi 11:6-59; 6:1-27; 13:39-64, Figs. 4-5.

71. At Step S107, the system detects and monitors “the coupler positions where changes occur in the signal from H to L and vice versa.” Odachi 11:33-42, 13:32-64, 6:27-57. At Step S108, these positions are stored in memory as position X1 and X2. Odachi 11:33-42, 13:32-64, 6:27-57.

72. At Step S109, the system calculates “alignment point XA,” which is “the midpoint between X1 and X2” and represents “the point ... where the primary inductive coupler ... is positioned closest to the secondary inductive receptacle.” Odachi 6:27-65, 7:4-13 (XA is “position where the coupler is just aligned with the secondary inductive receptacle”), 7:51-58 (XA is “alignment position ... to which the primary inductive coupler ... should be brought for alignment”), 11:43-62 (“target position XA where the coupler is just aligned with the secondary inductive receptacle”), 13:39-64 (describing same process for V_{RMS}), 13:32-38 (XA can be determined without X1 or X2).

73. At step S110, the system then moves the support arm, and the primary coupler, to this best alignment position XA. Odachi 11:50-59, 13:39-64 (describing same process for V_{RMS}).

74. If desired, this process can also be used to align the primary coupler with the secondary coupler in the “vehicle longitudinal direction,” which a POSA would understand refers to the Y-axis, as opposed to the described X-axis. Odachi

14:10-34. In that instance, the support arm is constructed to be “extensible linearly toward and away from the vehicle.” Odachi 14:19-29.

75. At Step S111, after the coupler is aligned in the X- or Y-axis, a “Z-axis motor” raises an “elevator” that moves the primary inductive coupler vertically upwards, closer to the secondary coupler into “an inductively coupled condition.” Odachi 11:60-12:7. This can use the same “principle of automatic positioning” as described for the Z-axis. Odachi 13:3-9.

76. At Step S112-S114, charging occurs by “generat[ing] a charging mode signal to the power circuit 53, which, then responding to the signal from the controller, starts to supply a charging current to the primary coil 32 of the inductive coupler 230, thereby initiating the battery charging operation.” Odachi 12:8-26. During charging, “the primary current flowing in the primary coil 32 and the secondary current induced in the secondary coil 4, as well as the voltages applied across the respective coils, are monitored.” Odachi 12:14-26.

77. At Steps S115-116, when charging is completed, the elevator vertically lowers the primary inductive coupler, and the support arm is retracted. Odachi 12:33-42.

B. Wang (Ex. 1008)

78. Wang is a “thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Electrical and Computer Engineering” at

the University of Auckland. Wang Cover. It is titled *Design Considerations for Inductively Coupled Power Transfer Systems* and is dated 2004. Wang Cover.

79. Like Odachi and the '654 patent, Wang discloses “inductively coupled” systems to “transfer electric power from a primary source (power supply) to one or more secondary loads (pickups)” with “no physical contact between the primary and secondary.” Wang i. One example of this work, as Wang explains, is to develop “a contact-less electric vehicle battery charger.” Wang i.

80. Chapter 1 of Wang is an “Introduction” to “Inductively Coupled Power Transfer,” or ICPT, systems. Wang v (Table of Contents). Chapter 2 then provides an “Overview of ICPT Systems.” Wang v.

81. As part of this “Overview,” Wang explains that each of the “primary and secondary” circuits can be “uncompensated,” or can have either “series compensation” or “parallel compensation.” Wang 24. Thus, there are nine “basic compensation topologies” for inductively coupled systems, as shown below.

2-3.5 BASIC COMPENSATION TOPOLOGIES

Three basic compensation choices exist for both the primary and secondary (series compensation, parallel compensation, or uncompensated). Combining the primary and secondary results in nine fundamental compensation topologies [18] as illustrated in Fig. 2-12.

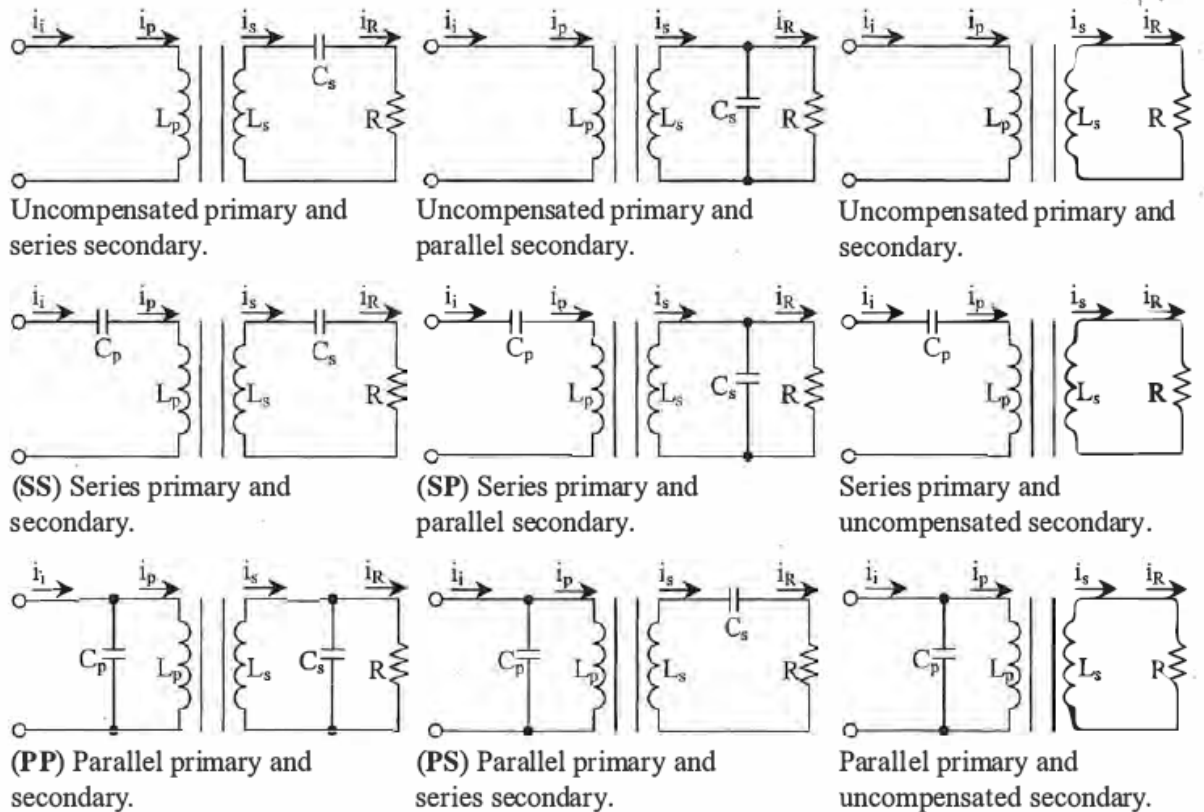


Fig. 2-12. Basic compensation topologies of ICPT systems.

Wang 24.

82. The top right “basic compensation topolog[y]” is an “uncompensated primary and secondary,” i.e. a primary coil coupled by mutual inductance to a secondary coil, with no added capacitors shown. Wang 24. A POSA would understand that this is the same arrangement described in Odachi: two “coils” with “inductive coupling” between them. See Odachi 9:30-43.

83. Wang focuses on “higher power applications” of inductive power transfer, and explains that in these applications, “[b]oth the primary and secondary of the electromagnetic structure are often compensated by capacitors to boost the power transfer capability.” Wang i, 4-5, 20, 47-48 (the “majority” of “medium-high power range” systems are “compensated”). This compensation is achieved by adding “a capacitor ... either in series ... or in parallel” with each coil, as shown in Figure 2-12 below. Wang 20-24.

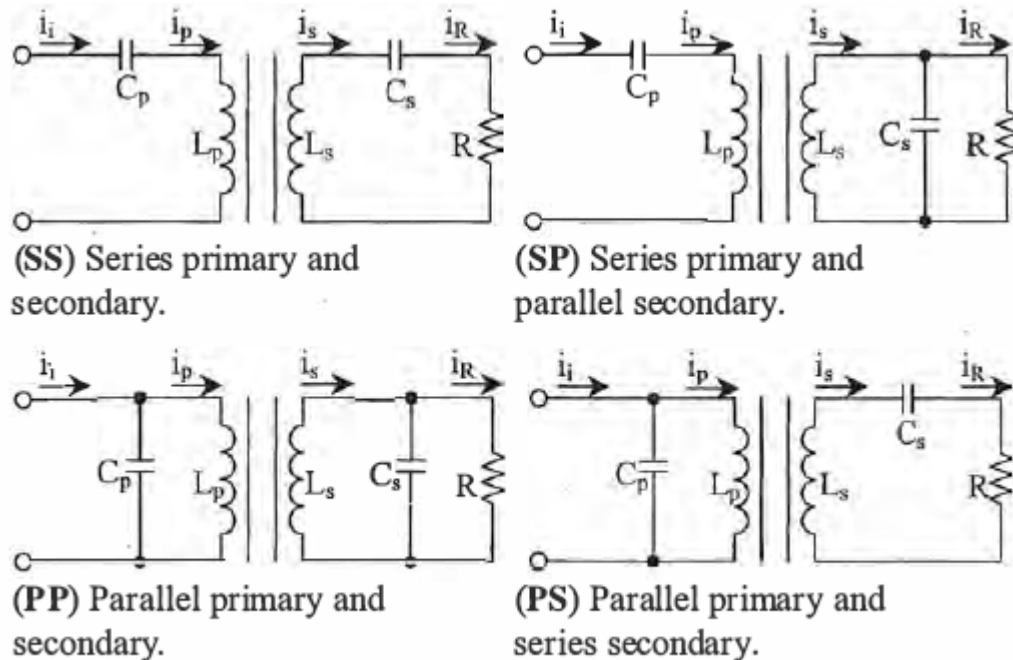


Fig. 2-12. Basic compensation topologies of ICPT systems.

84. Wang explains that each of the compensated primary and secondary coils are “resonant circuits” that are “normally” operated at a “resonant frequency ... equal to the nominal frequency” to provide “maximum power transfer.” Wang 11, 20-24, 47 (“the primary resonant circuit is magnetically coupled with one or

more secondary resonant circuits”); *see* Wang 60 (“the secondary resonant frequency is designed to be equal to the operating frequency in order to ensure maximum power transfer”).

C. Partovi (Ex. 1006).

85. U.S. Patent No. 7,952,322 to Partovi (“Partovi”) was filed on January 30, 2007. It is titled “Inductive Power Source and Charging System.”

86. Partovi discloses an “inductive power source and charging system” that “comprises multiple coils or set of wires,” as shown in Figure 3 below. Partovi 6:33-40, Figs. 1, 3.

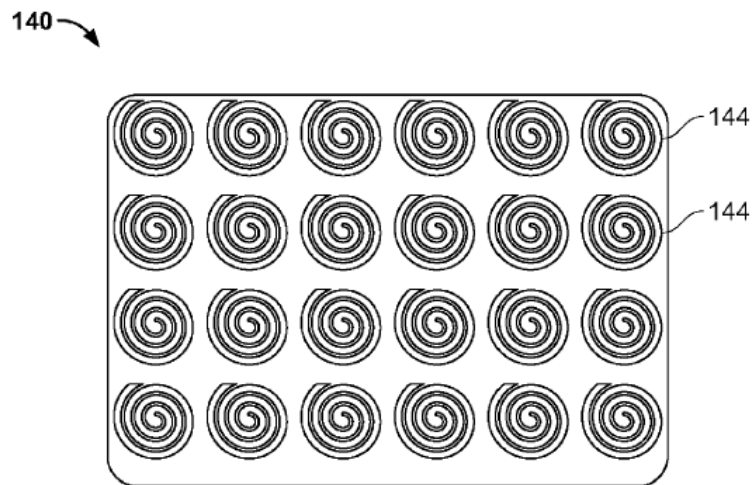


FIG. 3

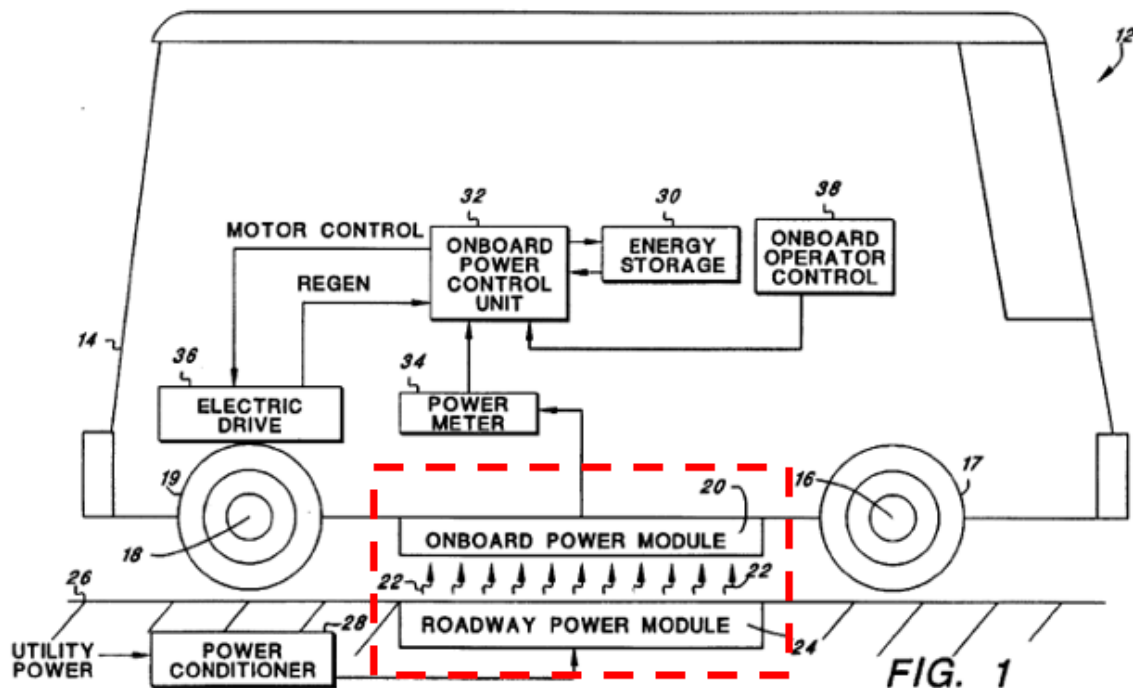
The “total area” of the “charger can be covered by coils ... that create[]” a “magnetic field,” allowing for charging “regardless of [the] position” of the device that needs to be charged. Partovi 8:53-59. When that device’s “receiver coil” “is generally aligned upon one or more primary coils in [the] base unit,” the primary

coils “are capable of being selectively switched or activated by a switch in the base unit associated with the one or more primary coils.” Partovi 26:23-30.

D. Ross (Ex. 1007)

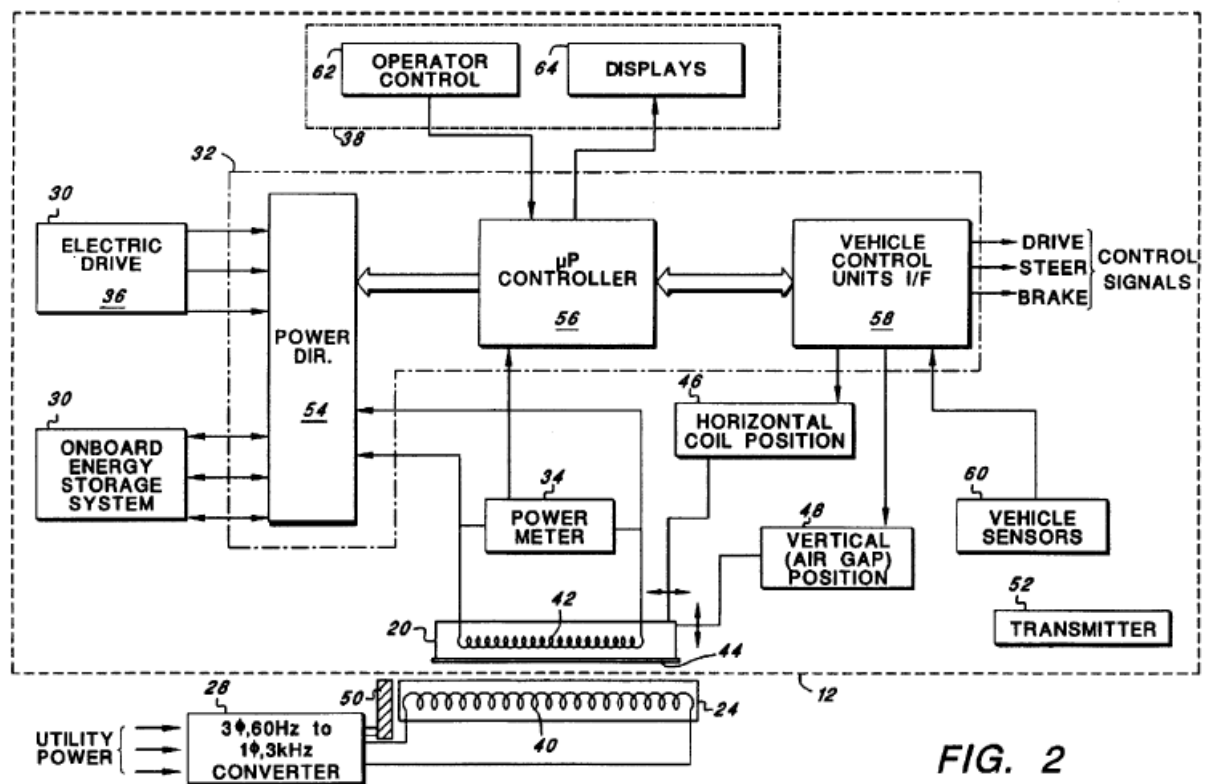
87. U.S. Patent No. 5,669,470 to Ross (“Ross”) issued on September 23, 1997, and is titled “Roadway-Powered Electric Vehicle System.” Ross Title.

88. Ross discloses a “roadway-powered electric vehicle” (“RPEV”) with a “power receiving module” that “receives electrical power” from “a roadway power transmitting module” for inductive coupling, as shown in Figure 1 below. Ross 7:57-8:13, Fig. 1. I have annotated this figure to highlight in red the roadway power module that provides power to the onboard power module via inductive coupling.



Ross Fig. 1 (annotated).

89. Ross’s “onboard power module,” which is also called the “power receiving module 20,” can be a “coil 42” that is “mounted on the underneath side of the RPEV.” Ross 9:10-43, Figs. 1-2. The “roadway power transmitting module 24” can be “a coil 40” that is “embedded in the roadway.” Ross 9:10-42, Figs. 1-2. The coils are shown in Ross’s Figure 2, which is a block diagram of the same system shown in Figure 1.



Ross Fig. 2; Ross 6:55-57, 9:10-29.

90. As Ross explains, the coils 40 and 42 are “coupl[ed]” by “inductive coupling.” Ross 9:30-42. “When a suitable ac electrical current flows through the

[transmitting] coil 40 at frequency f_1 , such current generates a magnetic field that varies at frequency f_1 .” Ross 7:57-8:13, 9:11-29, Fig. 1-2. That magnetic field “induces a voltage” so that “when [receiving] coil 42 is connected to a suitable load, an ac current is thus established in the coil 42 and power is effectively coupled from the [transmitting] coil 40 to the [receiving] coil 42.” Ross 7:57-8:13, 9:11-29, Figs. 1-2.

91. Ross’s system can provide wireless power from the roadway coil to the vehicle “at select locations,” including “at designated ‘stops’ of the vehicle, e.g. at designated passenger loading/unloading zones, parking garages, or the like.” Ross 6:12-24, 3:41-4:6 (describing inductive coupling from roadway to vehicle). When the vehicle approaches “a passenger loading/unloading zone,” “charging pad,” or other stopping area over an embedded transmitting coil, “an auto-positioning control ... effectively ‘takes-over’ the driving of the vehicle for the final 10-15 feet.” Ross 12:33-63 (loading/unloading zone), 18:1-10 (describing similar charging on “charging pad” in “garage”). 6:12-24 (“passenger loading/unloading zones, parking garages, or the like”). Once “the auto-positioning function is activated,” a “microprocessor controller 56” controls the “steering of the vehicle” so that “the vehicle is laterally positioned, to within a rough tolerance, e.g. ± 5 -10cm, of the optimum lateral position when the vehicle comes to its designed stopped location.” Ross 12:44-67.

92. Ross's system attempts to optimize the coupling between its two coils. Ross 5:40-58 ("advantageously optimiz[ing] the coupling efficiency of the power signal"). Because "the coupling efficiency is a function of the distance, or air gap, between the two coils ... as well as the relative alignment between the coils," Ross's system aligns the primary and secondary coils, and also minimizes the air gap between them. Ross 9:30-10:44.

93. Specifically, "in order to improve the coupling efficiency between the embedded coil 40 and the onboard coil 42," Ross's invention "mounts the coil 42 on a movable assembly 44." Ross 9:44-67. The position of the movable assembly is controlled by a "horizontal coil position unit 46" and a "vertical (air gap) coil position unit 48." Ross 9:44-67, 12:33-13:32 (describing how position units work)

94. After the vehicle has been driven into place and parked by the auto-positioning system, the "horizontal coil positioning unit 46" uses "conventional hydraulic[s] and/or electronic positioning devices" to move the vehicle-mounted coil and thus "further control[s] the lateral position of the coil 42 so that it is more closely aligned, e.g., to within ± 1 -2 cm, of the optimum lateral position." Ross 12:44-67.

95. In other words, Ross, like the '654 patent, uses a two-stage positioning method. First, the "auto-positioning control" steers the vehicle to a parking position over the roadway embedded coil, where it is "within a rough tolerance" of

the optimal coupled antenna position. Ross 12:33-50. Next, the horizontal coil positioning unit moves the entire movable assembly of the secondary coil “so that it is more closely aligned” with the primary coil. Ross 12:33-50.

96. In order to determine the “optimum lateral position” that results in the best coupling, the vehicle coil can be “laterally moved in one direction or the other” while “monitoring the change in the amplitude of the inductively received power signal” at the vehicle coil “to sense the relative lateral location of the coil[s]” Ross 13:15-32. The coil is “laterally position[ed]” using the “horizontal coil positioning unit 46 and/or the steering of the RPEV” at the “position that keeps the induced power signal at a peak or maximum level,” which indicates the strongest coupling between the coils. Ross 13:15-32.

97. After the coil is properly aligned laterally, the “vertical (air gap) positioning unit 48” can lower the “assembly 44” that the coil is mounted on “to reduce the air gap to near zero.” Ross 12:44-67. With an “air gap near zero, the onboard energy storage system 30 is charged ... through the inductive coupling link (which operates at maximum efficiency with a near zero air gap).” Ross 12:63-13:4.

98. Thus, “the positioning units 46 and 48, in combination with the steering of the RPEV 12 ... combine to allow the onboard coil 42 to be optimally

aligned with the embedded coil 40 so as to provide the maximum possible coupling efficiency between the two coils.” Ross 9:30-10:5.

IX. Ground 1a: Claims 13 and 15 Would Have Been Unpatentable Over Odachi

99. For the reasons discussed below, it is my opinion that Odachi teaches each claim element as arranged in claims 13 and 15 of the '654 patent.

A. Independent Claim 13

1. Claim Element 13[pre]: Preamble

100. The preamble of Claim 13 recites “[a] method, comprising.” Odachi teaches this.

101. As I discussed in my overview, Odachi discloses a “method and apparatus” for electric vehicle battery charging that uses “inductive coupling” between two coils, as I explain further below for the following elements. Odachi Abstract, 1:5-13, 2:15-20, 4:5-15, 8:1-54, 10:13-30 12:8-13 (all explaining how Odachi operates through inductive coupling).

2. Claim Element 13[a]: Guiding a Receiving Antenna into a First Alignment Position

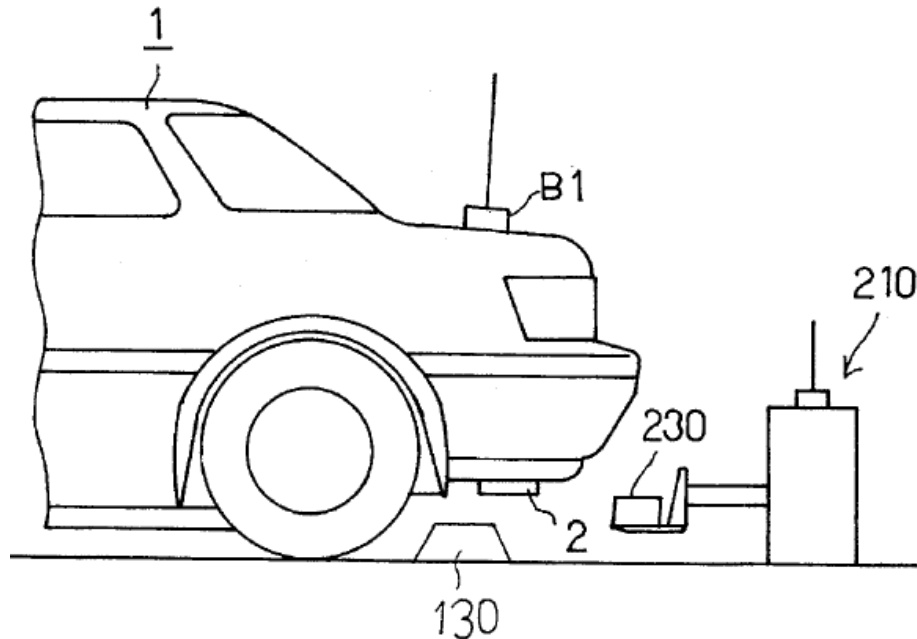
102. Claim 13 next recites “guiding a receiving antenna of a vehicle to a first alignment position relative to a transmitting antenna.” Odachi teaches this.

103. Odachi discloses an “electric vehicle” that has “a secondary inductive device or receptacle comprised of a core 3 and a coil 4 connected to a battery ... through an appropriate electric circuit” on its “bottom” side. Odachi 8:1-15; *see*

Odachi 4:5-15 (secondary inductive device is “power receiving”), Figs. 1-2. This “secondary inductive device” is the receiving antenna.

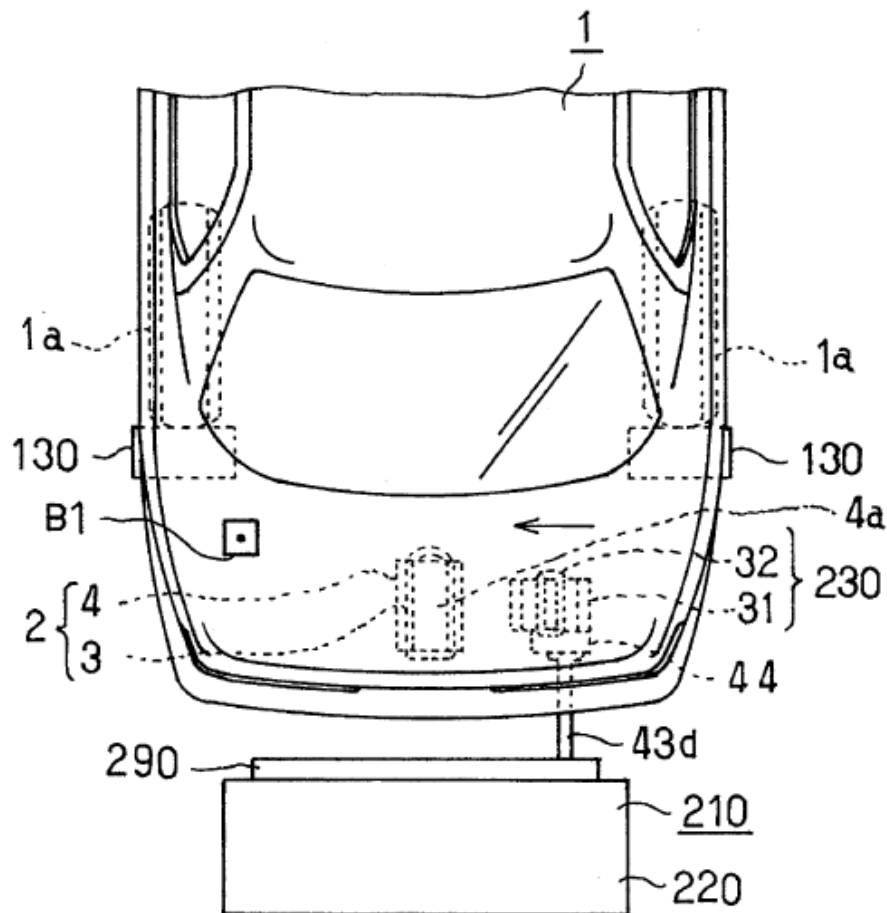
104. As shown in the figure below, in order to be charged, “the vehicle to be charged is parked in the garage with its rear wheels 1a placed in contact with the stops 130.” Odachi 8:1-15, 12:43-52 (describing “the parking operation by the driver”).

Fig. 6



Odachi Fig. 6. I note that Odachi’s Figure 7 shows another view of this same arrangement, as the car pulls into its parking spot. See Fig. 7 (showing car pulling into parking spot up against wheels stops); Odachi 3:51-53 (“Fig. 7 is a perspective view of the vehicle and battery charger of Fig. 6”).

105. A “ground battery charger 210 ... including a primary inductive device or coupler 230 comprised of a core 31 and a coil 32” is located “behind the stops.” Odachi 8:16-28. The primary inductive device, which is the claimed transmitting antenna, is mounted on a movable “support arm 43d,” as can be seen above. The support arm is not labeled in Figure 6, but Figure 11 (which is a top-down view of the same arrangement as Figure 6) confirms that it is the shown arm on which primary coupler 230 is mounted.



Odachi Fig. 11. When the vehicle is ready to begin charging, the support arm “swing[s]” out “from its retracted position” to its “projecting operative

position” shown above, also called the “rightmost, operative home position.” Odachi 10:64-11:10. During operation, the primary inductive device “engage[s] with the secondary inductive receptacle 230 [to] form a magnetic circuit” so that the vehicle can be charged through induction. Odachi 8:16-28, 8:40-54, 12:8-26.

106. Odachi explains that it was known to have wheel stops guide the vehicle to “a predetermined position ... so as to position a secondary core-coil device carried by the vehicle in confronting relation to a primary core-coil device.” Odachi 1:38-40. In the same manner, Odachi’s wheel stops “are positioned at such a spacing from the battery charger 210 that, when the vehicle 1 is parked in contact with the stops 130, the secondary receptacle is positioned substantially at the same spacing, for example, from the front 2201 of the casing 220 as the primary coupler 230.” Odachi 9:52-65. The stops “are arranged at such positions along the X-axis that, when the vehicle 1 is parked against the stops, the secondary inductive receptacle 2 carried by the vehicle is placed within the stroke range of the carriage 41d between E1 and E2, or the range of movement along the X-axis of the primary coupler.” Odachi 9:60-64. In other words, the positioning of the steps is what “make[s] possible” the “positioning of the primary coupler 230 with respect to the secondary receptacle 2,” in that it can be assured, if the vehicle’s wheels are abutting the stops, that the vehicle’s coil is in proper position for charging relative to the location of the charger coil. Odachi 9:27-65, 11:60-12:7 (“as long as the

vehicle is parked with its rear wheels 1a in contact with the stops 130, the primary coil 32 can be accommodated safely [for charging] ... even if the vehicle 1 is parked with a slight error in its longitudinal direction”).

107. When the vehicle is in place and parked, “wireless transmitter B1” on the vehicle transmits “a parking signal, an ID number signal, and a signal representing the condition of the battery,” which indicates “that the vehicle 1 has been parked properly.” and therefore charging can begin. Odachi 10:36-63.

108. Accordingly, a POSA would have understood that when the vehicle is driven to a position such that the wheels are against the wheel stops and parked, the secondary inductive device (or receiving antenna) mounted on the vehicle is guided to a first alignment position relative to the primary inductive device (or transmitting antenna) swung out to its “operative home position.” Odachi 1:38-40, 3:61-53, 8:1-15, 9:38-65, Figs. 6-7, 11, 14.

109. I note that the ’654 patent describes the same type of guiding into parking position, explaining that “the driver ... position[s] the vehicle” by “park[ing]” it, thereby providing “coarse positioning” of the antenna. ’654 patent 6:1-20; Fig. 6.

3. Claim Element 13[b]: Moving the antenna to improve alignment

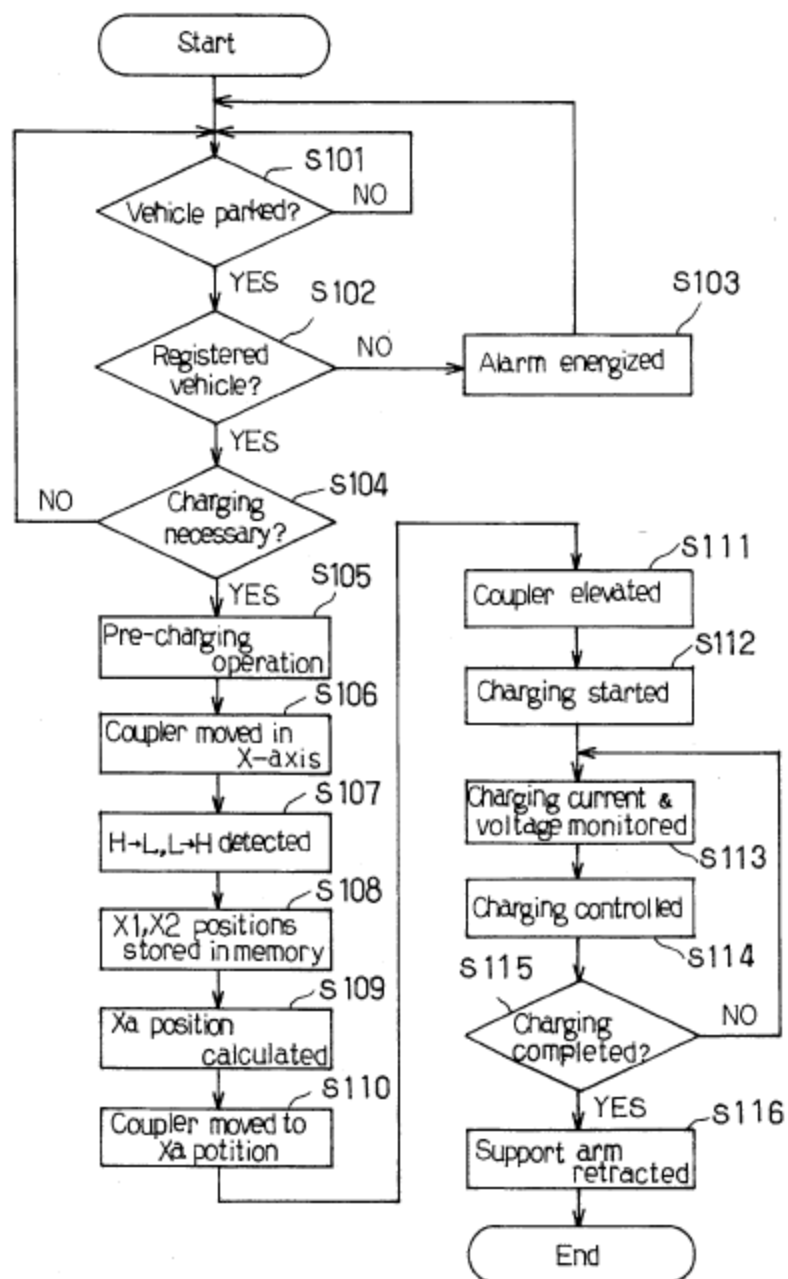
110. Claim 13 next recites “responsive to detecting a degree of coupling in the first alignment position between the receiving antenna and the transmitting

antenna that is measured at the receiving antenna, moving one of the receiving antenna and the transmitting antenna from the first alignment position to a second alignment position to improve alignment of the receiving antenna with the transmitting antenna and improve the degree of coupling.” Odachi teaches this.

111. I explain Odachi’s teachings in detail below. To summarize, however, Odachi moves its primary inductive device (i.e. transmitting antenna) from its home position (i.e. first alignment position) to a target position XA (i.e. second alignment position). At the target position XA, the primary inductive device is better aligned with the secondary inductive device and has improved coupling. The target position XA can be determined by monitoring an induced voltage, V_{RMS} , across the secondary coil. This induced voltage indicates the degree of coupling between the primary and secondary inductive devices, and is used to determine how far to move the primary inductive device for maximum coupling and best alignment.

112. Odachi teaches a “control unit 260” that has a “controller 51” for controlling the primary inductive device’s position. Odachi 9:66-10:12. When the vehicle is parked and ready to charge, the “controller” can be set to a “positioning mode” that “generat[es] to the power circuit 53 a positioning mode signal.” Odachi 11:6-59. Figure 14 below shows the positioning mode’s operation.

Fig. 14

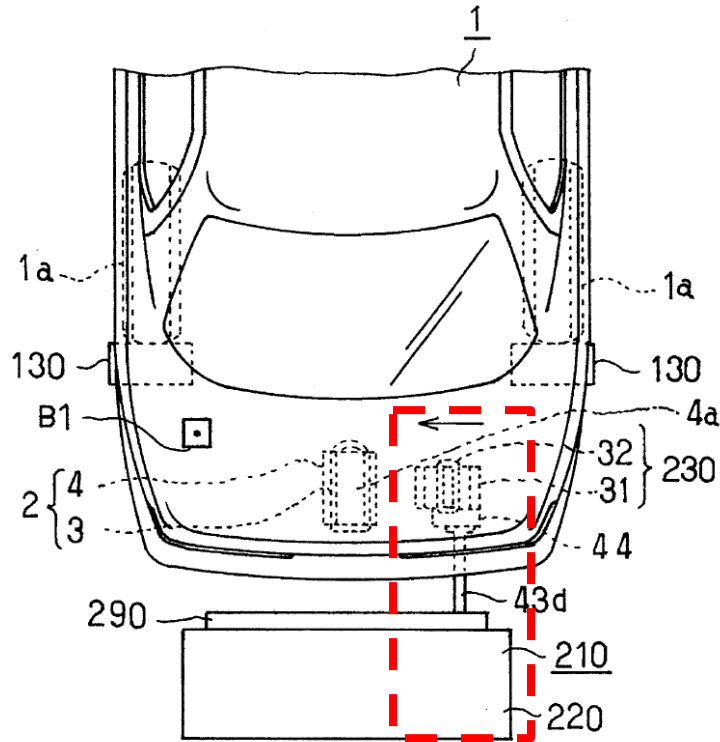


Odachi Fig. 14.

113. I described the steps of Odachi's positioning mode in detail in my Overview, which I incorporate here. *See* Section VIII(A). However, I discuss the relevant steps in more detail below.

114. At Step S105, "pre-charging operations" are performed including opening the door of the ground charger, sending a positioning mode signal, and swinging support arm 43d (which has primary inductive coupler 230 on it) out to "its rightmost, operative home position along the X-axis below the vehicle bottom as shown in Figure 11." Odachi 10:64-11:17. These pre-charging operations "may be performed automatically." Odachi 11:12-17.

115. At Step S106, after the "pre-charging operation[s]" are finished, the controller "starts the X-axis motor 41c" to "move the support arm 43d leftward from its operative home position E1 at a constant speed." Odachi 11:6-59; Fig. 11. I have annotated Figure 11 below to show the support arm 43d in its home position, and the leftward movement can be seen from the leftward arrow in Odachi's figure.

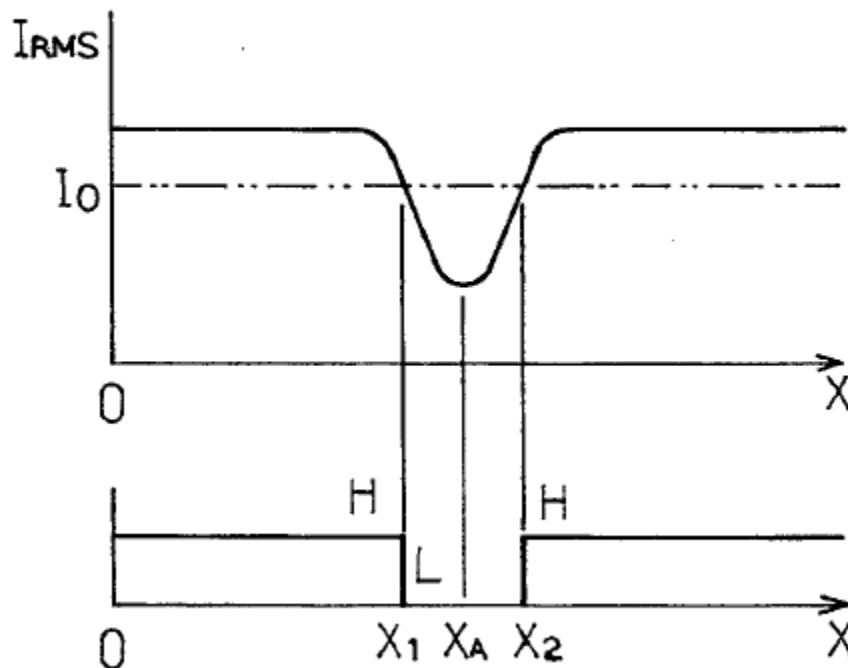


Odachi Fig. 11 (annotated).

116. As the support arm moves from right to left, a “check current I_{RMS} ” is “flowing in the primary coil.” Odachi 11:17-32. A monitoring circuit “monitors the check current,” and compares its value to a predetermined reference value I_0 . Odachi 11:17-32. The circuit “produces a high-level signal H while the value of the check-current I_{RMS} is greater than a predetermined reference value I_0 , and a low-level signal L while the value of the check current I_{RMS} is lower than the value I_0 .” Odachi 11:17-32; *see* Odachi 5:54-6:45, Fig. 4. As the support arm makes its sweep from right-to-left, the check current I_{RMS} gets lower as the primary inductive coupler moves closer to the secondary coupler, and then gets higher again as the primary coupler moves away from the secondary coupler. Odachi 6:10-45 (“the

value of the current I_{RMS} becomes minimum when the primary inductive coupler 6 is positioned closest to, or in alignment along the X-axis with, the secondary inductive receptacle” ... “[T]he magnitude of the current I_{RMS} varies with the function of the spaced distance between the primary coupler 6 and the secondary receptacle 2,” the check current I_{RMS} “decrease[s]”). The point where the primary coupler is “in alignment” is the point where “the electromotive force induced in the secondary coil 4 becomes the greatest,” and therefore the point where “the current I_{RMS} flowing in the primary coil 14 becomes the smallest.” Odachi 6:10-45, Fig. 4. This can be seen, for example, in Figure 4 below, where XA is the best-aligned position, producing the lowest I_{RMS} value.

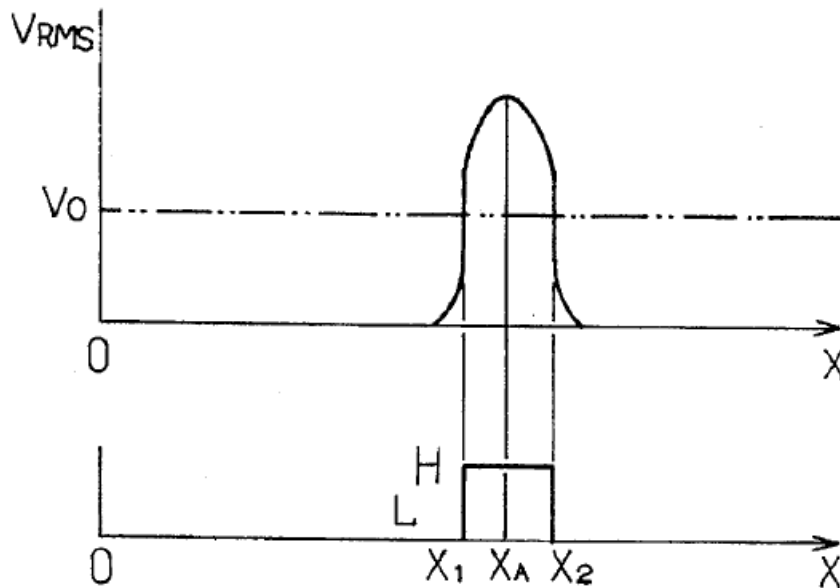
Fig. 4



117. Although Odachi describes the function of I_{RMS} with respect to its first embodiment (Odachi 6:10-45), Odachi also explains, and a POSA would have understood, that this is equally true for its second embodiment (Odachi 11:18-42).

118. The circuit stores in memory two positions, X1 and X2, which correspond to the position of the primary inductive coupler when the I_{RMS} comparison signal changes from High to Low, or from Low to High. Odachi 11:33-49, 6:28-45, Fig. 4.

119. Alternatively, instead of monitoring I_{RMS} , X1 and X2 can be determined “by monitoring a voltage V_{RMS} which is induced across the secondary coil on the vehicle by application of an AC voltage across the primary coil,” for example as shown in Figure 5 below. Odachi 13:29-64; *see* Odachi 3:1-5 (“it may be contemplated to provide monitoring means for detecting a change of electric current or voltage induced in the secondary coil and varying with the movement of the primary inductive device relative to the secondary device.”).

Fig. 5

Odachi Fig. 5. To measure V_{RMS} , “the vehicle has an electric circuit connected to the secondary coil for monitoring the voltage V_{RMS} and another circuit connected to the voltage monitoring circuit for generating discriminating signals H and L depending on the magnitude of the voltage V_{RMS} with respect to a predetermined reference voltage V_0 .” Odachi 13:29-64, Fig. 5. As can be seen in Figure 5, the highest V_{RMS} values indicate the best coupling. Odachi 13:29-64, Fig. 5. Otherwise, this process proceeds similarly to I_{RMS} . As the primary coupler sweeps right-to-left, the positions X_1 and X_2 are the positions where the discriminating signal switches from High to Low, or vice-versa. Odachi 13:29-64, Fig. 5.

120. A POSA would have understood that measuring V_{RMS} is one way of detecting the degree of coupling between the two coils, measured at the receiving coil. As Odachi explains, V_{RMS} indicates the “voltage ... which is induced across the secondary coil on the vehicle by application of an AC voltage across the primary coil.” Odachi 13:39-64. Thus, V_{RMS} is the magnitude of the voltage induced on the secondary coil from the primary coil due to inductive coupling—which is indicative of the level of inductive coupling between the primary coil and the secondary coil. Odachi 13:39-64. V_{RMS} and I_{RMS} are measured at every position as Odachi’s support arm sweeps from right-to-left, including at the starting operative home position of the support arm. Figs. 4-5, Odachi 10:64-11:42, 13:39-64; *see* 6:1-45 (describing I_{RMS} measurement). V_{RMS} goes up when the primary coil is closer to, and better aligned with, the secondary coil. It goes down when the primary coil is further away from, or less well aligned with, the secondary coil. *See* Odachi 13:39-64, Fig. 5. I note that this is the same manner of detecting for, or testing, coupling that is mentioned in the ’654 patent: “a measurement of the amount of power that is transferred to the receiving antenna.” ’654 Patent cls. 18-19. The magnitude of the induced voltage, along with the induced current, is one of two factors in the amount of power transferred to the receiving antenna, and scales proportionally with the amount of power.

121. After X_1 and X_2 are determined (regardless of whether by measuring I_{RMS} or V_{RMS}) Odachi's controller calculates the midpoint between X_1 and X_2 . Odachi 6:33-57, 7:51-58, 11:42-59, 13:53-64, Figs. 4-5. This midpoint is the "target position X_A where the coupler is just aligned with the secondary inductive receptable 2 along the X-axis," i.e. the point where the primary coupler is closest to the secondary, and therefore where coupling between the primary coil and secondary coil is strongest. Odachi 11:42-59; 13:52-64; 6:33-45, 7:10-13, 7:51-58, Figs. 4-5.

122. After position X_A has been calculated, the support arm moves the primary coil to this "alignment position X_A " (which corresponds to the claimed second alignment position) where the strongest coupling between the primary and secondary devices occurs. Odachi 11:42-12:7; 13:52-64; 6:33-45, 7:10-13, 7:51-58, Figs. 4-5. Alternatively, instead of calculating X_1 and X_2 , the device can "directly detect[] the minimum value" of I_{RMS} , or the maximum value of V_{RMS} , and move the primary coupler directly to that position. Odachi 13:32-38.

123. This same process can then be repeated to align the coils along the Y-axis, which is the "vehicle longitudinal direction." Odachi 14:19-32. In this arrangement, the support arm is "extensible linearly toward and away from the vehicle." Odachi 14:5-34.

124. Once the support arm moves the primary inductive coil to position XA in either the X-axis, Y-axis, or both, a “Z-axis motor” uses an “elevator” to move the primary inductive coil upwards along the Z-axis to a “position where the primary inductive coupler 230 is engaged with the secondary receptacle 2.” Odachi 11:55-12:7. This can be done by moving the elevator upward to a “predetermined position,” or alternatively, “automatic positioning” can be applied to the Z-axis by measuring coupling just as described above for the X- or Y-axes. Odachi 11:50-12:7; 13:2-9.

125. Odachi’s claims confirm that this automated positioning process can be used to automatically position the primary coupler in the best-aligned position in the X-, Y-, and Z-axis directions. For example, Claim 4 explains that “moving means for moving said primary device” can move the primary device in “a first direction,” a “second direction other than said first direction,” and a “third direction other than said first and second directions.” Odachi Cl. 4. Claim 2 similarly explains that the primary inductive device “is movable in three dimensional directions.” Odachi Cl. 2.

B. Claim 15: Moving Transmitting Antenna Laterally

126. Claim 15 recites “the method of claim 13, wherein moving one of the receiving antenna and the transmitting antenna comprises moving the transmitting antenna laterally relative to the receiving antenna.” Odachi discloses this.

127. As I explained above for element 13[b], Odachi's primary inductive device (the transmitting antenna) moves laterally relative to the secondary inductive device (the receiving antenna), for example along the x-axis or the y-axis. *See* Element 13[b]; Odachi 11:6-59 (describing movement along the "x-axis"), 14:19-32 (describing movement "in the vehicle longitudinal direction" along the Y-axis, performed in the same manner as the above-described X-axis), 11:60-12:7.

128. I note that Odachi's described directional adjustments are the same as what the '654 patent specification describes: an "x-y offset" or movement in the X-axis or the Y-axis directions. '654 Patent 6:15-24.

X. Ground 1b: Claims 1, 7, and 18 are Unpatentable Over Odachi and Wang

129. For the reasons discussed below, it is my opinion that Odachi with Wang teaches or renders obvious every element of claims 1, 7, and 18 of the '654 patent.

130. Specifically, as I explain further below, a POSA would have modified Odachi to use a compensating capacitor in series or in parallel with each of its transmitting and receiving coils (as taught in Wang) to yield a more efficient power transfer system. That modified system then meets every element of claims 1, 7, and 18.

A. Claim 1

1. Claim Element 1[pre]: Preamble

131. The preamble of Claim 1 recites “[a] transmitter system for wireless power.” Odachi teaches this.

132. Odachi’s system “charg[es] a battery of an electric vehicle” by using “inductive coupling” between a “primary coil connected to a power source” and a “secondary coil connected to the battery.” Odachi Abstract, *see also, e.g.* Odachi 12:14-26 (“During the battery charging operation, the primary current flow[s] in the primary coil 32 and secondary current [is] induced in the secondary coil”).

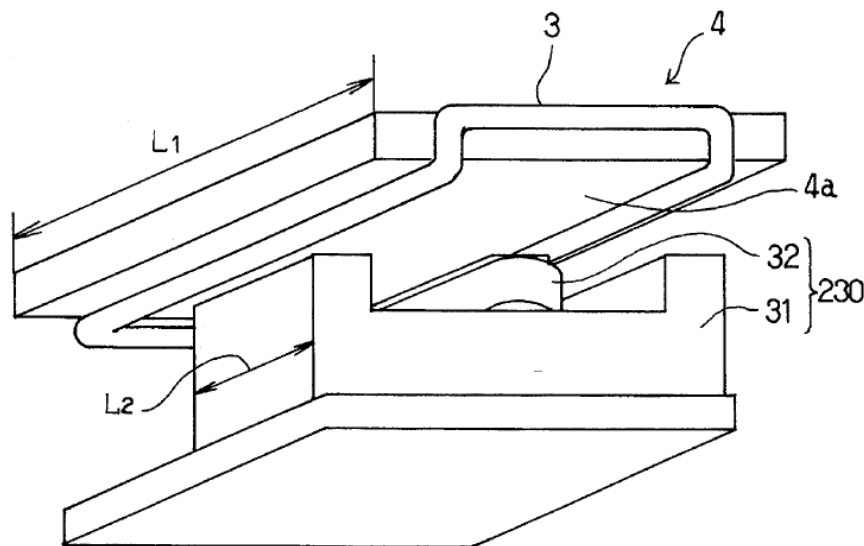
133. A POSA would have understood that Odachi’s system provides “wireless power” because it uses inductive coupling. Odachi Abstract. In other words, the current in the secondary coil exists because “the primary current flowing in the primary coil 32” creates a “secondary current induced in the secondary coil” — not because any current travels from the primary coil to the secondary coil by wire, or by any physical electrical contacts. Odachi 12:14-26. A POSA would have understood inductive coupling, as in Odachi, to be a wireless form of power transfer. For example, Wang explains that the term “inductively coupled” indicates a system that operates with “no physical contact between the primary and secondary.” Wang i.

134. I note that the ’654 Patent explains “wireless power” in a manner that is consistent with the explanation I provided above:

The words “wireless power” is used herein to mean any form of energy associated with electric fields, magnetic fields, electromagnetic fields, or otherwise that is transmitted from a transmitter to a receiver without the use of physical electromagnetic conductors.

'654 patent 2:5-9. Odachi provides “wireless power” under this description, as power is transferred from the primary coil to the secondary coil by magnetic or electromagnetic fields via inductive coupling, and not by the use of physical electromagnetic conductors. Odachi Abstract, 8:50-54; 11:60-12:26.

135. Odachi’s other disclosures make clear that its primary coil (“primary inductive coupler 230”) and secondary coil (“secondary coil 4”) exchange power wirelessly, and not through physical contact. For example, Figure 12 below provides a “perspective enlarged view of paired primary and secondary inductive devices.” Odachi 3:63-65.



Odachi Fig. 12. As can be seen in this figure, primary coil 32 is not contacting secondary coil 4. To the contrary, as Odachi explains, when the primary and secondary couplers are “engaged,” the “primary coil” sits “within the cavity 4a defined by the secondary coil 4.” Odachi 11:60-12:7. The primary coil is “smaller than the cavity ... so that a space is formed between the primary and secondary coils on both sides thereof along the major axes of the oval shape.” Odachi 8:40-54.

136. I have been asked by counsel to provide an alternative explanation, if I were to assume that Odachi does not expressly teach a system for “wireless power.” In that case, it nonetheless would have been obvious to a POSA to implement Odachi wirelessly, i.e. with its primary and secondary inductive couplers near to each other, but spaced a slight distance apart and not physically in contact, while remaining coupled for energy transfer.

137. A POSA would have understood, as Odachi states, that “electromagnetic induction occurs between the [primary] coupler and the receptacle when the former comes close to the latter receptacle. As a result, an electromotive force is induced in the secondary coil.” Odachi 6:1-7. In other words, Odachi makes clear that its two couplers need only be “close to” each other, and not in contact, to inductively transfer power. Odachi 6:1-7; *see* Odachi 4:41-47 (power is transferred via “magnetic circuit” that “induce[s] a secondary current

in the secondary coil.”), Fig. 12 (showing coupled coils with gap between them), 3:63-65 (further describing Fig. 12), 8:40-54 (“a space is formed between the primary and secondary coils”). A POSA would have had a reasonable expectation of success in this approach, as it would use the same fundamental operation (i.e. inductive coupling) already disclosed in Odachi.

138. Even if not expressly disclosed in Odachi, a POSA would have understood that inductively coupled systems for charging vehicles could have been, and frequently were, implemented wirelessly, such that this would have been obvious and straightforward to implement. For example, Wang describes an entire field of research into “inductively coupled power transfer” in which “electromagnetic fields [are used] to transfer electric power from a primary source (power supply) to one or more secondary loads (pickups),” with “no physical contact between the primary and secondary.” Wang i. As Wang explains, it was known to use such systems to build “contact-less electric vehicle battery charger[s].” Wang i. As a second example, the Lee paper (Ex. 1021) explains that “inductive power transfer systems” provided “[t]he ability to transmit power without contact,” and notes that “[t]his technology has found application in many fields such as electric vehicles.” Lee 839. As a third example, the Green paper (Ex. 1019) explains that “inductively coupled power transmission (IPT) system[s]” were used to power “electric vehicles.” Green 694. Unlike other methods of power

transfer, such as “electrified tracks,” these systems operated by “magnetic coupling,” and without “physical contact.” Green 694.

139. A POSA would have considered it obvious to implement Odachi in this wireless manner, not just because doing so was well-known but because wireless systems offered more convenience, better reliability, and more safety than wired systems. For example, as the Hu paper (Ex. 1020) explains, in systems that require direct contact between the primary and secondary in order to transfer power, there is “direct friction” between the components, which wears down the system and can cause mechanical failures due to “mechanical wear & tear” or “electrical erosion.” Hu 6. But these problems are not present in an inductively-coupled wireless power transfer system, which makes such wireless systems “very reliable and robust, requiring almost no maintenance.” Hu 6 (also noting that there is no “chemical erosion of the conductors,” and that the “non-contact” system “is not affected by dirt, dust, water, or chemicals”). Hu also notes that wireless inductive power transfer is safer than having current-carrying wires, because “there is no direct electrical contact in the path of the power flow, so it is spark free” and “there are no open live wires, thus the possibility of accidental electric shock is eliminated.” Hu 6.

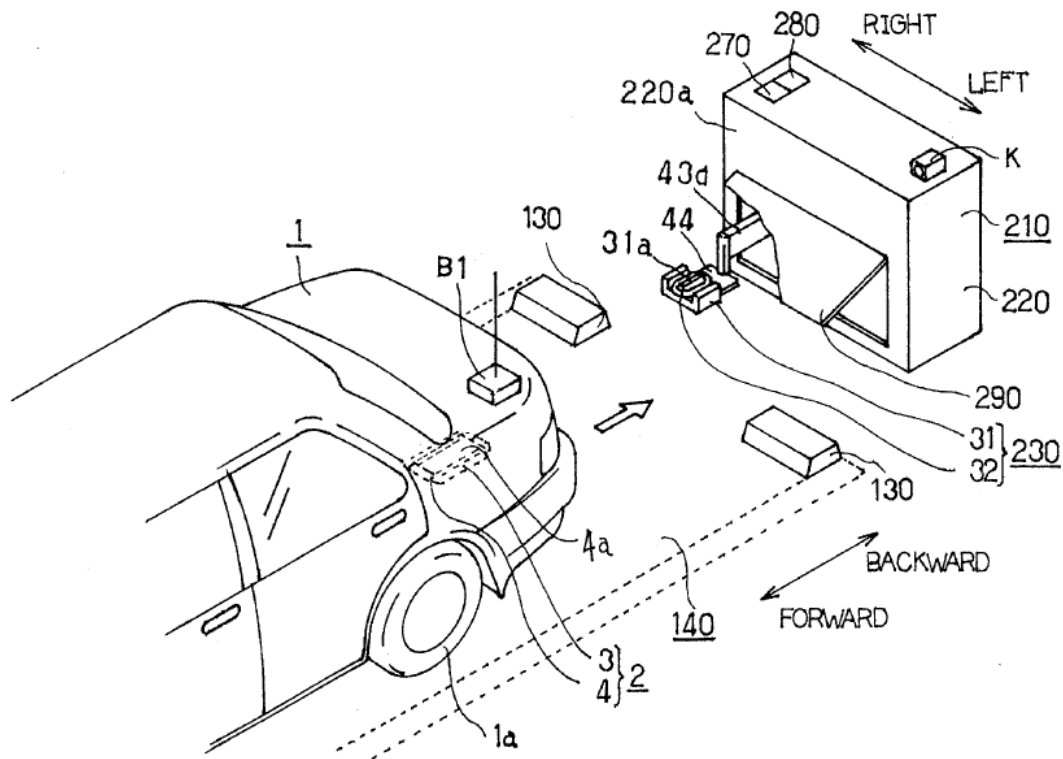
140. The Green paper similarly explained that wireless inductive power transfer was “very advantageous” as compared to transfer via wires or physical

contacts. Green 694. Because there are no electromechanical contacts to keep clean, the system “is immune to dirt, dust, and the environment... and spark free, robust, and reliable.” Green 694. For the same reasons, the Lee paper explained that wireless inductive power transfer systems “enables high reliability and easy maintenance,” such that the technology can be deployed “in hostile environments.” Lee 839.

2. Claim Element 1[a]: Transmitting Antenna

141. Claim 1 next recites “a transmitting antenna including an inductive element and a capacitor, said transmitting antenna being resonant at a first frequency, said transmitting antenna being configured to generate a wireless field for charging a device including a receiving antenna.” Odachi and Wang render this obvious.

142. Odachi discloses a “primary inductive device or coupler 230” as the claimed “transmitting antenna,” which is shown below in Fig. 7. Odachi Abstract, 8:16-28, Fig. 7, *see also* Odachi Fig 6.

Fig. 7

The primary inductive device has a “primary coil 32” wrapped around a “core.” Odachi Abstract, 8:16-54, 9:41-10:18. The primary coil is an “inductive element” of the transmitting antenna. *See Nilsson (Ex. 1024) 186* (explaining that “a coil of wire wound around a supporting core” is an “inductor”).

143. Odachi also describes an “electric vehicle” that has a “secondary inductive device or receptacle 2.” Odachi 8:1-15 (“an electric vehicle 1 in a garage 140 has on the bottom adjacent the rear end and thereof a second inductive device or receptacle 2 comprised of a core 3 and a coil 4 connected to a battery of the vehicle through an appropriate electric circuit.”). This electric vehicle with a

secondary inductive device is the claimed “device including a receiving antenna” that is charged. Odachi 8:1-15.

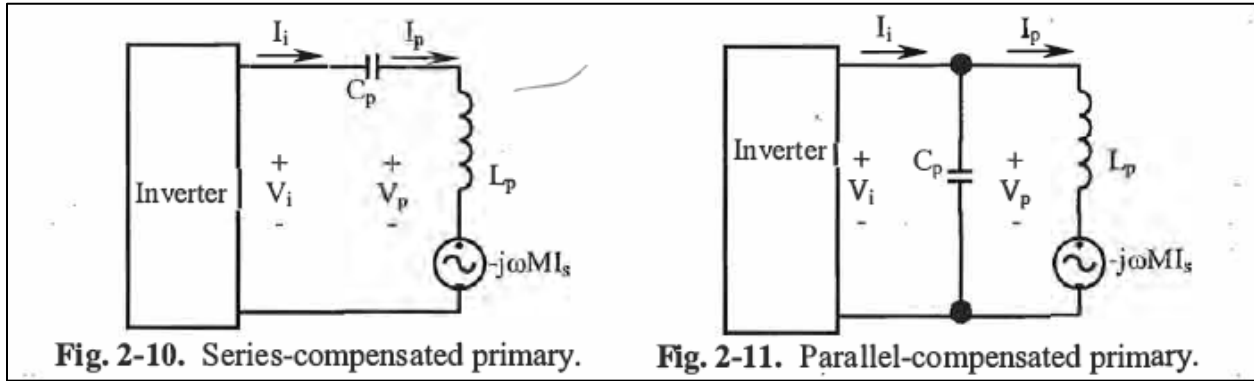
144. Odachi’s primary inductive device “form[s] a magnetic circuit” to “charge” an “electric vehicle” by “engag[ing] with [a] secondary inductive receptacle 230” on the vehicle. Odachi 8:40-48, 12:14-19. A POSA would have understood that in order to transfer energy by inductive coupling, the “magnetic circuit” that Odachi forms is a conduit through which a time-varying magnetic field transfers energy to the secondary receptacle for charging. Odachi 7:27-38 (“the AC current flowing in the primary coil 14 induces a similar current in the secondary coil 4 under the effect of electromagnetic induction and the AC current [is] thus transferred from the primary to the secondary”); 2:37-41 (“electromagnetic induction occurs between the two inductive devices, as a result of which an electric current is induced), 4:34-47 (“a magnetic circuit is formed”), 6:1-12 (“an electromotive force is induced in the secondary coil”); *see also* Nilsson 188 (“inductance is the consequence of a conductor linking a magnetic field”). By its nature, an inductor such as the coil of Odachi’s primary inductive device produces a magnetic field when alternating current is passed through it. This is mandated by the basic laws of induction and electromagnetism, including the Maxwell-Faraday equation. *See* Nilsson 186 (“The behavior of inductors is based on phenomena associated with magnetic fields. The source of the magnetic field is

charge in motion, or current. If the current is varying with time, the magnetic field is varying with time”). Thus, Odachi’s primary inductive device generates a wireless field for charging a device, because it is this wireless magnetic field that “form[s] a magnetic circuit to “charge” the electric vehicle. Odachi 8:40-48, 12:14-19.

145. Odachi does not mention capacitor or a resonant frequency, but a POSA would have found it obvious to include a capacitor connected to Odachi’s primary and secondary coils to create circuits that resonate at a certain frequency and generate (or, for the secondary coil, receive) a wireless magnetic field to charge the vehicle. This would have been a combination of known elements from the prior art (inductive coils and capacitors) using known techniques (forming a resonant circuit) that yielded predictable results (higher-powered inductively charging systems).

146. POSAs were well versed in inductor-capacitor resonant circuits like the ones described in Wang. Wang 47. Wang, like Odachi, describes a system for “inductively coupled power transfer (ICPT)” that uses “electromagnetic fields to transfer electric power from a stationary primary source to one or more movable secondary loads without contact.” Wang 1. In these types of systems, “a capacitor (C_p) can be connected in series ... or parallel ... with the primary winding [or

coil],” as shown in Wang’s Figs. 2-10 and 2-11 below. Wang 22-23, Figs. 2-10, 2-11.



Similarly, “[t]o compensate for the secondary inductance (L_s), a capacitor (C_s) can be connected either in series ... or parallel ... with the secondary winding [or coil].” Wang 20, Figs. 2-7, 2-8. A primary or secondary inductively coupled circuit in which a capacitor is used in series or in parallel with the inductor is referred to as a “compensated” circuit. Wang 20.

147. A POSA would have found it obvious to implement this “compensated” arrangement in Odachi by adding a capacitor C_p in series with or parallel to “coil 32” of the “primary inductive device,” and another capacitor C_s in series with or parallel to “coil 4” of the “secondary inductive device or receptacle” located on the vehicle, as Wang described. Wang 4-7, 11, 20-25, 38 (describing compensation techniques); *see also* Wang-IEEE (Ex. 1025) 996 (“primary parallel compensation is implemented by connecting the primary compensation capacitor C_p in parallel with the primary winding ... The secondary winding L_s is

compensated by the secondary compensation capacitor C_s connected in parallel with the winding”).

148. The use of capacitors to create compensated resonant circuits was well-known even beyond Wang. For example, Elbuluk is a 1986 doctoral thesis from the Massachusetts Institute of Technology that explained that “series-compensated” or “parallel-compensated” loads consisting of a “capacitor ... connected to the ... inductor” were “commonly considered” in the literature even at that time. Elbuluk (Ex. 1014) 19. As Elbuluk explained, compensating “capacitors are usually used with induct[ors]... to improve the power factor.” Elbuluk 19. Similarly, the Cook-086 patent, entitled “Wireless Power Apparatus and Methods,” explained that “well-known resonance equations” were known to be used for adding “a capacitor” to a “loop antenna” in order “to bring the loop antenna to resonance” in inductive power transfer systems. Cook-086 (Ex. 1012) 5:5-22.

149. When compensated, Odachi’s primary inductive device would then operate as a “primary resonant circuit” that is “magnetically coupled with one or more secondary resonant circuits” (the secondary inductive device or receptacle) to “supply power to a load” (Odachi’s vehicle). Wang 47. A POSA would have understood that, when compensated in this manner, Odachi’s primary inductive device would be resonant at a frequency. As Wang explains, a compensated

primary circuit has a “primary resonant frequency (when C_p is in resonance with L_p)” which “is normally designed to equal the nominal frequency.” Wang 23. Likewise, the compensated secondary circuit also has a “secondary resonant frequency (when C_s is in resonance with L_s)” which is “normally designed to equal the nominal frequency.” Wang 20. Thus, the primary circuit is resonant at its primary resonant frequency, and the secondary circuit is resonant at its secondary resonant frequency, both of which can be set equal to the nominal frequency. Wang 20.

150. Further, a POSA would have been motivated to use resonant circuits compensated by use of a capacitor in Odachi’s system because this design involved merely combining known prior art elements (inductive coils and off-the-shelf capacitors) assembled according to known ways (series or parallel resonant circuits) that produce predictable results (an inductive wireless power transfer system). Wang explains that compensating capacitors were not just sometimes used, but “[b]oth the primary and secondary of the electromagnetic structure” of an inductively coupled system” were “*often* compensated by capacitors to boost the power transfer capability of the pickup, while minimizing the VA rating of the power supply.” Wang 20. This was common enough that Wang refers to methods of compensating capacitors as a “basic compensation topologies.” Wang 20.

151. Further, Wang explains that the “*majority*” of “inductively coupled power transfer systems” operating “in the medium-high power range” were “compensated” with capacitors this way. Wang 47-48; *see also* Wang 4 (stating that “primary and secondary” coils were “*normally* compensated by capacitors”). A POSA would have understood, as Wang explains, that a contactless vehicle charger is the sort of medium-high power system that benefits from compensation. *See* Wang 71-72, 105 (30 kW contactless vehicle charger); Wang-IEEE 5 (30 kW “electric vehicle battery charging”).

152. Also, a POSA would have been motivated to use capacitor-compensated circuits as Wang describes in order to increase Odachi’s power transfer efficiency. As Wang explains, the reason that “primary and secondary” coils were “often compensated by capacitors” was to “boost the power transfer capability of the pickup, while minimizing the VA rating of the power supply.” Wang 20; *see* Wang 4 (A “high frequency,” which “is normally compensated by capacitors,” is needed “to increase the amount of power transferred”). Thus, relative to uncompensated circuits, “series and parallel secondary compensation improve the power transfer capability of the pickup.” Wang 21; *see also* Wang-IEEE 995 (explaining that “resonant circuits are normally employed in the primary and/or secondary networks [of ICPT systems] to boost the power transfer capability”). Likewise, compensation by using a capacitor creates “useful”

“voltage gain” or “current gain” in the primary coil. Wang 23-24; *see* Wang 38 (“The objective of series primary compensation is to achieve a voltage gain between the switching power supply and the primary coil, whereas parallel primary compensation is utilized to obtain a current gain”).

153. A POSA would have appreciated that by transferring power more efficiently or at higher voltage or current gain, Odachi’s modified system could charge larger, powerful vehicles, charge vehicles quicker, and overcome obstacles that might otherwise impede transfer efficiency. Wang 4-5 (describing “high power applications” of “inductive power transfer”).

154. A POSA could have implemented Wang’s resonant compensated circuits in Odachi’s system without much difficulty, and had a reasonable expectation of success in doing so, because this arrangement was well known to POSAs. As Wang explains, capacitors were “often” used to “boost the power transfer capability” in inductively coupled systems. Wang 47. These circuits — both uncompensated primary and secondary circuits (as originally in Odachi) and compensated circuits (as a POSA would modify Odachi) — were “fundamental” or “basic compensation topologies” with circuit diagrams and functionalities that were well known to a POSA. For example, as shown below, the “nine fundamental compensation topologies” included the “uncompensated primary and secondary”

originally used in Odachi, and four arrangements in which both the primary and secondary are compensated, either in series or in parallel.

2-3.5 BASIC COMPENSATION TOPOLOGIES

Three basic compensation choices exist for both the primary and secondary (series compensation, parallel compensation, or uncompensated). Combining the primary and secondary results in nine fundamental compensation topologies [18] as illustrated in Fig. 2-12.

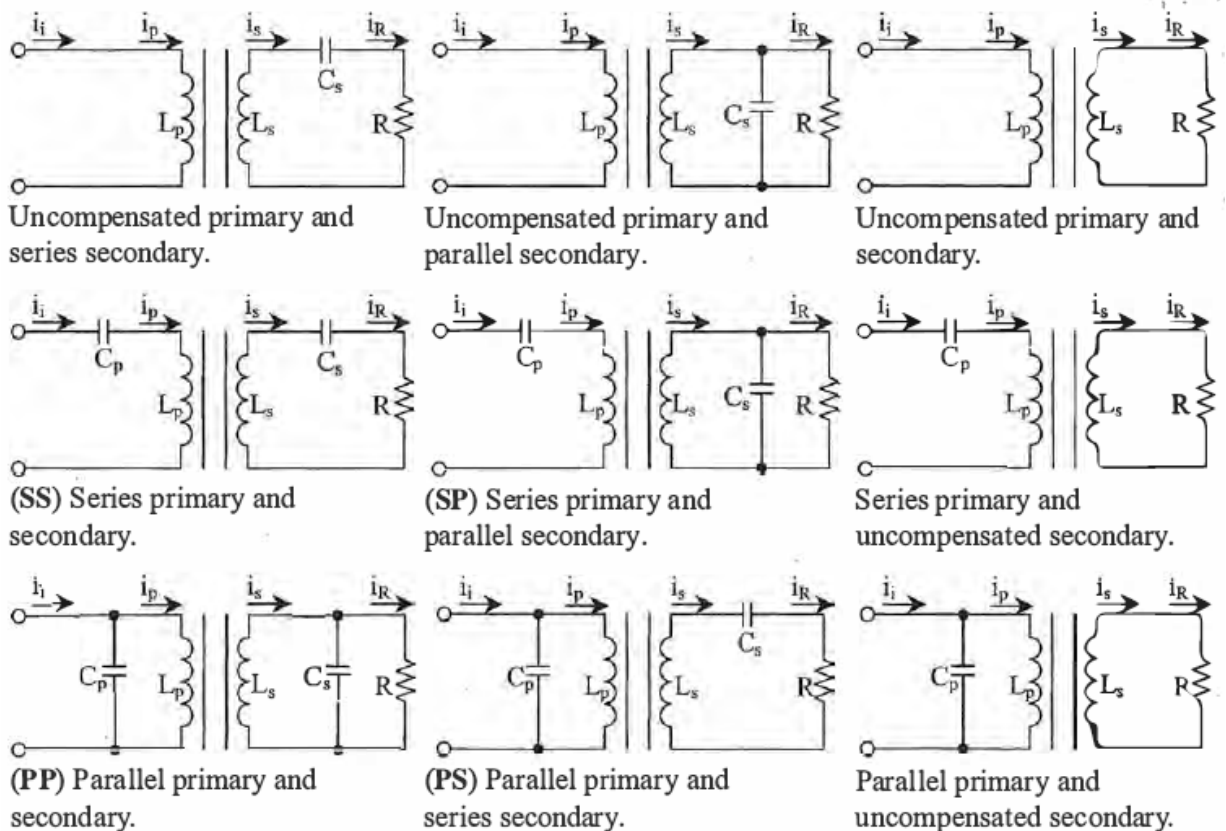


Fig. 2-12. Basic compensation topologies of ICPT systems.

Wang 24; *see also* Stielau (Ex. 1017) 86 (describing these circuits as “basic compensation topologies”).

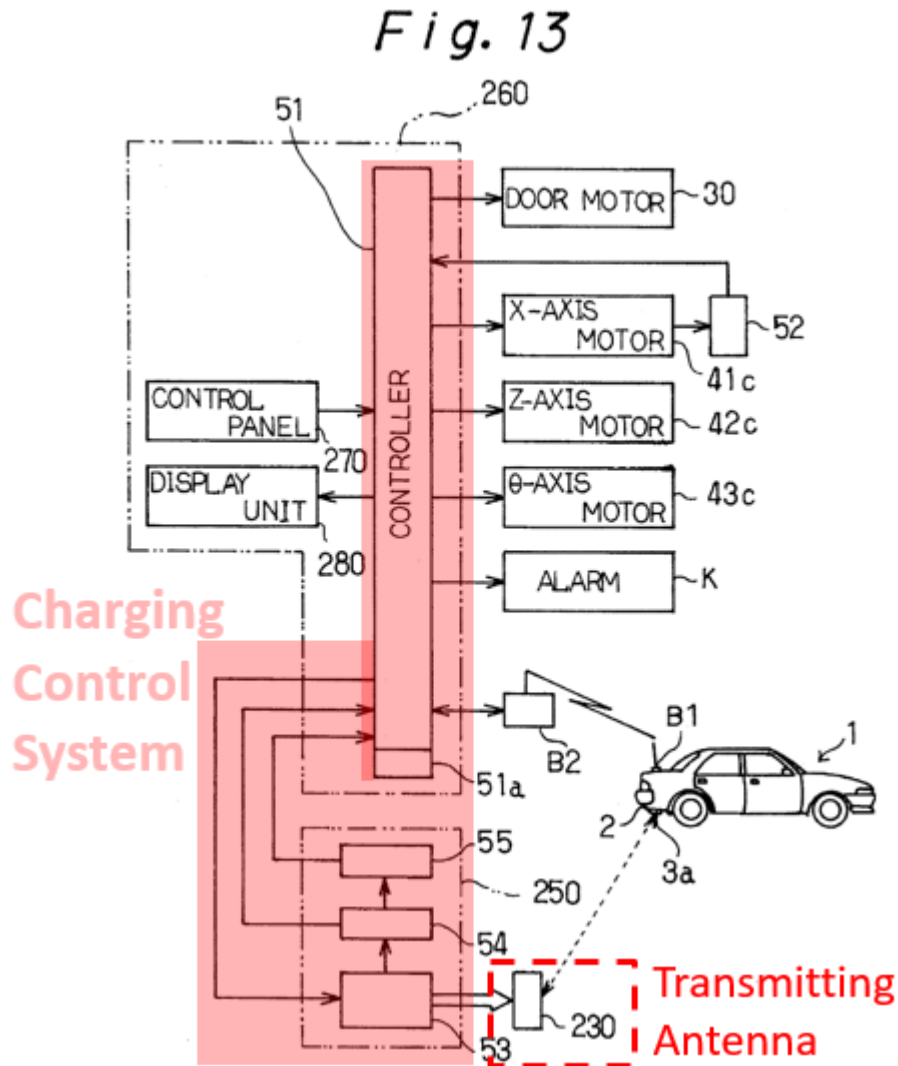
155. For all of the reasons above, a POSA would have considered it obvious to implement Odachi in view of Wang to have a compensated

arrangement, in which the primary inductive device (transmitting antenna) would then include a capacitor (compensating capacitor) and become resonant at a first frequency (the primary resonant frequency). The primary inductive device would continue to have an inductive element (primary coil) and to generate a wireless magnetic field for charging an electric vehicle via inductive coupling to the secondary inductive device.

3. Claim Element 1[b]: Charging Control System

156. Claim 1 next recites “a charging control system coupled to said transmitting antenna and configured to generate a signal at said first frequency and provide said signal to said transmitting antenna.” Odachi and Wang render this obvious.

157. Odachi’s “controller 51” and “power unit 250” collectively form a charging control system. That charging control system is coupled to the transmitting antenna, “primary inductive coupler 230,” as I have annotated in Fig. 13 below. Odachi Fig. 13.



Odachi Fig. 13 (annotated). Power unit 250 has a “power circuit 53,” which as shown by the arrows in the above figure is “connected to the controller 51” and also connected to “the primary coil 32 of the inductive coupler 230.” Odachi 10:13-30.

158. Odachi’s charging control system is configured to generate a signal (an “AC charging current”) at a first frequency, and provide this signal to the transmitting antenna. For example, Odachi explains that the power circuit 53

“selectively suppl[ies] to the coil an electric current for battery charging.” Odachi 10:13-30. As Odachi further explains, the system “generate[s] a charging mode signal to the power circuit 53, which, then responding to the signal from the controller, starts to supply a charging current to the primary coil 32 of the inductive coupler 230, thereby initiating the battery charging operation.” Odachi 12:8-14. By using this signal, Odachi’s controller “control[s] the primary current or voltage so that secondary current of constant value flows in the secondary coil.” Odachi 5:18-39, 7:27-38, 12:13-26.

159. Odachi does not specify which frequency the AC charging current is provided at and instead leaves that detail open for a POSA to implement. Odachi 5:18-39, 7:27-38, 12:13-26. When, as described above for Element 1[a], Odachi is implemented with compensating capacitors, the AC current signal that the power circuit 53 provides to the primary inductive coupler device would have the same frequency as the primary inductive device’s resonant frequency, in order to ensure maximum power transfer. *See* Element 1[a].

160. In other words, the AC charging signal is generated at the resonant frequency, because when the signal is fed to the compensated primary coil, it will cause the resonator to oscillate at that resonant frequency, which yields the best power transfer to the secondary coil. As Wang explains, an alternating current at “operational frequency ω ” drives the compensated primary circuit, and the

“primary current is normally controlled at the maximum rating to ensure maximum power transfer capability.” Wang 19, 16-17; *see also* Wang 17 (“a constant current I_p at a known frequency ω flows in the primary”). This “maximum power transfer” is “normally” achieved” by having the “secondary resonant frequency” and “primary resonant frequency” each “equal the nominal frequency (ω_0),” and then setting the “operating frequency around the resonating frequency (ω_0).” Wang 20, 23, 31-32; *see* Wang 32 (“the secondary resonant frequency is designed to be equal to the operating frequency in order to ensure maximum power transfer to the pickup”). Thus, a POSA implementing Odachi with compensated circuits would obtain maximum power transfer by ensuring that the secondary and primary have the same resonant frequency, and then operating the primary inductive device at that frequency by providing it with an AC charging current (the signal provided from the power unit) driven at that same frequency. Wang 20, 23, 31-32, 52 (explaining that the “magnetic coupling between the primary and secondary ... is dependent on the operating frequency of the primary power supply”).

161. A POSA would have known and been able to drive Odachi’s compensated primary device with a current signal that has an operating frequency equal to the resonant frequency of the primary and secondary coils, and this could be designed or determined using the formulas that Wang provides. *See* Wang 20-21 (providing formulas showing effect of “secondary compensation capacitance”

on nominal frequency and “pickup power”), 22-24 (providing the same for primary compensation).

4. Claim Element 1[c]: Alignment Controller

162. Claim 1 next recites “an alignment controller configured to test coupling of said transmitting antenna to the receiving antenna in the first alignment position and based on a degree of the coupling, the alignment controller further configured to adjust an x-y alignment of the transmitting antenna relative to the receiving antenna from the first alignment position to a second alignment position having a finer alignment between the receiving antenna and the transmitting antenna than the first alignment position to improve said coupling.” Odachi discloses this.

163. As I explained above for Element 13[b], Odachi discloses a “controller” that, when set in “positioning mode,” moves the primary inductive coupler from its “home position” along any or all of the X-axis, the Y-axis, and/or the Z-axis until it reaches “target position XA,” which is the position “where the coupler is just aligned with the secondary inductive receptacle.” *See* Element 13[b]; Odachi 11:6-59, 10:13-30; 13:46-53; 14:12-32.

164. Odachi determines the “target position XA” by sweeping the primary inductive coupler on a support arm across the region where the secondary coupler is located, and monitoring either a current across the primary coil (check current

I_{RMS}) or a voltage across the secondary coil (check voltage V_{RMS}). *See* Element 13[b], Odachi 10:13-30, 11:6-59, 13:39-64; 14:12-32

165. To be more specific, Odachi's system contains a circuit that compares either I_{RMS} or V_{RMS} to a reference value, and generates a high or low value signal indicating whether I_{RMS} or V_{RMS} is higher than, or lower than, the reference value. Odachi 10:13-30, 11:6-59, 13:39-64; 14:12-32. The positions of the coupler when the signal switched from high-to-low, or vice versa, are stored in memory as positions "X1" and "X2," and are averaged to determine "target position XA." Odachi 10:13-30, 11:6-59, 13:39-64; 14:12-32. Based on those calculations, the system then moves primary coupler to position XA, where it is best aligned with the secondary coupler for increased coupling. Odachi 10:13-30, 11:6-59, 13:39-64; 14:12-32; *see* Element 13[b].

166. This same functionality teaches Element 1[c]. Odachi's "controller" and related motors and circuitry function as an "alignment controller" because they set the system into "positioning mode" and ultimately enable the primary coupler to be automatically brought into an "alignment position XA" with the secondary coupler, such that inductive coupling can occur. Odachi 11:3-17, 11:55-12:7.

167. This controller and related circuitry is "configured to test coupling" of the transmitting antenna to the receiving antenna in a first alignment position. As the primary inductive coupler is swept across the region of the secondary

coupler, I_{RMS} and V_{RMS} are being constantly “monitored” and compared to a reference voltage. Odachi 6:1-45, 13:39-64, Figs. 4-5. For example, I_{RMS} and V_{RMS} are monitored when the primary coupler is at its “operative home position... E1,” and at every point along its movement path including positions “X1” and “X2.” See Element 13[b], 10:13-30, 11:3-59, 13:39-64; 14:12-32. Each of these positions of the primary coupler can constitute a “first alignment position.”

168. At each first position, Odachi’s monitoring of I_{RMS} and V_{RMS} , and its comparison of those values to a reference value, constitutes “test[ing] coupling,” because I_{RMS} and V_{RMS} change proportionally to the “electromagnetic induction ... between the coupler and the receptacle.” Odachi 6:1-45 (describing how I_{RMS} varies with coupling as primary device comes closer to and further from secondary device); 11:17-32 (confirming same for second embodiment); 13:39-64 (same for V_{RMS}). I_{RMS} and V_{RMS} indicate the degree of “coupling” because their changes directly (or inversely, in the fact of I_{RMS}) reflect changes in the amount of power being transferred to the secondary coupler via inductive coupling. Odachi 6:1-45, 11:17-32, 13:39-64. As Odachi explains, what is being measured is “the relative position ... where the electromagnetic force induced in the secondary coil becomes the greatest.” Odachi 6:12-27. I note that this is the same manner of testing coupling that is mentioned in the ’654 patent: “a measurement of the amount of power that is transferred to the receiving antenna.” ’654 Patent cls. 18-19.

169. In response to this testing, Odachi's alignment controller adjusts the X-axis, Y-Axis, and/or Z-axis of the primary antenna by moving the antenna to "target position XA." Odachi 11:42-59, 13:52-64, 14:19-32, 6:33-45, 7:10-13, 7:51-58, Figs. 4-5; *see* Element 13[b]. This is the claimed second alignment position. At this position, there will be finer alignment and better coupling between the primary and secondary, as position XA is the position "where the [primary] coupler is just aligned with the secondary inductive receptacle," i.e. the position where coupling is the strongest, as shown in the monitored I_{RMS} and V_{RMS} values. Odachi 11:50-59, 13:20-25 (coupler is "brought automatically into alignment"), 6:13-27 ("the primary inductive coupler 6 is positioned closest to, or in alignment along the X-axis with, the secondary inductive receptacle 2, as indicated at XA"), 6:16-27 ("the primary inductive coupler 6 can be considered to be in alignment with the secondary inductive receptacle 2 along the X-axis in the relative position thereof where the electromotive force induced in the secondary coil 4 becomes the greatest"), 9:41-52 ("the alignment position where the coupler is positioned just below the secondary receptacle 2 in facing relation to one another").

170. This alignment process would work in substantially the same way when Odachi's circuits are capacitor-compensated as taught by Wang.

B. Claim 7: Transmitting Power

171. Claim 7 recites “the transmitter system of claim 1, wherein said charging control system [is] configured to generate a signal of a type that, when output to said transmitting antenna, transmits power to a remote receiving antenna.” Odachi and Wang render this obvious.

172. As I explained above for Element 1[b], Odachi’s controller with power unit (i.e. the charging control system) generates an AC current signal that, when provided to the primary inductive device (i.e. the transmitting antenna) transmits power to the secondary inductive device mounted on the electric vehicle (i.e. the remote receiving antenna). *See* Element 1[b]; Odachi 11:60-12:26 (“the power circuit ... responding to the signal from the controller, starts to supply a charging current to the primary coil 32 of the inductive coupler 230, thereby initiating the battery charging operation.”), Fig. 13.

173. The AC current signal is of a type that transmits power because, as Odachi explains, “the primary current flowing in the primary coil” is what creates the “secondary current induced in the secondary coil,” resulting in the secondary device receiving power to charge its battery via . Odachi 12:14-26 (“the controller 51 controls the battery charging operation by controlling the primary current or voltage”).

C. Claim 18: Measuring Power

174. Claim 18 recites “the apparatus of claim 1, wherein the coupling test comprises a measurement of the amount of power that is transferred to the receiving antenna.” Odachi and Wang render this obvious.

175. As I explained above for Element 1[c], and also for Element 13[b], Odachi teaches that coupling is tested by monitoring I_{RMS} or V_{RMS} and comparing it to a reference voltage at various positions of the primary coupler including E1, X2, and X2. *See* Elements 1[c], 13[b]; Odachi 10:13-30, 11:6-59, 13:39-64; 14:12-32.

176. This coupling test is a measurement of the amount of power that is transferred to the receiving antenna, as I_{RMS} and V_{RMS} each directly or inversely indicate the amount of power transferred to the receiving antenna. V_{RMS} directly indicates the “voltage ... across the secondary coil on the vehicle,” which is one component of the transferred power. Odachi 13:39-64. I_{RMS} is “smallest” “where the electromotive force induced in the secondary coil ... becomes the greatest,” and thus inversely indicates the amount of power transferred to the secondary coil. Odachi 6:4-27. Because the instantaneous power received by the secondary coil is equal to the induced current multiplied by the induced voltage ($P=VI$), as a POSA would know, these measurements constitute measurements of the amount of power that is transferred to the receiving antenna.

XI. Ground 1c: Claims 4-6 Are Unpatentable Over Odachi, Wang and Partovi

177. For the reasons discussed below, it is my opinion that Odachi with Wang and Partovi teaches or renders obvious every element of claims 4-6 of the '654 patent.

178. Specifically, as I explain further below, a POSA would have modified Odachi to use an array of coils (as taught in Partovi), rather than a single primary coil, as its transmitting antenna. That modified system (with compensating capacitors as I explained earlier) meets every element of claims 4-6.

A. Claim 4: Antenna Array

179. Claim 4 recites “the transmitter system of claim 1, wherein said transmitting antenna includes an array of antennas that extend over a specified area of a parking space.” Odachi, Wang, and Partovi render this obvious.

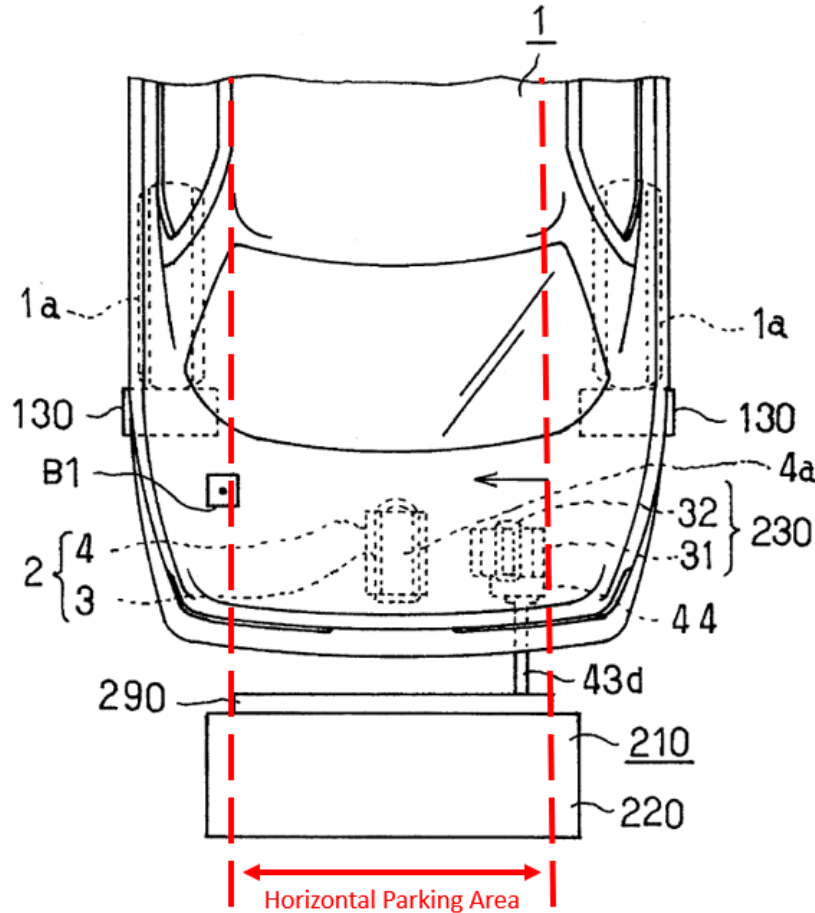
180. As I explained in my Overview, Partovi discloses an “inductive power source and charging system” that uses “multiple coils or sets of wires” in an “array,” rather than a single coil. Partovi 6:33-40, 8:60-9:6. By covering “the total area” of the charging space with multiple coils, Partovi’s system “allow[s] the operation of the mobile device charger regardless of position of the mobile device.” Partovi 8:52-59.

181. It would have been obvious to a POSA to implement Odachi (including when compensated, as described by Wang) to use an array of “multiple

coils,” as taught by Partovi, in place of the single primary coil described in Odachi. As detailed below, doing so would expand the “total area” that the charging system could reach, allowing for vehicles to be charged “regardless of [the] position of the [vehicle].” Partovi 8:53-59.

182. As Odachi explains, one of the goals of a wireless charging system is to “widen the permissible distance within which the vehicle should be parked.” Odachi 3:18-22, 12:42-52. Odachi does this by having the vehicle parked “against the [wheel] stops,” but this provides fairly limited range within which to charge the vehicle. Odachi 9:52-65. As Odachi acknowledges, its system allows for only “slight error” in the parking of the vehicle. Odachi 12:1-7.

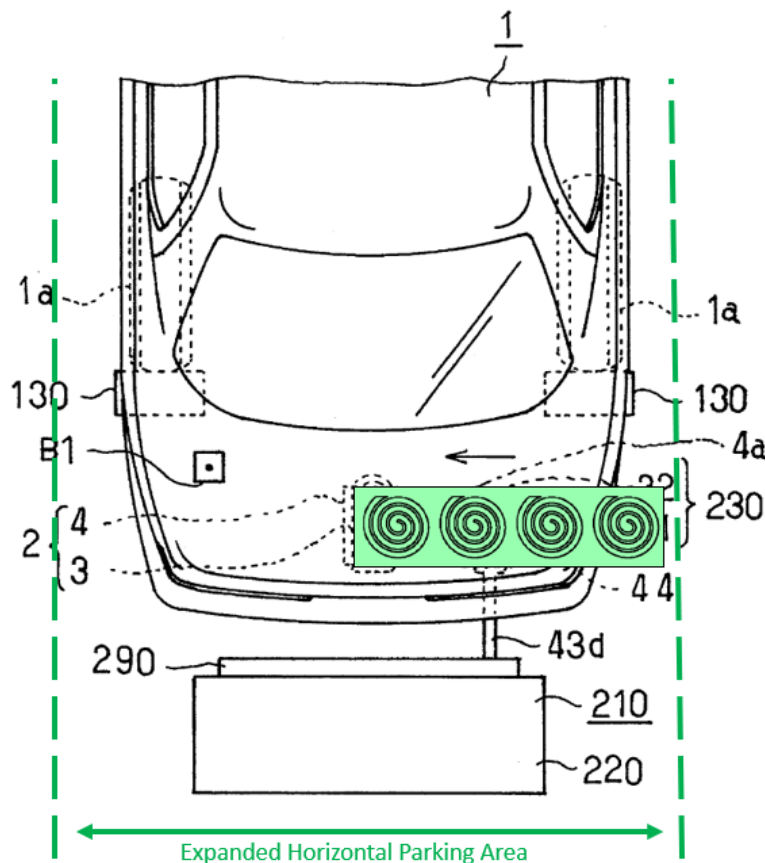
183. I have annotated Odachi’s Figure 11 to show the limitations of Odachi’s existing system.



Odachi Fig. 11 (annotated). While Odachi's unmodified system allows for some error in parking, the vehicle must be parked such that the secondary receptacle (2) is within the red horizontal parking area (i.e. the horizontal range of the primary coupler (230)). If the car is parked in such a way that its secondary coil falls outside of this horizontal range, the primary coil will not be able to reach the secondary coil, and so may not be able to charge the vehicle. Odachi 8:1-15, 2:33-55 (explaining that primary coupler must be “substantially close[]” to the secondary coupler for inductive charging), 6:6-27 (when the primary coupler is “away from the secondary receptacle ... the induced current in the secondary coil

is decreased”), 9:52-64 (secondary inductive receptacle must be “within the stroke range” or within “the range of movement ... of the primary coupler”).

184. In view of Partovi’s teaching of using multiple coils to increase the “total area” in which successful charging can occur, a POSA would have mounted an array of coils, rather than a single primary coil, on Odachi’s support arm 43(d). I have annotated one exemplary version of this combination below. As shown below, this modification would allow the array of coils to extend over a larger area of the parking space, and thus expand the “total area” in which the system can successfully charged a parked vehicle. Partovi 8:53-59.

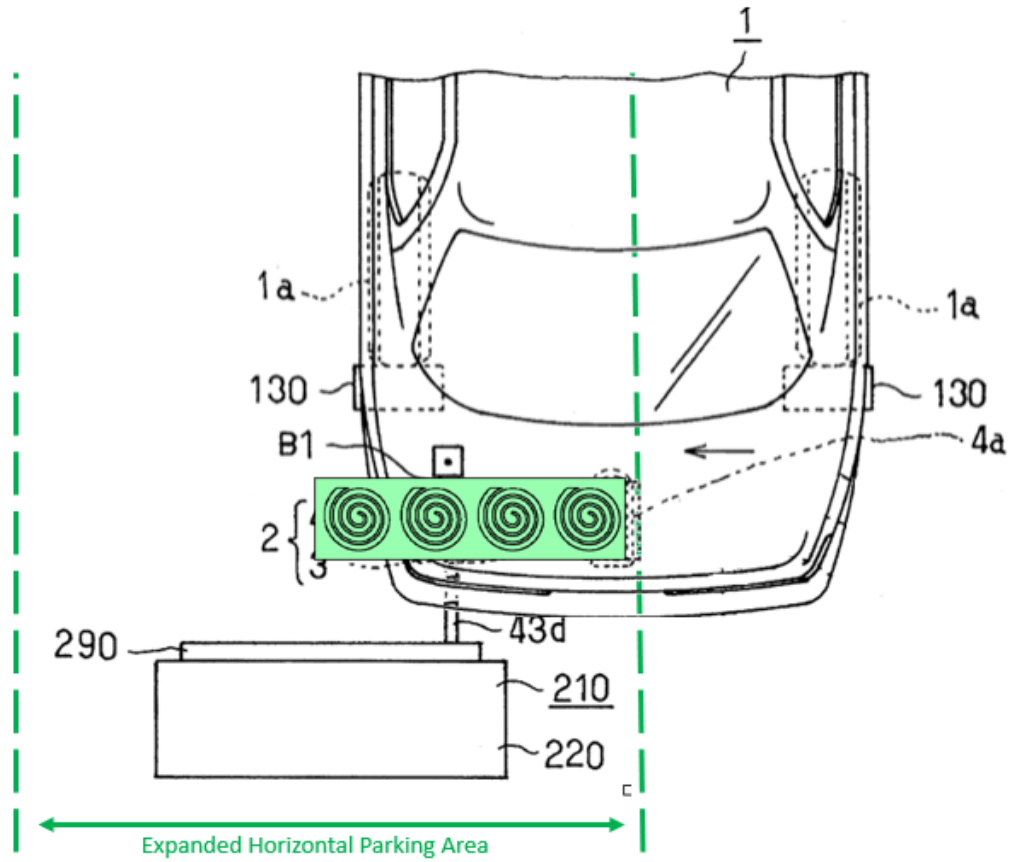


Odachi Fig. 11 (annotated with excerpted coil array from Partovi Fig. 3). By using an array of coils with wider total horizontal width, the horizontal parking range in which a vehicle can be parked for successful charging is expanded. Thus, vehicles that are parked in a less-centered manner can now be charged, as can larger vehicles, and vehicles whose shape otherwise prevents center-mounted vehicle coils. This further achieves Odachi's stated goal of "free[ing]" the vehicle driver "from laborious parking operations in positioning" the vehicle precisely. Odachi 7:39-50; 10:43-55 (vehicle must be "parked properly" to utilize Odachi's controller).

185. I note that while I have shown the coils above to be shaped like Partovi's coils for graphical clarity, a POSA could and would have created an array of coils each having the same size and shape as Odachi's original oval primary coil. Odachi Fig. 7, 11, 12, 8:1-11, 8:40-54 (describing shape). This would reduce any compatibility concerns with Odachi's existing secondary coil. In addition, although I have depicted the array above as a 1x4 coil array, it would have been obvious for the same reasons to create a larger array, such as a 3x4 or even 4x4 array, to cover even more area and allow charging of cars parked with even more error. For example, Odachi explains that its positioning system can also be used in the "vehicle longitudinal direction" (i.e., the Y-axis), and so a 4x4 array of coils

would extend the available charging area in both the X-axis direction and the Y-axis direction. Odachi 14:19-34.

186. Below, I have modified Odachi's Figure 11 to show a further example of how modifying Odachi to use an array of coils is beneficial. The car below is parked significantly off-center, in such a way that its secondary inductive coupler would have been outside the range of Odachi's original, unmodified, primary coupler. *See* Odachi 12:1-7 (system allows for only "slight error"). However, the use of an array of antennas expands the horizontal range of the charging system, allowing for the primary coupler to be properly aligned with, and effectively couple to and charge, the poorly-parked vehicle. Although I have shown this example with a car parked far rightward, this would be equally true, for example, with a car parked far leftward, or a car parked far backward.

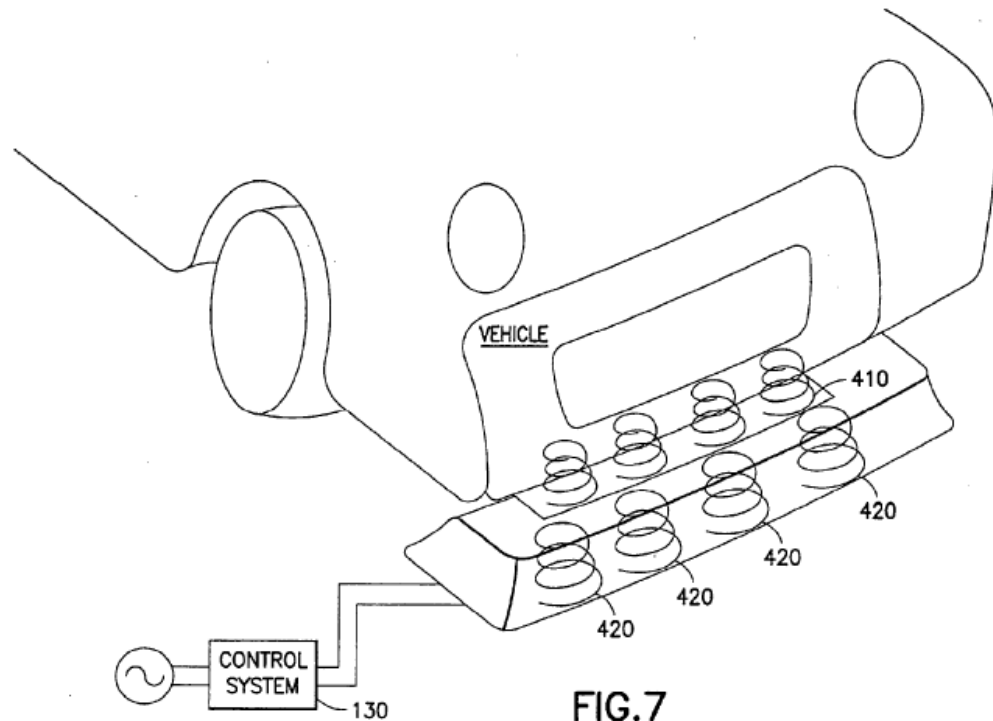


Odachi Fig. 11 (modified to show off-center parked car, and annotated with Partovi Fig. 3). In this manner, utilizing a coil array “widen[s]” “the range of permissible distance along the X-axis within which the vehicle should be parked,” which Odachi states (and a POSA would have understood) was beneficial in a charging system, in order to allow charging even of poorly-parked vehicles. Odachi 12:43-52. It is possible, in this arrangement, to transfer as much power as through Odachi’s original system. Even if that were not the case, however, a POSA would have considered it a suitable tradeoff to use an array of smaller coils with potentially less power transfer, in order to be able to charge vehicles that were less well-aligned in their parking. After all, without the array, a vehicle may be out of

the charging range entirely (no power transferred), and so even lower power transfer with smaller coils would have been more beneficial and less restrictive than not charging at all.

187. A POSA would have had a reasonable expectation of success in implementing this arrangement, as additional “coils” could have been added in the well-known manner already disclosed in Odachi. Odachi 4:16-34 (“primary coil 14 is wound ... with the axis of the coil winding extending in the same direction as the secondary coil”). A POSA would have understood, as Partovi explains, that no further specialized techniques or knowledge were needed to create a coil array. Partovi Abstract (stating that its invention can be implemented “by means of applying an alternating current to a winding, coil, or any type of current carrying wire.”).

188. A POSA also would have had a reasonable expectation of success in this arrangement because it would have already been well-known to a POSA to use a coil array to wirelessly charge devices, including in vehicle chargers. Mashinsky, for example, charged a vehicle using “short distance coupling” with “transmitters located in or on the road,” including “an horizontal or vertical array of conducting wires to create resonance” and transfer power wirelessly. Mashinsky (Ex. 1013) [0053], Figs. 7-8. This use of an array of multiple coils is physically similar to where Odachi’s array of coils would be located, as shown below.



Mashinsky Fig. 7. Similarly, Boys-638 described “an array of conductors beneath a roadway to allow powering of vehicles.” Boys-638 (Ex. 1009) 5:1-19, Figs. 12-13. Ross, which I describe in much more detail in Ground 2, disclosed using an array of “several [transmitting coil] modules ... laid end-to-end” to charge a vehicle. Ross 15:47-16:22. And Choi disclosed an inductive charging system using a “sending coil array including a plurality of sending coils.” Choi (Ex. 1015) Abstract, 2:35-56, 5:49-56 (inductive charger “of the present invention does not have a single coil ... but instead has a coil array including a plurality of coils” which “achieves the positional conformation between a primary coil and a secondary coil more easily than ... a single coil”).

189. Thus, a POSA would have viewed modifying Odachi to include Partovi's array of coils as simply a combination of known prior art elements (coils in an inductive charging system) according to known methods (placing coils in an array) to yield predictable results (a wireless power transfer system with increased "total area" of possible power transfer), and therefore would have considered it obvious.

B. Claims 5-6: Antenna Selection and Switch

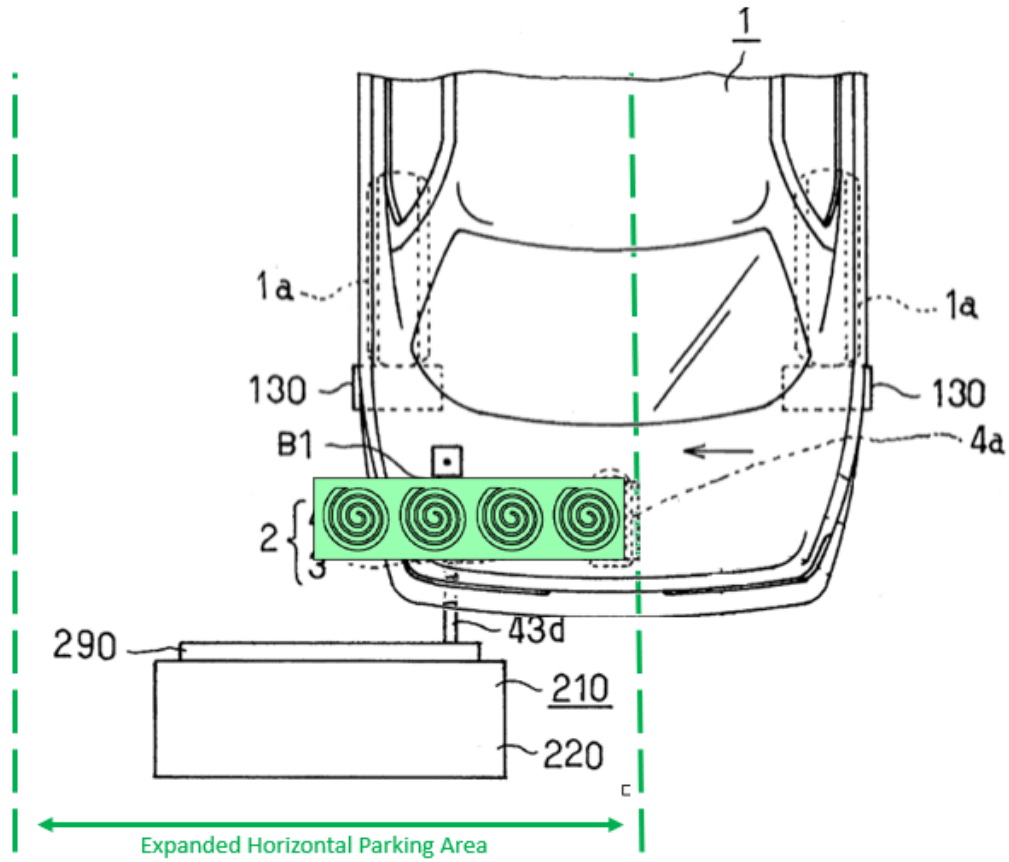
190. I address claims 5 and 6 together because they are closely related, and obvious for the same reasons.

191. Claim 5 recites "[t]he transmitter system of claim 4, wherein said charging control system is further configured to select one of said antennas of said array" and claim 6 recites "[t]he transmitter system of claim 5, further comprising a switching device connected between the charging control system and each of the antennas of the array, the switching device configured to transmit the signal to the selected antenna of the array." Odachi, Wang, and Partovi render these claims obvious.

192. A POSA, in implementing Odachi to use an array of coils, would have found it obvious to include Partovi's "switch in the base unit" that "selectively switch[es] or activate[s]" one of the primary coils at a time to charge the vehicle. Partovi 26:23-30. To make this modification, a POSA would have included a

switch between Odachi's "power circuit 53" and its "[array of] primary coil[s]." Odachi 10:13-30; Fig. 13. When the power circuit "selectively suppl[ies] ... an electric current for battery charging," it would supply that current to the switch, and the current would be provided from the switch only to the one selected primary coil in the array—the coil that is best-coupled to the secondary coil. Odachi 10:13-30, Fig. 13.

193. As exemplified in the modified figure below showing Odachi's Fig. 11 with Partovi's Fig. 3, only the right-most coil would be activated to charge the parked vehicle because that is the coil closest to, and best coupled to, the vehicle's coil.



Odachi Fig. 11 (annotated); *see* Odachi 2:45-55 (target position of the primary coil is where it “is positioned substantially closest to the secondary inductive device”), 3:6-17 (primary inductive device should be activated when “located substantially closest to the secondary inductive device”), 6:12-16 (“primary inductive coupler 6 is positioned closest to, or in alignment along the X-axis with, the secondary inductive receptacle”).

194. To determine which coil should be switched on, “the magnitude of the current I_{RMS} ” while in “positioning mode” would be monitored across each coil in the array as the support arm is swept leftward, like Odachi described for a single coil. *See* Odachi 11:6-42; *see* Element 1[c]. I_{RMS} is inversely proportional to the

level of coupling. Thus, the four I_{RMS} signals would be compared against each other, with the “smallest” I_{RMS} value indicating the “greatest” “electromotive force induced in the secondary coil,” which makes that coil the one that should be activated. Odachi 6:5-45. Alternatively, during the sweep each coil could be briefly activated independently to measure V_{RMS} , and only the coil with the highest V_{RMS} would be selected by the switch to receive current to provide power to the secondary device. Odachi 13:39-64.

195. For power transfer, a POSA would have been motivated to turn on only one coil at a time, rather than all coils in the array simultaneously, as Partovi teaches. Partovi 26:23-30 (primary coils are “selectively switched or activated”). Doing so would eliminate the possibility of one primary coil interfering with a nearby primary coil operating at the same frequency. It would also beneficially reduce power usage, as energy would not be wasted by turning on further-away coils that either were not coupled to the secondary receptacle at all, or were providing only, at best, inefficient power transfer compared to the better-coupled selected coil.

XII. Ground 2: Claims 8-10, 12-14, 16 and 19 are unpatentable over Ross, alone or in view of Wang

196. For the reasons discussed below, it is my opinion that Ross, alone or with Wang, teaches or renders obvious every element of claims 8-10, 12-14, 16 and 19 of the '654 patent.

197. Specifically, as I explain further below, a POSA would have modified Ross to use a compensating capacitor in series or in parallel with each of its transmitting and receiving coils (as taught in Wang) to yield a more efficient power transfer system. That modified system then meets every element of claims 8-10, 12-14, 16, and 19.

A. Independent Claim 13

1. Claim Element 13[pre]: Preamble

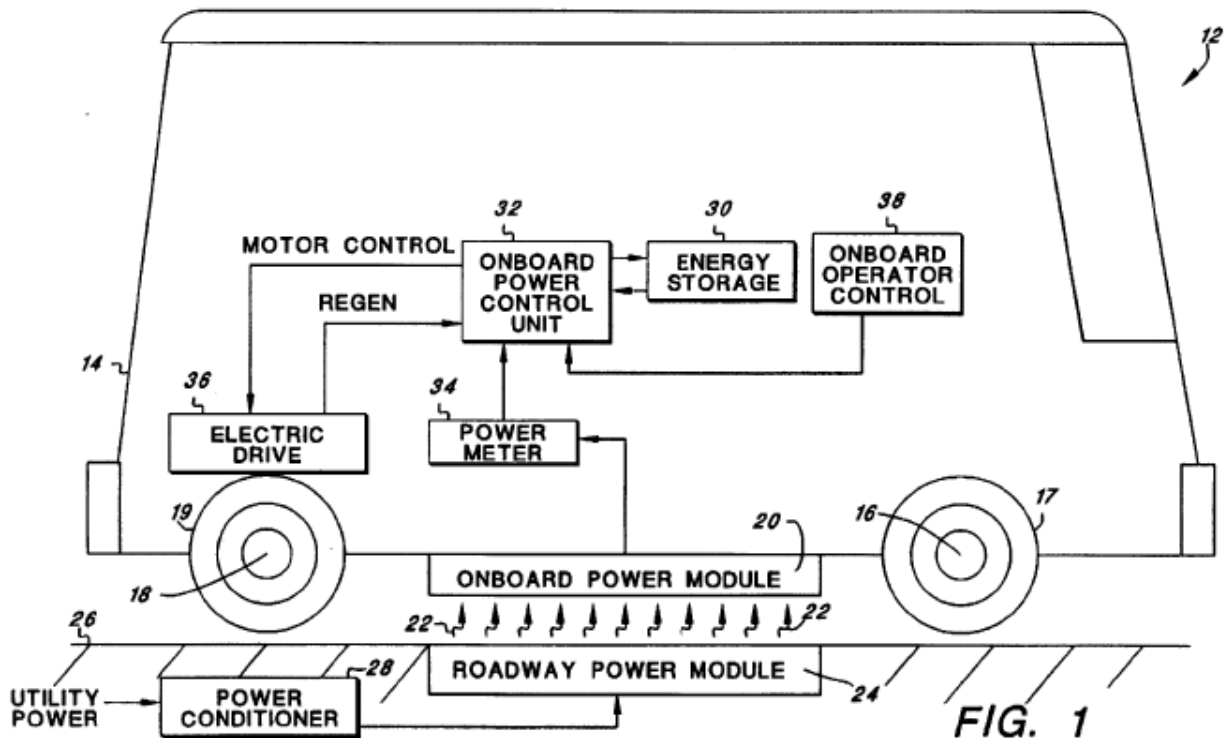
198. Claim 13's preamble recites "[a] method, comprising...." Ross teaches this.

199. Ross discloses "systems and methods" for implementing an "electric vehicle system that uses inductive coupling to couple electrical energy between embedded coils in the roadway and coils carried onboard the EV," including by "position[ing] the relative spacing ... and alignment between the onboard coil and the embedded coils in order to make the energy transfer from the roadway to the vehicle more efficient." Ross 20:29-41 (describing an "EV system that powers" electric vehicles using "a demand responding charging system or scheme"); *see* Ross Abstract ("A roadway-powered electric vehicle system"), 6:25-38 ("an EV system that uses inductive coupling to couple electrical power between embedded coils in a roadway and coils carried onboard the EV").

2. Claim Element 13[a]: Guiding a Receiving Antenna into a First Alignment Position

200. Claim 13 next recites “guiding a receiving antenna of a vehicle to a first alignment position relative to a transmitting antenna.” Ross teaches this.

201. As shown below in Fig. 1 of Ross, Ross discloses a “roadway-powered electric vehicle (RPEV).”



Ross Fig. 1. Ross explains that a “power receiving module 20” (the claimed receiving antenna) is “carried on the underneath side of the RPEV.” Ross 7:57-8:14 (The module 20 receives electrical power ... from a roadway power transmitting module”). The claimed transmitting antenna, namely a “roadway power transmitting module 24,” is “embedded in a roadway ... over which the RPEV travel.” Ross 7:65-7:5.

according to Faraday's law of induction." Ross 9:20-31. "[A]n AC current is thus established in the [receiving] coil 32 and power is effectively coupled from the [transmitting] coil 40 to the [receiving] coil 42." Ross 9:20-32. That transferred power is "stored in an onboard energy storage system" and used, among other functions, to power the vehicle's "electric drive." Ross 8:14-20, 8:54-64 (further describing an "onboard power control unit 32" that "selectively directs electrical power from the energy storage system 30 to the electric drive 36").

203. Ross's RPEV, and thus its receiving antenna, is guided into a first alignment position by being driven or parked over a coil embedded in the ground, which couples to the vehicle-mounted coil. Ross 12:32-62; *see* Ross Figs. 1-2, 4, 7, 7:11-13 (describing Fig. 7 showing "garaging"), 18:1-10 ("charging pad" can be "installed on the surface of a driveway or garage floor"). Specifically, when the RPEV approaches a "designated stop[]" such as "passenger loading/unloading zones, parking garages, or the like," "an auto-positioning control ... effectively 'takes over' the driving of the vehicle for the final 10-15 feet." Ross 6:12-34 (describing "designated stops"), 12:33-44 ("Some of the RPEV 'driving' functions of the RPEV, although normally under manual control of the operator ... may also be automated, or controlled by the controller 56 in accordance with a prescribed or preprogrammed regime"). This auto-positioning provides "a key feature of the

RPEV,” which is “to incorporate lateral, as well as vertical (air gap) positioning of the assembly 44 on which the coil 32 is mounted.” Ross 12:33-40.

204. In auto-positioning mode, “vehicle sensors ... sense the position of the [vehicle] relative to the roadway power transmitting module embedded in the roadway.” Ross 12:44-47; *see* Ross 13:5-15 (vehicle sensors can be “optical sensors,” or “acoustic, mechanical, and electromagnetic sensors”), 13:15-62 (explaining that the system can “monitor the change in the amplitude of the inductively received power signal” to determine positioning “instead of” or “in combination with” using the sensors). Then, “microprocessor controller 56” controls “the steering of the vehicle ... so that the vehicle is laterally positioned, to within a rough tolerance, e.g. ± 5 -10cm, of the optimum lateral position when the vehicle comes to its designed stopped location.” Ross 12:30-62. The “optimum lateral position” to which the vehicle is guided is the position where the vehicle’s coil is “optimally aligned with the embedded coil” in the roadway “so as to provide the maximum possible coupling efficiency between the two coils.” Ross 9:44-10:5.

205. This “rough tolerance” positioning can alternatively be performed “manual[ly],” instead of by auto-positioning, by having the vehicle “operator” “driv[e]” into the parking position. Ross 12:32-47.

3. Claim Element 13[b]: Moving antenna to improve alignment

206. Claim 13 next recites “responsive to detecting a degree of coupling in the first alignment position between the receiving antenna and the transmitting antenna that is measured at the receiving antenna, moving one of the receiving antenna and the transmitting antenna from the first alignment position to a second alignment position to improve alignment of the receiving antenna with the transmitting antenna and improve the degree of coupling.” Ross teaches this.

207. As I detail below, after Ross’s vehicle is parked in an alignment position that is within a “rough tolerance” of the embedded coil (the claimed “first” alignment position, as I explained in the previous section), the onboard coil module is moved to a second position (the claimed second alignment position) where the two coils are better aligned and have improved coupling. Ross 9:44-10:5, 12:10-62, 13:15-32. That movement is “responsive to detecting a degree of coupling” that is “measured at the receiving antenna” because the second position of the coil is an “optimum lateral position” that indicates maximum coupling, and is determined by “monitoring the change in the amplitude of the inductively received power signal,” and moving the coil to the position that “keeps the induced power signal at a peak or maximum level.” Ross 13:15-32.

208. As Ross explains, “to improve the coupling efficiency between the embedded coil 40 and the onboard [vehicle] coil 42,” the vehicle coil 42 is “mount[ed]” on a “movable assembly. Ross 9:44-62. The “horizontal position of

the movable assembly ... is controlled by a horizontal coil position unit 46,” which move the assembly using “conventional hydraulic and/or electronic positioning devices.” Ross 9:44-62, 12:52-62. Similarly, a hydraulic or electronic “vertical (air gap) coil position unit 48” controls the “vertical position of the assembly.” Ross 9:48-62, 12:52-62 (further explaining that the “vertical (air gap) coil position unit 48” is “realized, e.g., using conventional hydraulic and/or electronic positioning devices.”).

209. Once the vehicle has been “stopped” or parked using auto-positioning, as I explained above for Element 13[a], “the horizontal coil positioning unit ... further controls the lateral position of the coil 42 so that it is more closely aligned, e.g., to within ± 1 -2 cm, of the optimum lateral position.” Ross 12:52-62. This optimal position is the position that “provide[s] the maximum possible coupling efficiency between the two coils.” Ross 9:40-10:5 (“the positioning units 46 and 48, in combination with the steering of the RPEV 12 ... combine to allow the onboard coil 42 to be optimally aligned with the embedded coil 40 so as to provide the maximum possible coupling efficiency between the two coils.”). Once the coils are horizontally aligned, the vertical positioning unit “lower[s]” the coil assembly towards the road and the embedded coil “to reduce the air gap to near zero,” and charging can begin. Ross 12:42-62.

210. A POSA would have understood that this process is “responsive to detecting a degree of coupling that is measured at the receiving antenna” because when Ross moves the coil assembly from a first “rough” alignment position (i.e., within 5-10cm of optimal coupling) to a second “more closely aligned” position (i.e. within 1-2cm of optimal coupling), the system is measuring coupling at the vehicle coil and using that measurement to determine how and where to move the coil to the better-coupled position. Ross 12:52-62. For example, Ross moves its vehicle coil to “the optimum lateral alignment” that achieves “the maximum possible coupling efficiency between the two coils.” Ross 9:44-66; *see* Ross 9:50-10:5 (“optimum lateral alignment of the assembly relative to the embedded coil ... allows a maximum amount of power to be coupled”), 6:25-39 (“laterally and vertically position[ing] the relative spacing and alignment between” the two coils “to minimize the air gap” and “maximize the alignment between the coils, thereby making the power transfer ... more efficient.”).

211. Ross determines this optimal position with maximum alignment and coupling by, for example, “monitoring the change in the amplitude of the inductively received power signal as the coil 42 is laterally moved in one direction or the other.” Ross 13:20-32. To do so, the “processor controller ... laterally positions the coil ... using the horizontal coil positioning unit ... to maintain the coil 42 at a lateral position that keeps the induced power signal at a peak or

maximum level.” Ross 13:15-32. This “induced” or “inductively received” power signal is indicative of the power received and measured at the vehicle coil. Ross 13:15-52; *see* Ross 9:15-42 (system “induces a voltage” in “coil 42” of “onboard power receiving module”). Further, Ross teaches that it is possible to measure the power coupled to the vehicle using a power meter. Ross 3:66-67 (“A power meter, carried onboard the vehicle, monitors how much power is coupled to or used by the vehicle”). Because the amplitude of the inductively received power signal increases with an increased degree of coupling, the amplitude of the inductively received power signal indicates the degree of coupling and reflects the level of “power ... effectively coupled from the [transmitting] coil 40 to the [receiving] coil 42.” Ross 9:20-46; *see also* Ross 3:66-67.

212. I note that Ross’s manner of detecting a degree of coupling by measuring “the amplitude of the inductively received power signal” is the same manner of detecting or testing coupling that is mentioned in the ’654 patent: “a measurement of the amount of power that is transferred to the receiving antenna.” ’654 Patent cls. 18-19.

B. Claim 14: Moving Receiving Antenna Laterally

213. Claim 14 recites “the method of claim 13, wherein moving one of the receiving antenna and the transmitting antenna comprises moving the receiving antenna laterally relative to the transmitting antenna.” Ross teaches this.

214. As I explained above for claim element 13[b], Ross discloses moving “the lateral position” of the vehicle-mounted coil using a “horizontal coil positioning unit,” to bring the two coils into alignment. *See* Element 13[b]; Ross 12:44-62 (“once stopped, the horizontal coil positioning unit ... further controls the lateral position of the coil 42 so that it is more closely aligned, e.g. to within +/- 1-2cm, of the optimum lateral position”). A POSA would understand that adjusting the “lateral position” of the vehicle-mounted coil moved the vehicle-mounted coil “laterally relative to the transmitting antenna” as claimed, as the transmitting coil is embedded in the roadway. *See, e.g.* 12:44-62. As I further explain below for claim 9, a POSA would understand Ross’s “lateral” coil movement to include both the X-axis and Y-axis directions.

C. Claim 16: Moving Receiving Antenna Perpendicularly

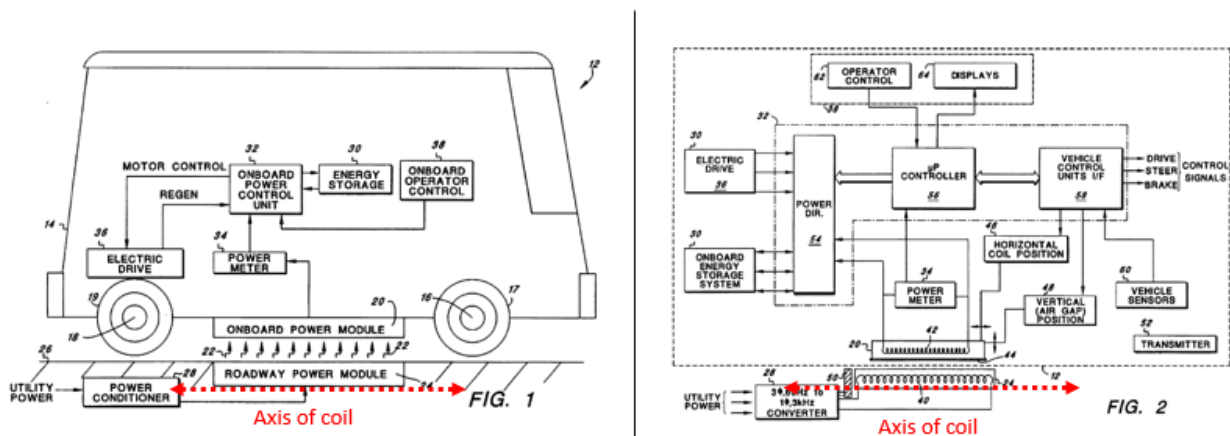
215. Claim 16 recites “the method of claim 13, wherein moving one of the receiving antenna and the transmitting antenna comprises moving the receiving antenna along an axis that is perpendicular to one of a transmitting antenna coil and a receiving antenna coil.” Ross teaches this.

216. As I explained above for claim element 13[b], Ross discloses changing the “lateral” (or “horizontal”) and “vertical position” of the vehicle-mounted coil by moving the coil to achieve “optimum” alignment with a “near zero” air gap. *See* Element 13[b], Ross 12:44-62. A POSA would have understood

this to mean that, for example, the receiving coil can be moved in the X-axis or Y-axis directions (both of which are “horizontal” or “lateral”) as well as in the Z-axis direction (“vertical”) relative to the transmitting coil for alignment, as I explain further below. Ross 12:32-13:4. I incorporate here my discussion of claim 9 below, which further explains this same concept.

217. Because Ross’s receiving coil can be moved in any of the X-, Y-, and Z-axis directions in order to obtain better coupling, Ross discloses that its receiving coil can move “along an axis that is perpendicular to one of a transmitting antenna coil and a receiving antenna coil” as claimed, regardless of which geospatial direction that axis corresponds to.

218. As one example of how this element is met, Ross shows in Figures 1-2 below that the road-embedded coil 40 runs from front-to-back along the length of the vehicle.



Ross Figs. 1-2. When the vehicle is parked, “the horizontal coil positioning unit” “control[s] the lateral position of the [vehicle embedded] coil” to “closely

align[]” the two coils. Ross 12:33-62. If the vehicle is not perfectly aligned on the roadway over the embedded coil, meaning that it is not centered within a traffic lane or parking space, the horizontal coil positioning unit will move the vehicle coil leftward or rightward across the traffic lane or parking space. Ross 12:33-62, Figs. 1-2. This “lateral position[ing]” is along an axis perpendicular to a radially-directed axis of the transmitting coil, as shown above. In the figure above, the axis of the coil is left-to-right across the page (towards the front/back of the vehicle), while the axis of the coil movement is into the page (towards the side of the vehicle), and thus perpendicular.

219. As a second example, as part of Ross’s alignment the “vertical (air gap) positioning unit” “lowers” the vehicle coil assembly towards the roadway to reduce the air gap for charging. Ross 12:57-13:4. That movement is vertical, and therefore perpendicular to the transmitting coil, as I have annotated it above. Ross Figs. 1-2, *see also* Ross Fig. 7 (showing vehicle coil movement), 9:44-55 (“the vertical position of the assembly 44 is controlled by a vertical (air gap) coil positioning unit”).

D. Independent Claim 8

1. Claim Element 8[pre]: Preamble

220. Claim 8’s preamble recites “[a] receiver system for wireless power.” Ross discloses this.

221. Ross teaches a “roadway-powered electric vehicle” (“RPEV”) with a “power receiving module” that “receives electrical power” from “a roadway power transmitting module.” Ross 7:57-8:13; *see* Ross 9:10-10:5 (describing wireless power transmission by “inductive coupling”), 16:38-50 (“non-contacting inductive coupling energy transfer system”), Fig. 1 (showing wireless transfer of energy with arrows 22), Fig. 7 (showing wireless gap between charging pad and vehicle).

2. Claim Element 8[a]: Receiving Antenna

222. Claim 8 next recites “a receiving antenna coupled to a device, the receiving antenna including a coil and capacitor that are resonant at a first frequency.” Ross and Wang render this element obvious.

223. Ross discloses the claimed receiving antenna coupled to a device by disclosing an “onboard power receiving module 20” that is “mounted on the underneath side of the [roadway-powered electric vehicle] RPEV.” Ross 7:57-8:13 (“Mounted on the underneath side of the RPEV 14 is an onboard power receiving module 20”), Figs. 1-2 (showing receiving module mounted to vehicle); The onboard power receiving module can be or include “a coil.” Ross 9:10-29; *see also* Ross 9:30-43 (“coil 42 being carried on the underneath side of the RPEV 12”), 20:29-40 (“coils carried onboard the EV”).

224. In addition, Ross teaches a “roadway power transmitting module 24” that can be “embedded in the roadway.” Ross 9:10-43, Figs. 1-2, 7. The power

transmitting module can also be or include “a coil.” Ross 9:10-29 (“the preferred roadway power transmitting module 24 is simply a coil”).

225. The power transmitting coil “generates a magnetic field that varies at frequency f_1 ” “[w]hen a suitable ac electrical current flows through” it, such that the magnetic field then “induces a voltage” in the power receiving coil. Ross 9:11-29. As Ross explains, “when [receiving] coil 42 is connected to a suitable load, an ac current is thus established in the coil 42 and power is effectively coupled from the coil 40 to the coil 42.” Ross 9:11-29; 9:30-32 (explaining that “the coupling between the coils ... is referred to as inductive coupling.”).

226. Ross does not mention a capacitor or resonant frequency, but a POSA would have found it obvious (in view of Wang) to use a capacitor connected to each of Ross’s transmitting coil and receiving coil to make circuits that resonate at a particular frequency for efficient energy transfer. Combining a capacitor with Ross’s transmitting and receiving coils in this way involves merely combining known prior art elements (inductive coils and capacitors) using known methods (forming a resonant circuit) that lead to a predictable results (an efficient inductive charging system).

227. Inductor-capacitor resonant circuits like those described in Wang were well known in the art to POSAs. Wang 47. Like Ross, Wang describes an “inductively coupled power transfer (ICPT)” system that uses “electromagnetic

fields to transfer electric power from a stationary primary source to one or more movable secondary loads without contact.” Wang 1. In this type of system, “a capacitor (C_p) can be connected in series ... or parallel ... with the primary winding [or coil].” Wang 23. Similarly, “[t]o compensate for the secondary inductance (L_s), a capacitor (C_s) can be connected either in series ... or parallel ... with the secondary winding [or coil],” as the figures below show.

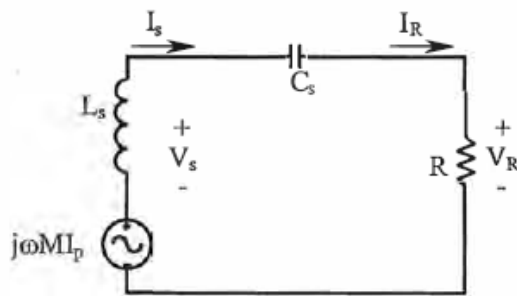


Fig. 2-7. Series-compensated secondary.

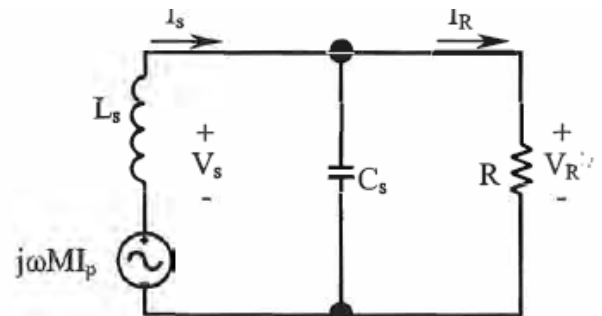


Fig. 2-8. Parallel-compensated secondary.

Wang 20.

228. Implementing this arrangement, known as “compensating” an inductive circuit with capacitors, in Ross would have been obvious to a POSA. This implementation would be accomplished by connecting a capacitor C_p in series with or parallel to “embedded coil 40” of the “roadway power transmitting module,” and another capacitor C_s in series with or parallel to “onboard coil 42” of the “onboard power receiving module” on the vehicle. Ross 9:11-29, *see* Wang 4-7, 11, 20-25, 38 (describing compensation techniques).

229. As a result of these compensating capacitors, Ross's onboard power receiving module would operate as a "secondary resonant circuit" that is "magnetically coupled" to the "primary resonant circuit" (the roadway power transmitting module) to "supply power to a load" (the RPEV). Wang 47. As in the unmodified version of Ross, current flowing through the transmitting coil "at frequency f_1 ... generates a magnetic field that varies at frequency f_1 ," which "induces a voltage" in the receiving coil. Ross 9:10-32.

230. A POSA would have understood that a compensated version of Ross's onboard power receiving module was resonant at a first frequency. As Wang explains, a compensated secondary circuit has a "secondary resonant frequency (when C_s is in resonance with L_s)" which is "normally designed to equal the nominal frequency." Wang 20.

231. A POSA would have been motivated to use capacitor-compensated resonant circuits in Ross. I incorporate by reference my earlier explanation of why a POSA would have been motivated to use capacitor-compensated circuits in Odachi, which similarly applies here, in addition to the explanation below. *See* Ground 1b, Element 1[a].

232. Specifically, the addition of compensating capacitors to an inductively coupled power transfer system would have been merely a combination of previously known elements from the prior art (inductive coils and off-the-shelf

capacitors) assembled according to known methods (connected in series or parallel resonant circuits) that yield in predictable results (an efficient inductive wireless power transfer system). Wang confirms, this, explaining that “the primary and secondary [coils]” of an ICPT system “[we]re *often* compensated by capacitors,” which were “basic compensation technologies.” Wang 20. In fact, Wang explains that the “*majority*” of “inductively coupled power transfer systems” that operated “in the medium-high power range” were “compensated” with capacitors in this manner. Wang 47-48; *see also* Wang 4 (“primary and secondary windings ... [were] *normally* compensated by capacitors”). A POSA would have understood, as Wang explains, that a contactless vehicle charger is the sort of medium-high power system that benefits from compensation. *See* Wang 71-72, 105 (30 kW contactless vehicle charger); Wang-IEEE 5 (30 kW “electric vehicle battery charging”); Ross 16:23-32 (conventional vehicle chargers charge at “6 KW to 10 KW” at home), 15:10-45 (Table 1 showing that power transmitting module and power receiving module can each be “200 kW”).

233. A POSA would have further understood that the use of capacitor-compensated circuits in Ross would increase Ross’s ability to efficiently transfer power. As Wang explains, “series and parallel secondary compensation *improve the power transfer capability of the pickup*,” as compared to uncompensated circuits. Wang 21; *see also* Wang-IEEE 995 (“resonant circuits are normally

employed in the primary and/or secondary networks [of ICPT systems] to boost the power transfer capability”). Thus, a POSA would have known that “primary and secondary” coils “[we]re often compensated by capacitors” because doing so “boost[s] the power transfer capability of the pickup, while minimizing the VA rating of the power supply.” Wang 20; *see* Wang 4 (“[T]o increase the amount of power transferred” requires “high frequency” which “is normally compensated by capacitors”). Likewise, “useful” “voltage gain” or “current gain” in the primary coil is achieved by compensating the primary. Wang 23-24; *see* Wang 38 (“The objective of series primary compensation is to achieve a voltage gain between the switching power supply and the primary coil, whereas parallel primary compensation is utilized to obtain a current gain”).

234. By modifying Ross’ system to use capacitor-compensated resonant circuits, a POSA would have recognized that the system could transfer power more efficiently, or at higher voltage or current gain. That would beneficially allow the system to wirelessly charge more powerful vehicles with larger batteries, charge vehicles quicker, and otherwise compensate for obstacles that might impede transfer efficiency. Wang 4-5 (“high power applications” of “inductive power transfer”).

235. Finally, an arrangement using resonant compensated circuits in an inductively coupled system such as Ross’s was well-known, thus making this

arrangement easy for a POSA to implement. As explained above, capacitors were “often” used to “boost the power transfer capability of the pickup” in similar systems where power is delivered “over large air gaps via magnetic coupling.” Wang 47. Both uncompensated primary and secondary circuits (as Ross describes) and compensated circuits (as a POSA would modify Ross) were “fundamental” or “basic compensation topologies” with circuit diagrams and functionalities would have been well-known to a POSA. Wang 24; *see also* Stielau 86 (describing the same arrangements as “basic compensation topologies”). For example, as shown below, the “nine fundamental compensation topologies” disclosed in Wang included the “uncompensated primary and secondary” originally used in Ross, and four arrangements in which both the primary and secondary are compensated, either in series or in parallel.

2-3.5 BASIC COMPENSATION TOPOLOGIES

Three basic compensation choices exist for both the primary and secondary (series compensation, parallel compensation, or uncompensated). Combining the primary and secondary results in nine fundamental compensation topologies [18] as illustrated in Fig. 2-12.

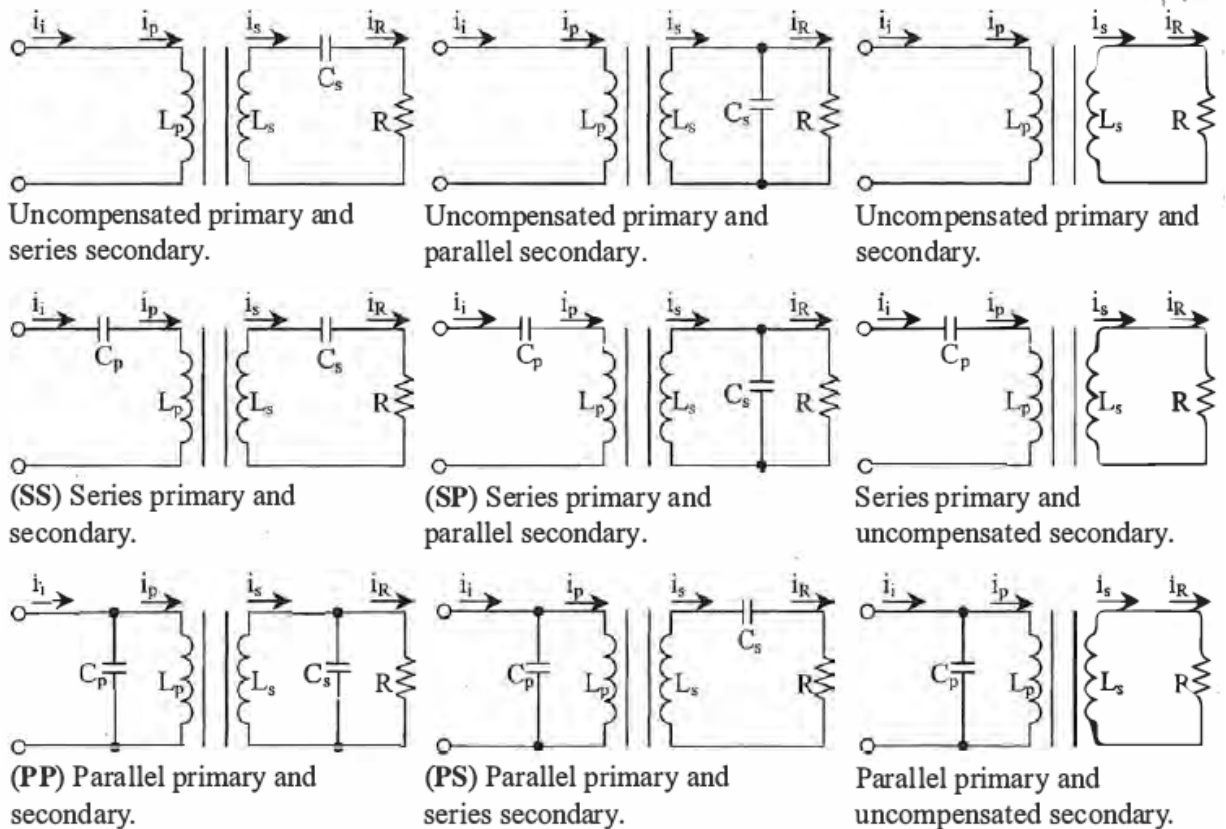


Fig. 2-12. Basic compensation topologies of ICPT systems.

Wang 24; *see also* Stielau (Ex. 1017) 86 (describing these circuits as “basic compensation topologies”). Wang provides these basic models and circuit diagrams of each, which a POSA could use to implement this arrangement in Ross.

236. For all of the reasons above, a POSA would have considered it obvious to implement Ross in view of Wang to have a compensated arrangement for more efficient power transfer, in which the onboard power receiving module

would then include a compensating capacitor in addition to its coil, and would be resonant at the secondary resonant frequency.

3. Claim Element 8[b]: Guidance Control System

237. Claim 8 next recites “a guidance controller configured to guide the receiving antenna of the device to a first alignment position relative to a transmitting antenna that is not physically connected to said device coupled to the receiving antenna.” Ross discloses this.

238. As I described above for Element 8[a], Ross teaches a “roadway power transmitting module” that transfers power to a “onboard power receiving module” (the claimed transmitting and receiving antennas, respectively) and that the receiving module is mounted to an RPEV (the claimed device). Ross 7:57-8:13, Figs. 1-2, 9:10-32; *see* Element 8[a]. The power transmitting module is not physically connected to the RPEV, as the RPEV drives on the road and can thus move while the transmitting module is embedded in or under the road, creating an “air gap” between them. Ross 9:37-43, 12:56-62, Figs. 1-2, 7; *see* Element 8[pre].

239. As I explained above for Element 13[b], Ross teaches “steering” the RPEV to a position “rough[ly]” over an embedded coil in the road and thus guides the RPEV and its onboard power receiving module into a first alignment position relative to the roadway-embedded power transmitting module. *See* Element 13[b]. Ross explains that this process can be “automated, or controlled by the controller

56,” which corresponds to the claimed “guidance controller.” Ross 12:33-62 (“the steering of the vehicle is then controlled by the microprocessor controller 56 so that the vehicle is laterally positioned, to within a rough tolerance... of the optimum lateral position when the vehicle comes to the designated stopped location.”); *see* Element 13[b].

4. Claim Element 8[c]: Lifting Device

240. Claim 8 next recites “a lifting device for said receiving antenna configured to lift and lower said receiving antenna.” Ross teaches this.

241. As I explained above for Element 13[b], Ross discloses a “vertical (air gap) positioning unit 48.” This corresponds to the claimed lifting device. Ross 9:47-50 (“the vertical position of the assembly 44 is controlled by a vertical (air gap) coil position unit 48”), 12:56-62 (“the vertical (air gap) positioning unit 48 lowers the assembly 44 so as to reduce the air gap to near zero”); *see* Element 13[b]. Using “conventional hydraulic and/or electronic positioning devices,” this vertical positioning unit “lowers” the “assembly 44 on which the coil 42 is mounted” “to reduce the air gap to near zero.” Ross 12:33-67. With an “air gap near zero, the onboard energy storage system 30 is charged ... through the inductive coupling link (which operates at maximum efficiency with a near zero air gap).” Ross 12:63-13:4. “[T]he vertical positioning unit 48 raises the assembly

44 back up to its normal position on the underneath side of the RPEV frame” after charging is complete. Ross 12:63-13:4.

5. Claim Element 8[d]: Alignment Controller

242. Claim 8 next recites “an alignment controller configured to sense a degree of coupling of said receiving antenna and the transmitting antenna based on a detection of the coupling that is measured at the receiving antenna, the alignment controller being further configured to move said receiving antenna from the first alignment position to a second alignment position to better align the receiving antenna with the transmitting antenna.” Ross discloses this.

243. This element is met by the same functionality that I described above with respect to claim element 13[b], as I further detail below. *See* Element 13[b].

244. Ross discloses a “horizontal coil position unit 46” that, alone or with the controller 56 and related sensors and circuitry, corresponds to the claimed “alignment controller.” After the vehicle has been “steer[ed]” to a first position and “stopped,” the horizontal coil position unit “further controls the lateral position of the coil 42 so that it is more closely aligned” with the coil embedded in the roadway. Ross 12:32-63; *see* Element 13[b]. The horizontal coil position unit moves the vehicle coil assembly laterally from its previous position “within a rough tolerance, e.g. ± 5 -10 cm of the optimum lateral position” (the claimed first alignment position) to a better-aligned position “within ± 1 -2 cm of the optimum

lateral position” (the claimed second alignment position). Ross 12:32-63, 13:15-32 (explaining that alignment can be based on sensing magnitude of inductively received power signal).

245. A POSA would have understood that this lateral movement better positions the receiving antenna into alignment with the transmitting antenna because, as Ross explains, the positioning unit “allow[s] the onboard coil 42 to be optimally aligned with the embedded coil 40 so as to provide the maximum possible coupling efficiency between the two coils.” Ross 9:44-54; *see* Ross 9:60-10:4 (“optimum lateral alignment of the assembly 44 relative to the embedded coil ... allows a maximum amount of power to be coupled”), 6:25-39 (“laterally and vertically position[ing] the relative spacing and alignment between” the two coils “in order to minimize the air gap” and “maximize the alignment between the coils, thereby making the power transfer ... more efficient.”).

246. A POSA would have further understood that the horizontal coil position unit and controller are “configured to sense a degree of coupling” as claimed, and move the vehicle coil in response to this measured degree of coupling. This measurement is how the unit determines how far, and in what direction, to move the coil to be “optimally aligned” and to achieve “the maximum possible coupling.” Ross 9:44-10:5, 12:44-62. Further, Ross teaches that it is possible to measure the power coupled to the vehicle using a power meter. Ross 3:66-67 (“A

power meter, carried onboard the vehicle monitors how much power is coupled to or used by the vehicle”).

247. For example, when the vehicle is “stopped,” the horizontal positioning unit and controller may “sense the relative lateral location of the [receiving] coil 42 to the [transmitting] coil 40.” Ross 13:15-32. “[I]nstead of,” or “in combination with” using “sensors,” this “approximate lateral position may be determined by monitoring the change in the amplitude of the inductively received power signal as the coil 42 is laterally moved in one direction or the other.” Ross 13:15-32. The horizontal positioning unit moves the coil to achieve or maintain the “lateral position that keeps the induced power signal at a peak or maximum level.” Ross 13:15-32.

248. As I explained above for Element 13[b], a POSA would have understood that measuring the “amplitude of the inductively received power signal” and using that information to “keep[] the induced power signal at a peak or maximum level,” thereby obtaining “optimum lateral position,” constitutes sensing the degree of coupling, and moving the coil in response. *See* Element 13[b]. As Ross explains, the purpose of this sensing is to move the coil to the location that “provide[s] the maximum possible coupling efficiency between the two coils.” 9:44-66. One way of detecting this level of coupling is to monitor “the amplitude

of the inductively received power signal,” which indicates the level of coupling between the two coils; *See* Element 13[b].

249. I note that Ross’ disclosure of “monitoring the change in the amplitude of the inductively received power signal” is the same manner of testing or sensing a degree of coupling that is mentioned in the ’654 patent: “a measurement of the amount of power that is transferred to the receiving antenna.” ’654 Patent cls. 18-19.

E. Claim 9: X-Y Axis Alignment Control

250. Claim 9 recites “the receiver system of claim 8, further comprising an x-y alignment control configured to automatically align said receiving antenna to better align the receiving antenna with the transmitting antenna by moving said receiving antenna in x and y directions based on a degree of coupling between the receiving antenna and the transmitting antenna.” Ross discloses this. Or, at a minimum, Ross renders it obvious.

251. As I explained above for Element 8[d], Ross teaches a “horizontal coil positioning unit” that, along with a controller and related circuitry and sensors, moves the vehicle-mounted coil to “the optimum lateral position” based on a detected degree of coupling, i.e. “the amplitude of the inductively received power signal.” Ross 12:32-62, 13:15-32; *see* Element 8[d].

252. A POSA would have understood that the components described above (i.e. Ross's horizontal coil positioning unit with controller and related sensors and circuits) constitute an x-y alignment control that automatically aligns the vehicle coil with the transmitting coil based on that detected coupling, since the positioning control units move the power receiving antenna laterally based on the degree of coupling. *See* Elements 13[b] (detecting coupling), 8[d] (sensing degree of coupling); Ross 13:15-32 ("the approximate lateral position may be determined by monitoring the change in the amplitude of the inductively received power signal as the coil 42 is laterally moved in one direction or the other maintain[ing] the coil 42 at a lateral position that keeps the induced power signal as a peak or maximum level").

253. A POSA would have understood that the word "lateral," as used in Ross, indicates movement in both the X-axis and Y-axis directions because these directions are on the "lateral" or horizontal plane as opposed to the "vertical" alignment that Ross separately discusses. *See* Ross 12:33-62 ("lateral, as well as vertical (air gap) positioning"). Ross does not separately mention the X- or Y-axes, but only contrasts "lateral" position with "vertical" positioning. Ross 6:25-39 ("onboard systems and methods are provided that laterally and vertically position the relative spacing and alignment between the onboard coil and the coils selectively embedded in the roadway in order to minimize the air gap between the

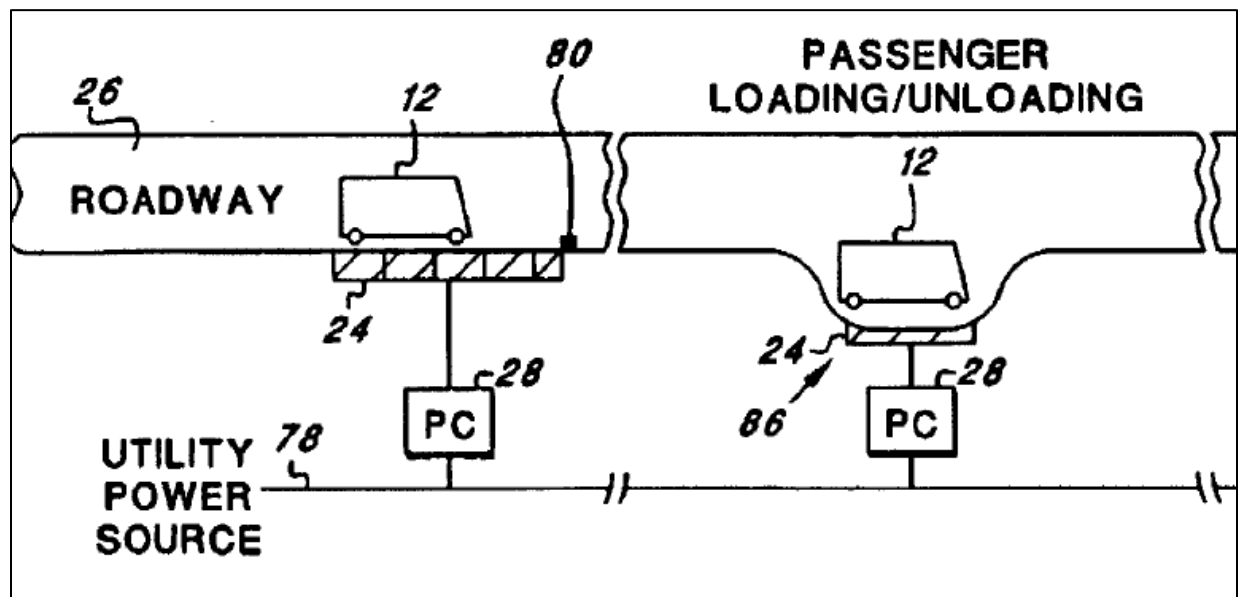
coils”), 9:52-10:5 (“reduction in the air gap, coupled with optimum lateral alignment... allows a maximum amount of power to be coupled”), 11:59-67 (“controlling the lateral and vertical position of the assembly”), 12:32-62 (“lateral, as well as vertical (air gap) positioning”), 20:35-41 (“laterally and vertically position the relative spacing ... to make the energy transfer from the roadway to the vehicle more efficient, reducing the air gap to near zero”).

254. Ross’s description of its vehicle coil as being moved by a “horizontal coil positioning unit” further confirms that the coil can be moved in both the X- and the Y-axis directions. A POSA would understand “horizontal” movement to refer to movement in the plane parallel to the ground – which would include both the X- and Y-axis directions. For example, Collins Dictionary defines “horizontal” as “flat and level with the ground, rather than at an angle to it” Collins (Ex. 1026) 1; *see* Collins 2 (“parallel to the plane of the horizon; not vertical”), 3 (“at right angles to the vertical; parallel to level ground” ... “contained in a plane parallel to the horizon”). Cambridge dictionary similarly defines “horizontal” as “parallel to the ground.” Cambridge (Ex. 1027) 1; *see* Cambridge 2 (“level to the ground, rather than up or down”). And the Britannica Dictionary defines “horizontal” as “positioned from side to side rather than up and down,” and “parallel to the ground.” *Brittanica* (Ex. 1028) 1. Each of these definitions further supports a POSA’s understanding that “horizontal coil positioning” as used in Ross would

mean movement in the plane parallel to the ground: i.e., movement in both the X- and Y-axis directions.

255. This understanding is confirmed by Ross's teaching that "laterally and vertically position[ing]" the coil alignment "minimize[s] the air gap between the coils and maximize[s] the alignment between the coils." Ross 6:25-39; *see* Ross 6:35-39 ("the air gap may advantageously be minimized to zero"), 9:43-10:4 ("the air gap between the onboard coil 42 and the embedded coil 40 may be reduced to zero, or near zero"), 12:33-13:4 (system "operates at maximum efficiency with a near zero air gap"), 20:35-41 ("laterally and vertically position the relative spacing ... to make the energy transfer from the roadway to the vehicle more efficient, reducing the air gap to near zero"), Fig. 7 ("zero air gap"). The ability to reduce the air-gap near zero through lateral and vertical positioning suggests to a POSA that "lateral" positioning includes both the x- and y-axis direction positioning. Ross 6:35-39. If Ross's "lateral" positioning only moved the coil along one of the X-axis or the Y-axis, for example, energy transfer would be severely limited by potential misalignment along the other axis, contrary to Ross's stated goals of having a "maximum" amount of power transfer. Ross 6:30-39, 9:55-10:5 ("optimum lateral alignment ... allows a maximum amount of power to be coupled"). Thus, a POSA would understand Ross in context to mean that "lateral" positioning includes movement in both the x- and y- axis directions.

256. Figure 4 of Ross also supports a POSA's understanding that "lateral" positioning includes movement in both the X-axis and Y-axis directions. As shown in the below excerpt, when Ross's vehicle pulls into a "passenger loading/unloading zone" from the "roadway," it moves both in the direction of the roadway (driving forward) and in the side-to-side direction across the roadway (pulling over to the side of the road).



Excerpt of Ross Fig. 4. Ross refers to this process, in which "an auto-positioning control ... effectively 'takes over' the driving of the vehicle for the final 10-15 feet" as ensuring that the vehicle "is laterally positioned." Ross 12:33-62. Thus here, as elsewhere in Ross, a POSA would have understood "lateral" to mean movement both in the direction of traffic, as well as side-to-side across traffic (what I refer to above as both the X-axis and the Y-axis directions).

257. I have been asked by counsel to address an alternative hypothetical in which Ross does not disclose moving the vehicle coil in both the X- and Y- axis directions. Even in this case, a POSA would have found it obvious to implement Ross such that the coil assembly moves in both the X- and Y-axis directions to achieve Ross's "optimum lateral position." Ross 12:32-64. As explained above, Ross already teaches the importance of, as well as the mechanisms for, properly aligning the vehicle coil to the embedded roadway coil in a "vertical" direction and "lateral" direction(s), to obtain optimum coupling. Ross 6:30-39, 9:55-10:5, 12:32-64, 13:5-32. Implementing this lateral alignment in both the X- and Y- axis directions would have been obvious to a POSA because these are the only two "lateral" axes. In addition, automatically aligning the coils in both the X- and Y-axis directions would maximize coupling. As Ross explains, "coupling efficiency is a function of the distance, or air gap, between the two coils 40 and 42, as well as the relative alignment between the coils." Ross 9:20-42. A POSA would have understood that automatically aligning Ross's coils in both the X- and Y-axis directions would achieve a smaller air gap, with better "relative alignment," and thus greater "coupling efficiency," than a system that only aligned its coil in one direction. See Ross 6:36-39 (explaining that by "using such onboard systems and methods, when the EV is stopped, the air gap may advantageously be minimized to zero."); 9:44-55 ("positioning units ... allow the onboard coil 42 to be optimally

aligned with the embedded coil so as to provide the maximum possible coupling efficiency between the two coils”), 9:55-66 (“reduction in the air gap, coupled with optimum lateral alignment of the assembly 44 relative to the embedded coil 40, allows a maximum amount of power to be coupled from the embedded coil 40 to the onboard coil 42”).

F. Claim 10: Magnetically Induced Signal Circuitry

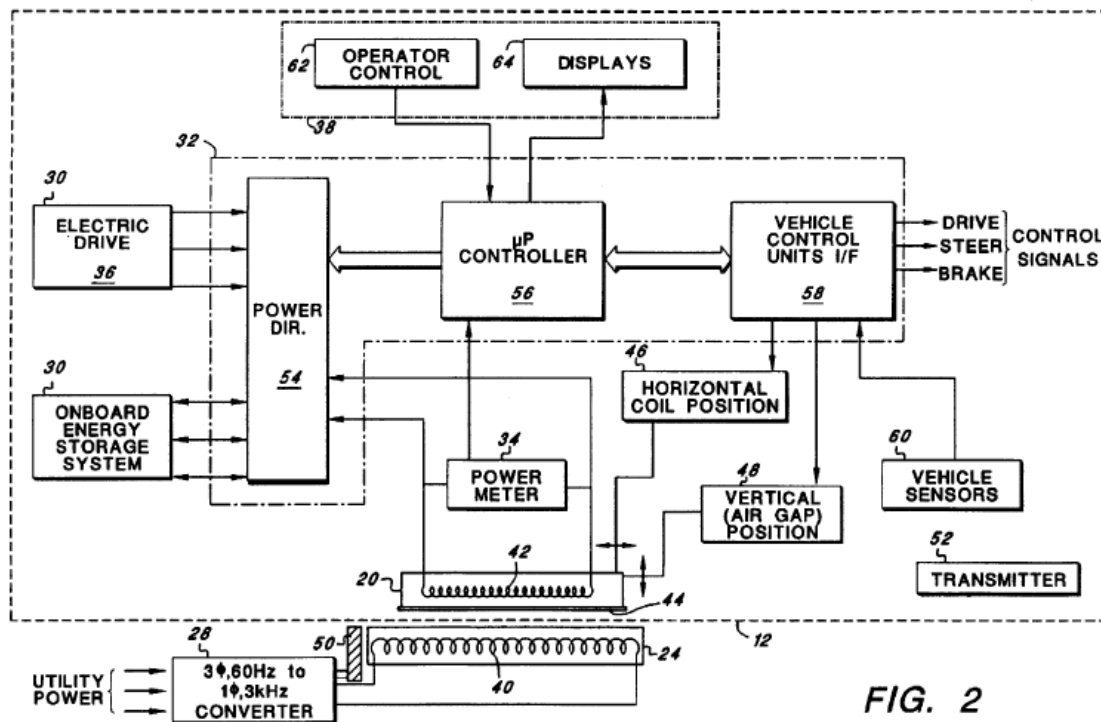
258. Claim 10 recites “the receiver system of claim 8, further comprising circuitry that receives a magnetically induced signal from said receiving antenna and produces power therefrom.” Ross teaches this.

259. Ross discloses circuitry (for example, vehicle coil 42, power director 54, drive train 36, onboard energy storage system 30) that receives a magnetically induced signal from the onboard power receiving module (i.e., the voltage and current induced in the power receiving module from the roadway transmitting module) and produces power from that received signal to drive the vehicle, as I explain further below.

260. Ross teaches an “electric vehicle system” that “uses inductive coupling to couple electrical energy between embedded coils in the roadway and coils carried onboard the EV.” Ross 20:29-40. This electrical energy is generated by “varying magnetic field [that] cuts through the [transmitting] coil 42 and induces a voltage therein according to Faraday’s law of induction.” Ross 9:11-20.

“When the coil 42 is connected to a suitable load, an ac current is thus established in the coil 42 and power is effectively coupled from the coil 40 to the coil 42.” Ross 9:21-29. Thus, power is transmitted from transmitting coil 40 of embedded roadway power transmitting module 24 to receiving coil 42 of the onboard vehicle power receiving module 20 via magnetic “inductive coupling.” Ross 9:4-44.

261. The magnetically induced power received by vehicle coil 42 “is coupled through a power director 54 to the onboard energy storage system 30,” as shown in Figure 2 below. Ross 11:37-49.



262. The received power is then further “directed, as required, from the energy storage system 30 to the electric drive train 36,” which in turn drives the vehicle by “provid[ing] the motive force for propelling the front and/or rear

suspension systems.” Ross 11:37-49; 8:54-9:4, Fig. 2. Thus, Ross teaches having circuitry (vehicle coil 42, power director 54, drive train 36, onboard energy storage system 30) that receives a magnetically induced signal from the receiving antenna (voltage and current induced from transmitting module 24 into receiving module 20) and transfers that power to the vehicle coil, and then to the power director, energy storage system, and electric drive train, to power the electric vehicle’s motors.

G. Claim 12: Battery Operated Vehicle

263. Claim 12 recites “the receiver system of claim 8, wherein said receiving antenna and said lifting device are part of a battery operated vehicle.” Ross discloses this.

264. As I explained above for Elements 8[a] and 8[c], Ross discloses that the “power receiving module 20,” which corresponds to the claimed receiving antenna, and the “vertical (air gap) coil position unit,” which corresponds to the claimed lifting device, make up part of a “roadway-powered electric vehicle (RPEV),” which in turn is operated by an “electromechanical battery.” Ross 7:57-8:1 (power receiving module), 8:14-20, 8:47-64 (conventional battery can be used), 9:44-54 (describing vertical positioning unit) 20:8-16 (describing battery); *see also* Ross 6:58-62 (“the on-board energy storage system of Fig. 2 is preferably realized

using a plurality of electromechanical battery (EMB) modules”), 6:4-7 (further describing battery), Figs. 1-2, 7; *see* Elements 8[a], 8[c].

H. Claim 19: Measurement of Power

265. Claim 19 recites “the apparatus of claim 8, wherein the sensed degree of coupling comprises a measurement of the amount of power that is transferred to the receiving antenna.” Ross discloses this.

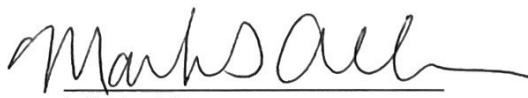
266. As I explained above for Elements 13[b] and 8[d], Ross teaches moving the receiving coil mounted on the vehicle to the optimum coupling position by, for example, “monitoring the change in the amplitude of the inductively received power signal” as the coil moves and placing the coil “at a lateral position that keeps the induced power signal at a peak or maximum level.” Ross 13:15-32, 9:44-50; 9:60-10:4 (“optimum lateral alignment of the assembly relative to the embedded coil ... allows a maximum amount of power to be coupled”), 6:25-39; 12:32-64; *see* Elements 13[b], 8[d].

267. A POSA would have known and understood that both the “amplitude of the inductively received power signal” and “peak or maximum level[s]” of the “induced power signal” are measurements that indicate the amount of power received at, and therefore transferred to, the receiving antenna. Ross 13:15-32 .

XIII. Conclusion

All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true. Further, I am aware that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001. I declare under penalty of perjury that the foregoing is true and correct.

Executed on 11/3/2023 (date), in Philadelphia, PA (city, state).


Mark Allen