

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re *Inter Partes* Review of:)
U.S. Patent No. 10,027,184)
Issued: Jun. 17, 2018)
Application No.: 15/170,397)
Filing Date: Jun. 1, 2016)

For: **Foreign Object Detection In Wireless Energy Transfer Systems**

**DECLARATION OF DR. MARK ALLEN IN SUPPORT OF
PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 10,027,184**

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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. 10,027,184 (“the ’184 patent”) (Ex. 1001). The ’184 patent relates to a “wireless energy transfer system” that transfers energy using a “source resonator,” and includes a “foreign object debris detection system” utilizing “magnetic field sensor[s].” See, e.g., ’184 patent, claim 1.

2. I understand that InductEV is petitioning for IPR of claims 1-13 and 16 of the ’184 patent and requests that the United States Patent and Trademark Office (“PTO”) cancel those claims.

3. In preparing this Declaration, I have reviewed the ’184 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. 10,027,184 B2 (“’184 patent”)
1002	File History for U.S. Patent No. 10,027,184 B2 (“’184 FH”)
1005	U.S. Patent Application Publication No. 2010/0084918 A1 (“Fells”)
1006	U.S. Patent Application Publication No. 2009/0299918A1 (“Cook”)
1007	U.S. Patent No. 6,075,433 (“Ono”)
1008	Chwei-Sen Wang, <i>Design Considerations for Inductively Coupled Power Transfer Systems</i> (2004) (Ph.D. dissertation, University of Auckland) (“Wang Thesis”)
1011	U.S. Patent No. 8,749,334 B2 (“Boys”)
1012	U.S. Patent No. 9,774,086 B2 (“Cook-086”)
1013	U.S. Patent Application Publication No. 2010/0109445 A1 (“Kurs”)
1014	U.S. Patent No. 7,656,244 B2 (“McCorquodale”)
1015	U.S. Patent No. 7,978,017 B2 (“Pernia”)
1016	U.K. Patent Application No. GB2414121 A (“Stevens”)
1018	D. Ferrazzin, et al., <i>Hall Effect Sensor-Based Linear Transducer</i> , Proceedings of the 1999 IEEE, Int’l Workshop on Robot and Human Interaction (IEEE, Sept. 1999), 219-224 (“Ferrazzin”)
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”)

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Ex.	Description
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	James E. Lenz, <i>A Review of Magnetic Sensors</i> , Proceedings of the IEEE, vol. 78, no. 6 (June 1990), 973-989 (“Lenz”)
1023	Excerpts from <i>McGraw-Hill Dictionary of Scientific and Technical Terms</i> (6th ed. 2003)
1024	Excerpts from James W. Nilsson & Susan A. Riedel, <i>Electrical Circuits</i> (8th ed. 2008) (“Nilsson”)
1025	Chwei-Sen Wang, et al., Investigating an LCL Load Resonant Inverter for Inductive Power Transfer Applications, <i>IEEE Transactions on Power Electronics</i> , vol. 19, no. 4 (IEEE, July 2004), 995-1002 (“Wang-IEEE”)
1026	Excerpts from <i>Wiley Electrical and Electronics Engineering Dictionary</i> (2004)
1027	William H. Wilkinson, Integrated Hall Effect Sensor, <i>Journal of the Microelectric Engineering Conference</i> , vol. 3, iss. 1, art. 37 (1989), 215-220 (“Wilkinson”)
1028	Larry Dickerman & Jessica Harrison, A New Car, A New Grid, <i>IEEE Power & Energy Mag.</i> (Mar./Apr. 2010), 55-61 (“Dickerman”)
1029	U.S. Patent Application Publication No. 2010/0277121 A1 (“Hall”)
1031	SAE International, <i>SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler</i> , J1772 (rev. Jan. 2010) (“SAE Standards”)
1032	Excerpt from Frederick Emmons Terman, <i>Electronic and Radio Engineering</i> (4th ed. 1955) (“Terman”)

Ex.	Description
1033	Claire Weiller, <i>Plug-in Hybrid Electric Vehicle Impacts on Hourly Electricity Demand in the United States</i> , Energy Policy 39 (2011), 3766-3778 (“Weiller”)

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 ’184 patent at the time of the alleged invention, which I have been asked to assume September 9, 2011, 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 1-13 and 16 of the ’184 patent, as arranged in the claims, as follows:

1. Fells teaches or renders obvious every element of claims 1, 8, and 11.
2. Fells in combination with Cook teaches or renders obvious every element of claims 2-7, 9-10, and 16.
3. Fells, either alone or in combination with Ono, teaches or renders obvious every element of claim 12
4. Fells in combination with Cook and/or Wang Thesis teaches or renders obvious every element of claim 13

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 '184 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 '184 patent, and related prior art, from the perspective of such a person at the time of the alleged inventions. I understand that the '184 patent was filed on June 1, 2016, and claims priority to multiple applications, the earliest of which is a provisional application that was filed on September 9, 2011.

41. It is my opinion that a person of ordinary skill in the art in the 2011 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 September 9, 2011, 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 '184 patent and the prior art in the relevant time frame, which I have been asked to assume is September 2011. My opinions in this declaration apply that assumption, and reflect how a POSA would have viewed the '184 patent and the prior art in approximately September 2011, 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 '184 patent are directed to foreign object debris detection for a wireless power system that was 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 '184 Patent And Background

A. The '184 Patent

45. The '184 patent is titled "foreign object detection in wireless energy

transfer systems.” The patent describes wireless energy transfer and methods for detecting foreign object debris on wireless power transmission systems. ’184 patent, 1:16-19.

46. The ’184 patent does not claim to have invented a new type of wireless power transmission. Instead, it states that “[e]nergy or power may be transferred wirelessly using a variety of known radiative, or far-field, and non-radiative, or near-field, techniques.” ’184 patent 1:20-35. These known techniques included “wireless charging systems that rely on an oscillating magnetic field between two coupled resonators.” ’184 patent 1:36-53; 2:45-47.

47. The ’184 patent explains that when power is wirelessly transferred “between two coupled resonators,” foreign objects debris (FOD) located between the resonators can interfere with the operation of the system. ’184 patent 1:35-53. “Metallic objects and/or other objects inserted between the resonators may interact with the magnetic field of the wireless power transfer system in a way that causes the metallic and/or other objects to perturb the wireless energy transfer and/or to heat up substantially. ’184 patent 1:35-53; 2:1-13 (“some FOD may interact with the magnetic field in a way that may perturb the characteristics of the resonators used for energy transfer, may block or reduce the magnetic fields used for energy transfer, or may create a fire and or burning hazard. In some applications special precautions may be necessary to avoid combustible material objects becoming hot

enough to ignite during power transfer. Some metallic objects can heat up and have enough heat capacity to cause a burn or discomfort...”).

48. To avoid these problems, the ’184 patent states that wireless power transfer systems may detect the presence of foreign object debris and may turn the system off or down in response. ’184 patent, 1:41-53 (“users of wireless power transfer systems may wish to detect the presence of these ‘foreign objects’ and may wish to control, turn down, turn off, alarm, and the like, the wireless power transfer system”).

49. The ’184 patent describes two types of “methods and designs for detecting or mitigating the effects of FOD [foreign object debris] in the vicinity of the wireless energy transfer system.” ’184 patent 2:14-16, 3:32-46. The first is “passive mitigation techniques” such as placing a “cover” or “enclosure” around the system that may “keep FOD from entering the regions between resonators.” ’184 patent 3:32-46.

50. The second is “active mitigation” techniques that measure “perturbations in the magnetic field” around the resonators using “sensors and/or gradiometers” that are “positioned in the magnetic field.” ’184 patent, 2:20-26, 4:33-38.

51. The ’184 patent does not claim to have invented a new type of sensor. Instead, it explains that “any combination of sensors,” including known sensors

like “temperature sensors,” “electrical field sensors,” “magnetic field sensors,” “weight sensors,” “pressure sensors,” or “optical sensors,” can detect foreign object debris. ’184 Patent 7:60-8:4.

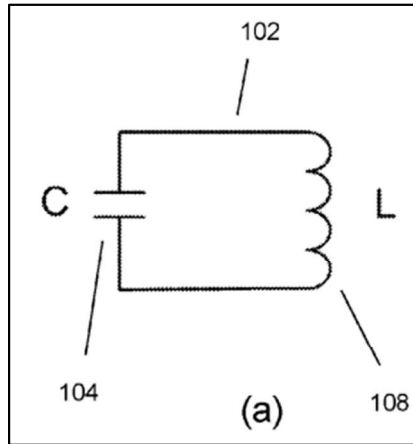
52. In one embodiment, the sensors comprise “loops of wire” connected to circuitry that measures the loops’ electrical characteristics — the voltage, current, and phase. ’184 patent, 2:26-34. The coil loops “develop an oscillating voltage in the presence of an oscillating magnetic field,” so that a connected “read out amplifier” detects whether, due to the presence of a foreign object, the magnetic field is non-uniform. ’184 patent, 8:6-21. “[I]f FOD is detected,” the system can then “decide whether to turn down or shut down the system.” ’184 patent, 11:38-39.

53. This technique can be applied to electric vehicle charging, and with electric vehicle charging, foreign object detection can be repeated at various times. ’184 patent, 11:22-50. First, before a vehicle even arrives at the source resonator, “low-power diagnostic tests can be performed without the vehicle present” to check for foreign objects. ’184 patent, 11:42-45. Then, after the vehicle is positioned over the source resonator but before it begins charging, the detector may “verify that the source is still free of FOD.” ’184 patent, 11:46-49. Finally, while charging, the detector can verify that no foreign object has “moved onto the coil.” ’184 patent, 1:49-50.

B. Background On Resonators

54. The '184 patent does not explain what a resonator is, or how one can be formed. It does not provide, for example, circuit diagrams, construction guidance, or other instruction on how to build a resonator. A POSA would not need the '184 patent to explain these things, because they were already well-known. For example, the '184 patent explains that “power may be transferred wirelessly using a variety of known radiative, or far-field, and non-radiative, or near-field techniques as detailed in commonly owned U.S. Patent application Ser. No. 12/613,686 published on May 6,2010 as U.S. 2010/010909445.”¹ '184 patent 1:20-35. That application, which I call “Kurs,” explains that “a resonator may be defined as a system that can store energy in at least two different forms, and where the stored energy is oscillating between the two forms.” Kurs [0085]. For example, a resonator can be formed from either a series or parallel connection of an inductor and a capacitor, as shown, for example, in Figure 6(a) below.

¹ I note that there appears to be a typographical error in the '184 patent, as it lists Kurs as patent publication number “2010/010909445.” Based on the matching serial number and publication date, it is clear to me, and would have been clear to a POSA, that this was intended to reference Kurs, which is publication number 2010/0109445.



Kurs Fig. 6(a); [0030] (resonator can be “a capacitively-loaded inductor loop”); [0135] (describing “minimal circuit model of an electromagnetic resonator” shown above).

55. A POSA would have understood that such electromagnetic resonators, and the way that they interact and exchange energy, was well-understood and described in various introductory textbooks on AC theory. For example, Dr. Frederick Terman’s seminal textbook *Electronic and Radio Engineering*, Fourth Edition (published in 1947) was directed to describing the “basic tools of the electronic and radio engineer” (Terman at Preface) and described the “elementary voltage, current, and impedance relations of series resonant circuits [that] are discussed in every book on alternating currents”:

Analysis of Series Resonant Circuit. The elementary voltage, current, and impedance relations of series resonant circuits are discussed in every book on alternating currents. The basic quantitative relations are listed below for convenient reference.

$$\text{Resonant frequency} = f_0 = \frac{1}{2\pi \sqrt{LC}} \quad (3-2)$$

$$Z_s = R + j\left(\omega L - \frac{1}{\omega C}\right) \quad (3-3a)$$

$$|Z_s| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} \quad (3-3b)$$

¹ The circuit Q can also be defined as

$$Q = 2\pi \frac{\text{energy stored in circuit}}{\text{energy dissipated in circuit during one cycle}} \quad (3-1)$$

This relation follows from the fact that the energy stored in the inductance L when the current I is maximum (i.e., when all the stored energy is in the inductance) is $I^2L/2$, where I is the peak current. At the same time, the energy lost per cycle in the circuit resistance R is $I^2R/2f$, where f is the frequency.

$$\tan \theta = \frac{\omega L - (1/\omega C)}{R} \quad (3-4)$$

$$I = \frac{E}{Z_s} = \frac{E}{R + j[\omega L - (1/\omega C)]} \quad (3-5)$$

$$\text{Current at resonance} = I_0 = \frac{E}{R_0} \quad (3-6)$$

$$\text{Voltage across inductance} = j\omega LI \quad (3-7a)$$

$$\text{Voltage across capacitor} = \frac{-j}{\omega C} I \quad (3-7b)$$

where E = voltage applied to circuit

I = current flowing in circuit, amp

f = frequency, cycles

$\omega = 2\pi f$

$Q = \omega L/R$

R = total series resistance of tuned circuit

L = inductance, henrys

C = capacitance, farads

Z_s = impedance of series circuit

θ = phase angle of impedance

Subscript ₀ denotes values at resonant frequency

Terman 45-46; *see also generally* Terman 44-50 (providing further information on series resonant circuit behavior).

56. Dr. Terman similarly described the related “fundamental relations” for parallel resonant circuits, where an inductance branch is formed in parallel with a capacitance branch:

The fundamental relations of a parallel resonant circuit are derived in every introductory book on a-c circuit theory, and are listed below for convenient reference.

$$\text{Parallel impedance} = Z = \frac{Z_c Z_L}{Z_c + Z_L} = \frac{Z_c Z_L}{Z_s} \quad (3-9)$$

$$\text{Line current} = \frac{E}{Z} \quad (3-10)$$

$$\text{Inductive branch current} = \frac{E}{Z_L} = \frac{E}{R_L + j\omega L} \quad (3-11)$$

$$\text{Capacitive branch current} = \frac{E}{Z_c} = \frac{E}{R_c - (j/\omega C)} \quad (3-12)$$

where E = voltage applied to circuit

$Z_c = R_c - (j/\omega C)$ = impedance of capacitive branch

$Z_L = R_L + j\omega L$ = impedance of inductive branch

$Z_s = Z_c + Z_L$ = series impedance of circuit

Z = impedance of circuit when connected in parallel

$R_s = R_c + R_L$ = total series resistance of circuit

$\omega = 2\pi$ times frequency

$Q = \omega L/R_s$ = circuit Q

These equations are fundamental to every parallel circuit, irrespective of the circuit Q , the frequency, or the division of resistance between the branches.

Terman at 51-52; *see also* Terman at 53-57 (providing further information on series resonant circuit behavior).

57. Dr. Terman also provided the physics and equations relating to mutual coupling of coils that are in separate circuits (*see generally* Terman at 19-21, 53-

77) as well as more specifically the “Behavior of systems involving resonant primary and resonant secondary circuits” (*see generally* Terman at 63-72).

C. The Challenged Claims

58. The '184 patent recites two independent claims, claims 1 and 16, and fourteen dependent claims, claims 2-15.

59. Claim 1 recites the following requirements, with designations I have added in brackets for reference to different parts of the claim:

[1pre] A wireless energy transfer system with foreign object debris detection, the system comprising:

[1a] a wireless energy transfer source comprising a source resonator configured to generate an oscillating magnetic field; and

[1b] a foreign object debris detection system comprising:

[1c] at least one magnetic field sensor; and

[1d] at least one readout circuit configured to measure one or more electrical parameters of at the at least one magnetic field sensor,

[1e] wherein the at least one magnetic field sensor is positioned within the magnetic field of the wireless energy transfer system; and

[1f] wherein the foreign object debris detection system is configured to verify that foreign object debris has not moved onto or over the source resonator during generation of the oscillating magnetic field.

60. Similarly, Claim 16 recites the following elements with designations I've added in brackets for reference to different parts of the claim:

[16pre] A method of detecting foreign object debris in a wireless energy transfer system, the method comprising:

[16a] performing a health and/or status check of a source resonator of the wireless energy transfer system

[16b] verifying that no foreign object debris has moved onto or over the source resonator;

[16c] positioning a vehicle over the source resonator;

[16d] verifying that no foreign object debris has moved onto or over the source resonator;

[16e] generating an oscillating magnetic field using the source resonator to transfer energy wirelessly to the vehicle to charge a battery of the vehicle; and

[16f] verifying that no foreign object debris has moved onto or over the source resonator during the transfer of energy.

D. Prosecution History

61. I have reviewed the prosecution history of the '184 patent ('184 FH, Ex. 1002), and understand that none of the prior art that I discuss in this declaration (i.e. Fells, Cook, Ono, or Wang Thesis) was discussed by the Patent Applicant or the Examiner.

VII. Claim Construction

62. 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 '184 patent.

63. 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 '184 patent under any reasonable construction of the claim terms.

VIII. Overview of the Prior Art

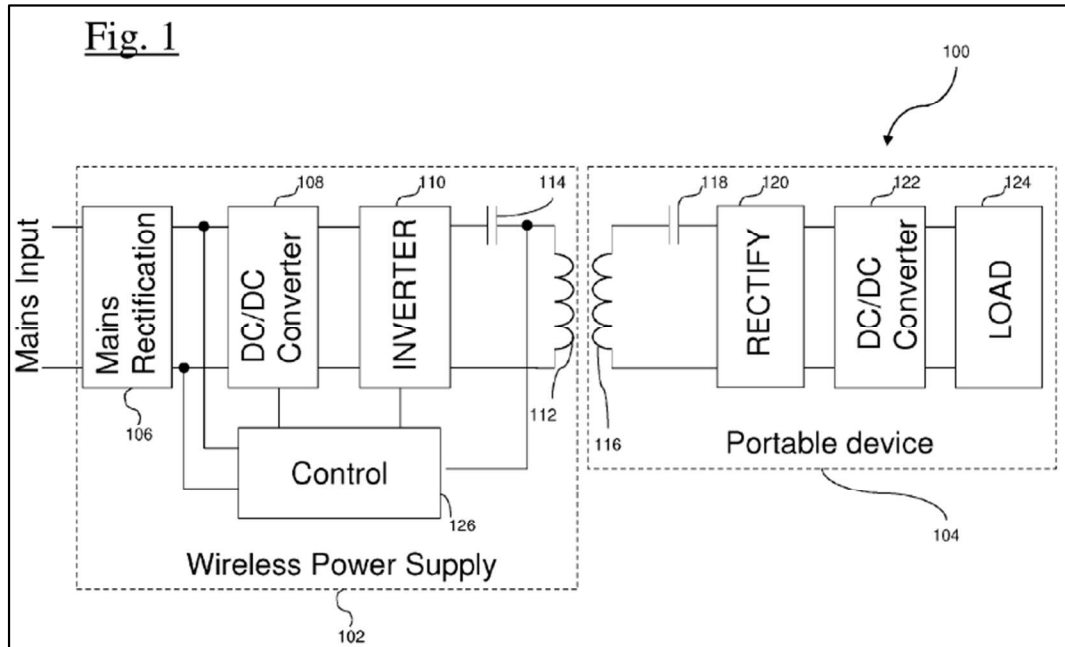
64. I have been informed that the documents described in this section constitute prior art to the '184 Patent. I am not a lawyer and do not purport to be an expert in determining whether a document constitutes prior art.

A. Fells (Ex. 1005)

65. U.S. Patent Application Publication No. 2010/0084918 to Julian Andrew John Fells and David W. Baarman ("Fells") was filed on October 2, 2009 and published on April 8, 2010.

66. Fells is titled "Power System," and describes a "wireless power supply." Fells [0007]. Fells is like the '184 patent in that it describes a "wireless power system" that transfers energy from one coil to another using "electromagnetic induction." Fells [0189], [0191].

67. Fells begins by showing “an example of a wireless power system” that “uses electromagnetic induction,” as was already known in the prior art. Fells [0189].



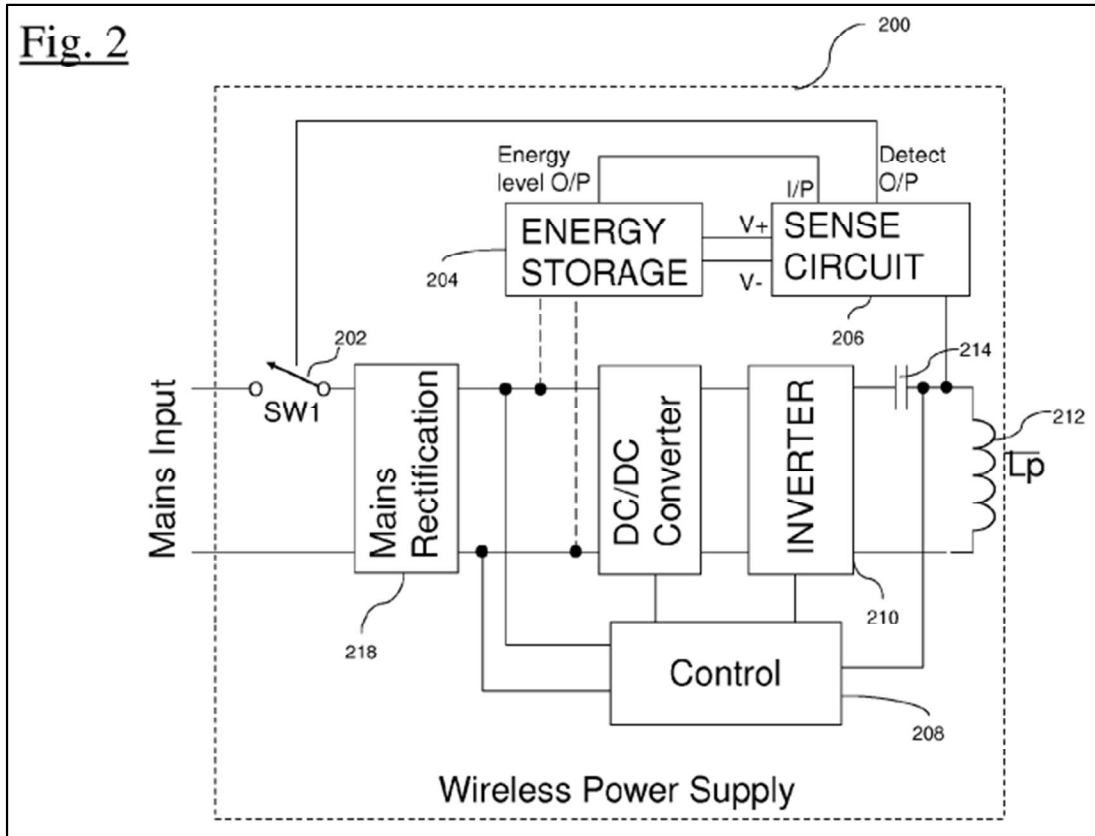
Fells Fig. 1; *see* Fells [0143], [0189]. The “wireless power supply ... takes electrical power and transmits this power to a portable device.” Fells [0189]. More specifically, “the charger takes an AC electrical input from the mains,” which is “rectified using a mains rectifier to produce DC power.” Fells [0189]. That DC power “is down-converted to a lower voltage,” and the down-converted voltage “is used to drive an inverter.”² Fells [0189]. The inverter “generates an AC voltage

² For ease of readability, capitalization is normalized when quoting from the Fells reference.

which is applied to [a] tank circuit,” or resonator, made of “capacitor 114 and a primary coil 112.” Fells [0189]. The portable device also includes a resonator, as it “has a secondary coil 116, and sometimes a resonant capacitor 116, which couples to the primary coil 112, thereby producing a voltage.” Fells [0189]. The “load” shown in Fells’ portable device “is representative of the power-requiring parts of the portable device,” including “for example the battery and charging circuit.” Fells [0189]. A “control element” in the wireless power supply “is used to adjust the DC/DC converter 108 to regulate the coil voltage and generate the pulse width modulated signals for the inverter,” and also “may be used for device detection and to detect the presence of foreign objects which could adversely affect operation.” Fells [0189].

68. The remainder of Fells does not discuss the “portable device,” but describes alternative arrangements and improvements to the wireless power supply. Thus, a POSA would have understood that the wireless power supply described throughout Fells wirelessly transmits power from its primary coil to the secondary coil of a portable device in substantially the same manner described for Fells’ Figure 1 and in paragraph [0189].

69. Fells’ Figure 2 describes a version of the wireless power supply that is similar to Figure 1, but adds “a switch an energy storage unit ... and a sense circuit.” Fells [0191].



Fells Fig. 2. These added components allow the wireless power supply to enter a “standby” mode, also called “Ultra Low Power or ULP mode” in which the switch SW1 “is open, so that no power is drawn from the mains.” Fells [0191]. In ULP mode “the only power drawing element is the sense circuit 206.” Fells [0191].

70. The sense circuit “detects when an object is placed in (or removed from) the proximity of the wireless power supply.” Fells [0191]. If an object is placed nearby or removed from the wireless power supply, switch SW1 is closed “allowing the circuits in the wireless power supply 200 to receive power.” Fells [0191]. The wireless power supply’s “control element” then determines “i) whether there is a valid device present, ii) if there is a valid device whether it

desires power, [and] iii) whether there is a foreign object present.” Fells [0191]. “If there is a valid device requiring power” and “no foreign objects [are] present,” the wireless power supply’s “control unit 208 will activate the inverter 210 to supply current to the tank circuit, which includes the primary coil 212 and capacitor 214, to deliver power to the portable device.” Fells [0191].

71. The remainder of Fells describes various ways to implement the components of the wireless power supply shown in Fig. 2. *See, e.g.* [0197] (“Fig. 4 shows one way of implementing the sense circuit”); [0198] (“Fig. 5 shows the sense circuit using one type of oscillator...”); [0206] (“Fig. 7 illustrates by example how the ultra low power circuit 700 interacts with the main wireless power circuit”); [0256] (“Fig. 23 shows an alternative embodiment in which a single processor 3202 is used instead of separate processors”); [0264] (“one implementation of a sense circuit using a microcontroller unit”); [0288] (“in the embodiment illustrated in Fig. 40, a sense circuit that acts as a proximity detector is used”). A POSA would have understood from reading Fells, however, that each of these “examples” or “embodiments” uses the same basic components of Fig. 2 (except where otherwise specified) and wirelessly transfers power from the power supply to a portable device in the same manner described for Fig. 2. *See generally* Fells [0189], [0191]-[0305]. For example, Fells describes all of these various configurations and examples, collectively, as “the current embodiment of the

invention.” Fells [0305].

E. Cook (Ex. 1006)

72. U.S. Patent Application Publication No. 2009/0299918 to Nigel P. Cook and David F. Allred (“Cook”) was filed on May 28, 2008 and published on December 3, 2009.

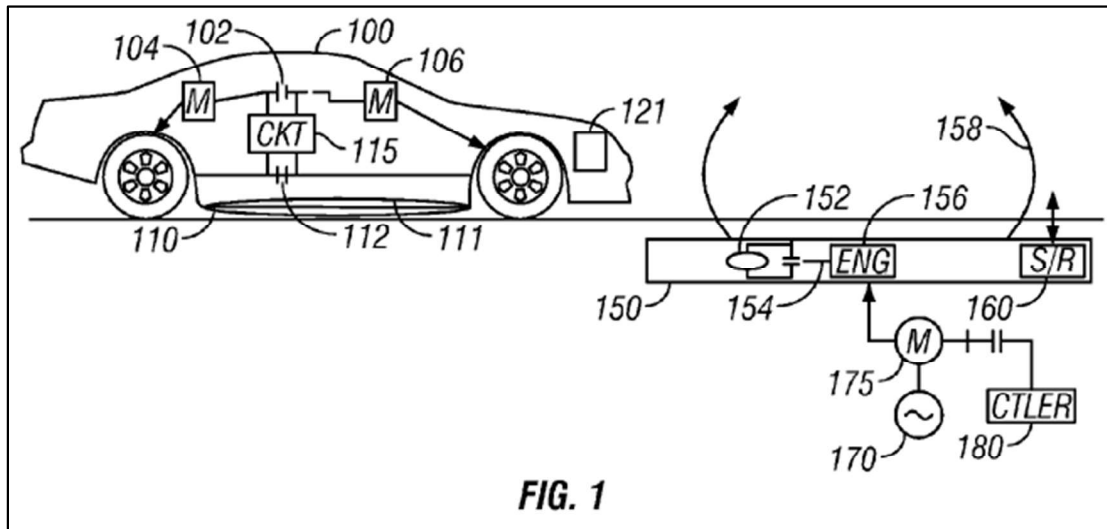
73. Cook is titled “[w]ireless delivery of power to a mobile powered device.” Cook, Title. Like the ’184 patent and Fells, Cook describes that “wireless delivery of power may be used to provide power to a load,” including by “forming a magnetic field and receiving a magnetic field in a resonant antenna that is resonant with at least one characteristic of a magnetic field. The power transmission may also be done inductively.” Cook [0001].

74. Cook describes a “system that automatically detects the presence of an automobile [and] can operate wirelessly to recharge the battery therein.” Cook, Abstract, Title, [0002] (“The present application describes wireless delivery of power to a mobile powered device such as an automobile”).

75. As Cook explains, POSAs at the time understood that “[d]elivery of electric power to automobiles may become more prevalent as electrically powered automobiles enter and occupy a more significant portion of the market.” Cook [0006]. As electric vehicles became more popular, “it may be desirable to wirelessly deliver power to an electric powered mobile device, such as an

automobile.” Cook [0008].

76. To accomplish this, as shown below, Cook teaches a “[c]harger 150” that includes “a coil 152, a capacitor 154, and a charging circuit 156 that produces signal of appropriate frequency for magnetic transmission.”



The charger “may produce a magnetic field shown generally as 158. Whenever an appropriate vehicle comes into range of the magnetic field 158, it may receive power from that magnetic field, and hence be charged thereby.” Cook [0013]. Cook’s claims make clear that the coil 152 and capacitor 154 of the charger can constitute “a magnetically resonant antenna which includes an inductor and a capacitor, and has a Q value greater than 1000.” Cook Claim 6; *see* Claim 8 (“supplying magnetically resonant power via said wireless transmitter); Claim 13 (“said wireless transmitted supplies power using a magnetically resonant antenna which includes an inductor and a capacitor, and has a Q value greater than 1000”).

77. As shown in Figure 1 above, Cook also teaches an “electrically powered automobile [that] includes at last one battery 102.” Cook [0009]. The battery “may be the primary power source of the automobile,” such as by “driving an electric motor 104, 106 which may drive vehicle wheels.” Cook [0009]-[0010]. Or the battery may “operate at least one electronic mobile system of the automobile.” Cook [0009].

78. The automobile “also includes at least one magnetic resonant antenna shown as 110 formed from an inductive loop 111 in parallel with a capacitor 112.” Cook [0011]. This “forms an LC circuit with a relatively high Q, for example a Q that is higher than 1000.” Cook [0011]. The antenna “receives a magnetic signal” from a “transmitter,” such as the charger, and has a “receiving circuit 115 [that] converts that power into output current,” which can be used “for directly driving the motors 104, 106 but more preferably is used for charging the battery 102.” Cook [0011].

79. The charger “may be located within the ground near a parking space,” such the antenna of the vehicle “comes into range of [the] wireless charging circuit” when parked in that space. Cook [0011].

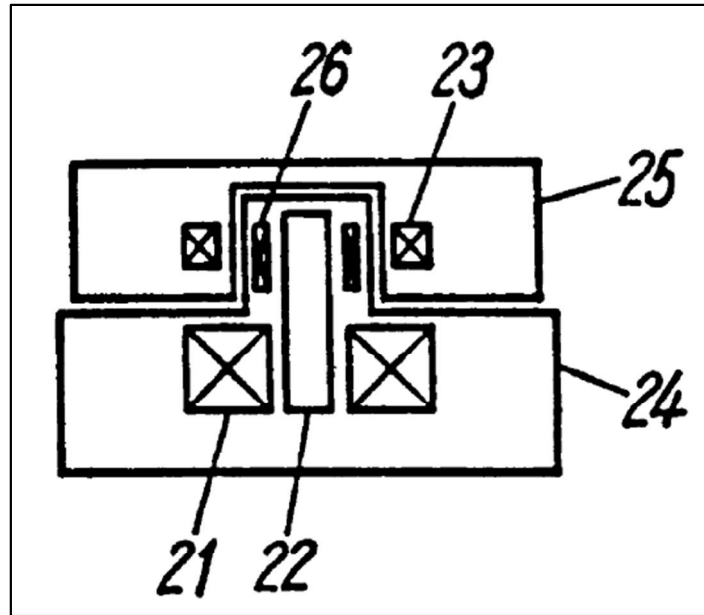
F. Ono (Ex. 1007)

80. U.S. Patent No. 6,075,433 to Makoto Ono, Yoshiyuki Nakai, Hideki Okura, and Satoru Taniguchi (“Ono”) was filed on March 12, 1999 and issued on

June 13, 2000.

81. Ono, like Fells and the '184 patent, describes a wireless power transfer system that has a “non-contact type power supply unit” that transfers power “from a primary side to a secondary side,” using “[m]agnetic coupling.” Ono 1:11-15, 2:40-53. Because “foreign objects” near or on the coils can result in “abnormal heating,” Ono discloses “installing a detector coil” for “the detection of foreign objects.” Ono 1:50-64, 4:3-14, 4:29-27. “[B]y monitoring the voltage of the detector coil ... it can be known whether” an object that is close by “is the secondary coil or some foreign object.” Ono 4:3-50.

82. Ono discloses that the two sides are “packed in separate enclosures that are completely independent from each other.” Ono 1:11-15. The primary coil and detector coil are mounted inside of a “primary enclosure 24,” while the secondary coil is in a separate “secondary enclosure 25.” Ono 4:25-26. The figure below shows the “detector coil 26” and “primary coil 21” both inside of “primary enclosure 24.” Ono 4:3-50.



Ono Fig. 2.

G. Wang Thesis (Ex. 1008)

83. The doctoral dissertation by Chwei-Sen Wang titled *Design Considerations for Inductively Coupled Power Transfer Systems* (“Wang Thesis”) states that it was authored in 2004. Wang Thesis, Cover. A stamp on the second page of the document states that it was processed by the University of Auckland Library in October 2005.

84. Like the ’184 patent (as well as Fells and Cook), Wang Thesis discloses using “inductively coupled power transfer (ICPT) 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,” such as in a “contact-less vehicle battery charger.” Wang Thesis 3.

85. Wang Thesis is divided into multiple chapters in which the later

chapters build on the findings of the earlier chapters, as a POSA would have known was common in doctoral theses. The first two chapters offer an “Introduction” and “Overview” of inductively coupled power transfer systems. Wang Thesis v-vi. Chapter Three “develop[s] a general load model” for ICPT systems, and “validates the theoretical load model” by “designing” a “contact-less electric vehicle battery charging system.” Wang Thesis vi-vii, 71. Chapter Four lays out in more detail this “design methodology for an ICPT system.” Wang Thesis vii. Chapters Five and Six describe ways to “improve power transfer” using “tuning” in fixed- or variable- frequency systems. Wang Thesis viii. Chapter Seven conducts a “sensitivity analysis” using those proposed tuning improvements, and Chapter Eight designs and “LCL Resonant Inverter” for ICPT applications. Wang Thesis viii-ix. Chapter 9 offers “Conclusions and future Work.” Wang Thesis ix.

86. Wang Thesis offers a thorough and comprehensive background, history, theory, and application of using magnetically coupled resonators to wirelessly provide power to vehicle systems. It explains that the first such system was proposed “more than a hundred years ago,” and refined designs “suitable for practical industrial applications” were known as early as 1994. Wang Thesis 1-4.

87. Wang Thesis explains, as a POSA would have known, that the “fundamental structure” of such a system is “primary” coil connected to a “secondary” coil via “electromagnetic coupling.”

1-2 FUNDAMENTAL STRUCTURE OF ICPT SYSTEMS

The block diagram of an ICPT system is shown in Fig. 1-4. The system can be separated into six subsystems that include the switching power supply, the primary compensation, the electromagnetic coupling, the secondary compensation, the secondary switching controller and the load.

The power source of an ICPT system is usually the electric utility supplying voltage and current at a line frequency of 50 or 60Hz, single or three phases. For portable applications, the power source can be a battery supplying dc voltage and current.

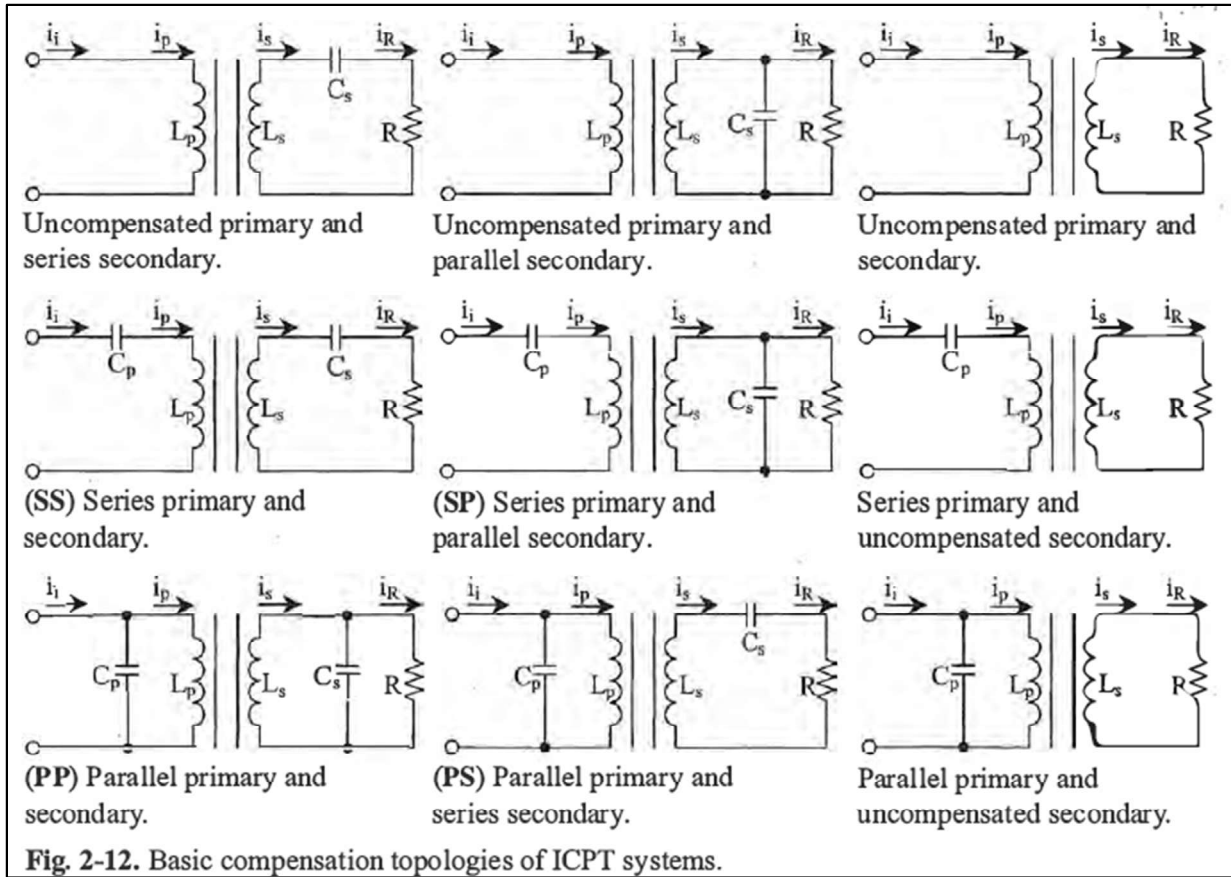
In order to increase the amount of power transferred via the electromagnetic structure in a practical ICPT system, the power supply is used to provide high frequency voltage and current (normally above the audible range). The reactance of both the primary and secondary windings increases in proportion to increases in the operating frequency, and as such is normally compensated by capacitors. A secondary switched mode controller may be used to control the power flow to the load.



Fig. 1-4. The block diagram of an ICPT system.

Wang Thesis 4. Each coil is normally “compensated” by the inclusion of a capacitor connected to it, either in series or in parallel, creating a resonant circuit.

Wang Thesis 4, 15-20 (basic structure), 20-21 (secondary compensation and resonance), 22-24 (primary compensation and resonance). The combination of uncompensated, parallel-compensated, or series-compensated circuits “results in nine fundamental compensation technologies” for ICPT systems:

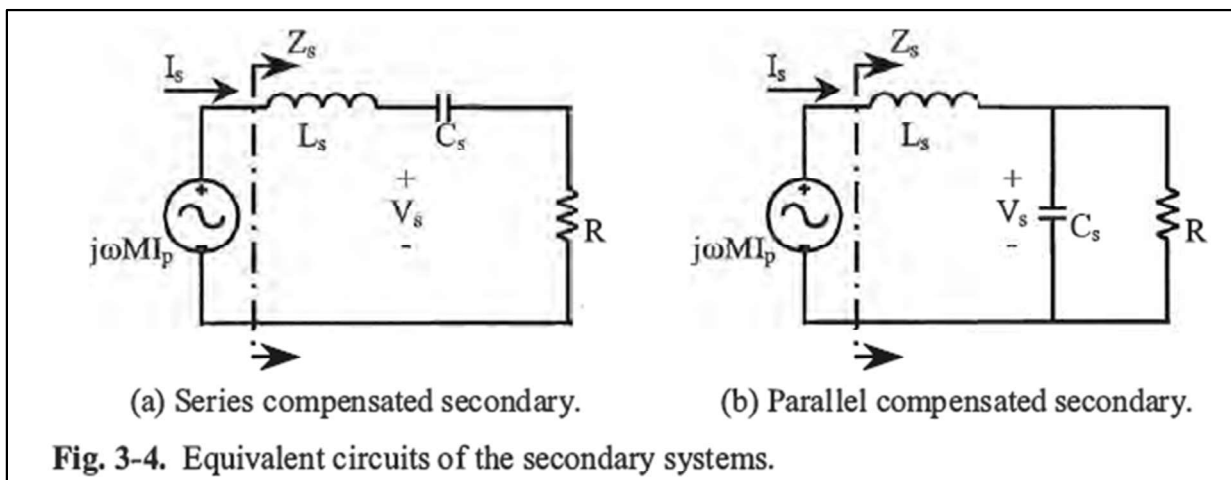


Wang Thesis 24.

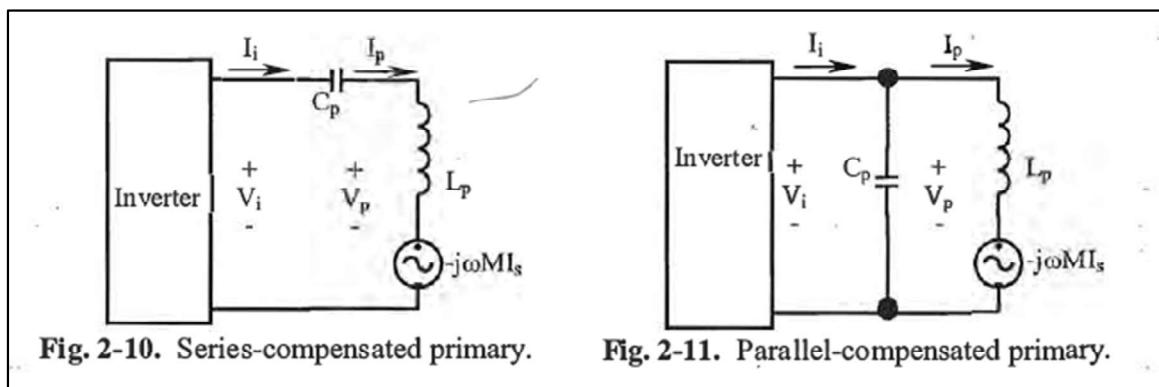
88. After introducing the basic “topologies” of an ICPT system, Wang Thesis describes the operation of such a system in more detail. “ICPT systems are normally designed to deliver power from a stationary primary source to one or more movable secondary loads (pickups) over large air gaps via magnetic coupling.” Wang Thesis 47. “In such a system, the primary resonant circuit is magnetically coupled with one or more secondary circuits that supply power to a load.” Wang Thesis 47. “Both the primary and pickup secondary are often compensated using capacitors connected in series or parallel to booster the power

transfer capability while minimizing the VA rating of the power supply.” Wang Thesis 47.

89. Wang Thesis then “develops a model to generally quantify the characteristics” of such a system, in order to “better facilitate the design of an ICPT system.” Wang Thesis 47. The model provides “equivalent circuits of series and parallel compensated secondary” “resonant circuits,” as shown below.



Wang Thesis 51; *see* Wang Thesis 20-22, 47-51 (describing “secondary resonant circuit”). The model similarly provides series and parallel equivalent circuits for a primary resonant circuit:



Wang Thesis 23; *see* Wang Thesis 22-24, 54-66 (describing primary resonant circuit). Formulas are provided in order to calculate the “operating conditions for maximum power transfer” from primary to secondary. Wang Thesis 61-62.

90. Wang Thesis then “validate[s] the theoretical load model” by designing “a contact-less electric vehicle battery charging system.” Wang 71-74. The designed system “delivers 30kW across a 45mm air gap at a nominal frequency of 20 kHz with a primary current I_p of 150A.” Wang Thesis 71. This system was designed “using the design methodology proposed in” Chapter 4.

91. Chapter 4 explains, as a POSA would have known, that “optimization and design of an ICPT system relies strongly on experience and experimental verification.” Wang Thesis 77. Designing a wireless resonator-based power transfer system requires “suitable design choices for the operating frequency, the primary current, the electromagnetic structure, the primary and secondary compensation, the pickup regulator, and the high frequency switching power supply.” Wang Thesis 77. These variables are related in the below formulas that determines the overall “power transfer capability” of the system:

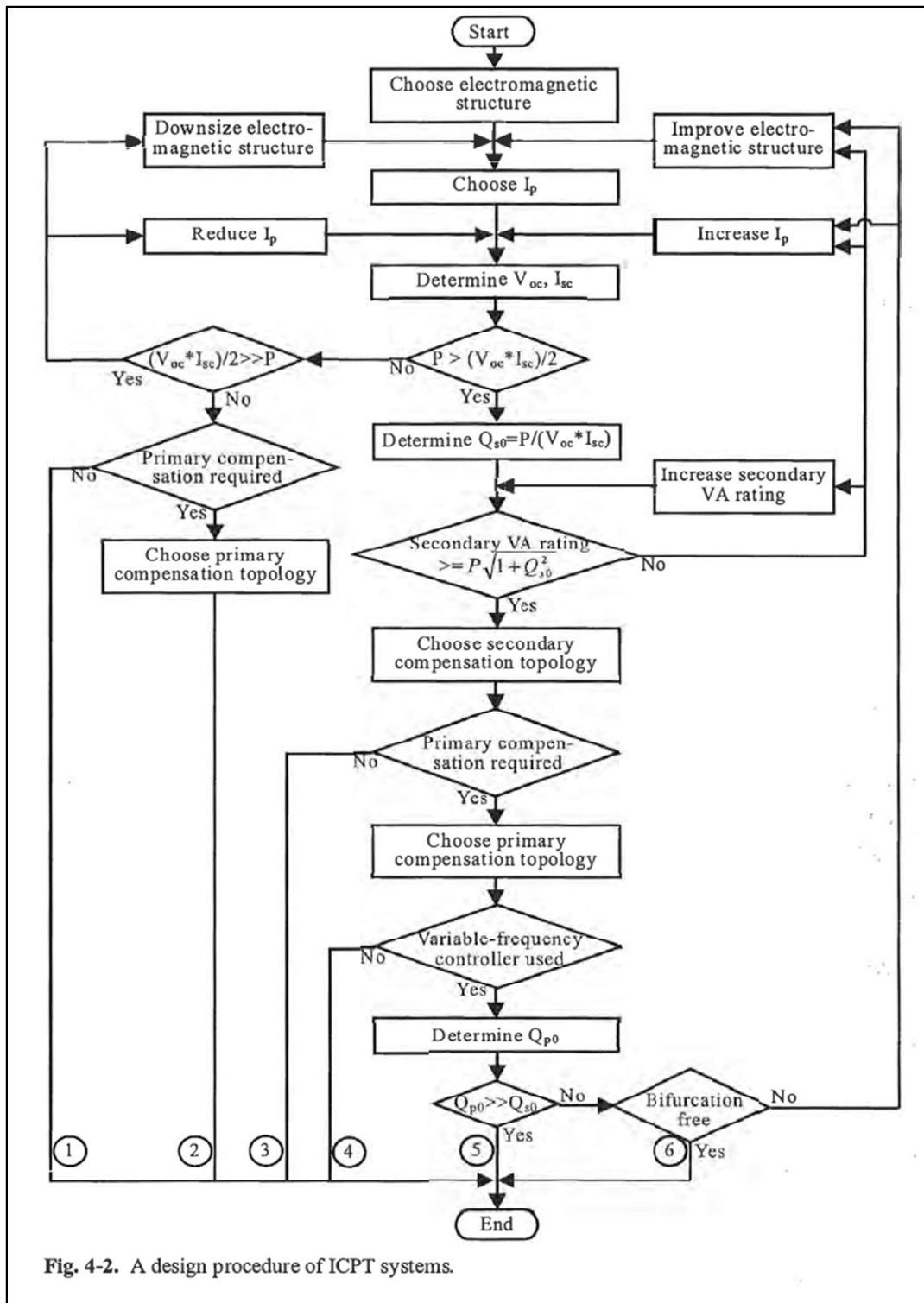
4-2 A DESIGN PROCEDURE

The power transfer capability of a compensated pickup in an ICPT system (developed in section 2-3.2) was determined as:

$$P = V_{oc} I_{sc} Q_{s0} = \omega_0 I_p^2 (k^2 L_p) Q_{s0} = \omega_0 I_p^2 \left(\frac{M^2}{L_s} \right) Q_{s0} \quad (4-1)$$

Wang Thesis 77. By selecting these variables appropriately, a POSA would be able to use the formulas and procedures laid out in Wang Thesis to achieve their desired “controllable power transfer capability over a specified operating range with minimum total cost.” Wang Thesis 77-79.

92. Specifically, Wang Thesis explains that a POSA can “achieve the desired power” in an ICPT system by adjusting “four major design factors: the operating frequency (ω_0), the primary current (I_p), the magnetic design factor ($k^2 L_p = M^2 / L_s$) and the secondary quality factor (Q_{s0}).” Wang Thesis 79. The thesis then provides a flowchart of an “iterative design procedure” that can be used to select and adjust these “design factors” to develop a functional ICPT system with the desired total output:



Wang Thesis 80. By following the flowchart and “design procedures” laid out in Wang, a POSA would have been able to design an ICPT system to achieve a

particular desired power by adjusting the “design factors” discussed. *See Wang Thesis* 108. This includes power supply systems of up to 30kW, as discussed in Sections 3-11 and 4-6. *Wang Thesis* 71-72, 105-110.

IX. Ground 1: Claims 1, 8, and 11 would have been obvious over Fells

93. For the reasons discussed below, it is my opinion that Fells teaches or renders obvious each claim element as arranged in claims 1, 8, and 11 of the ’184 patent.

94. Specifically, Fells teaches every element of claims 1, 8, and 11.

95. However, to the extent anyone may argue that Fells does not teach certain elements, I explain below that these elements also would have been obvious to a POSA reading Fells, in view of Fells’ disclosures and a POSA’s knowledge.

A. Independent Claim 1

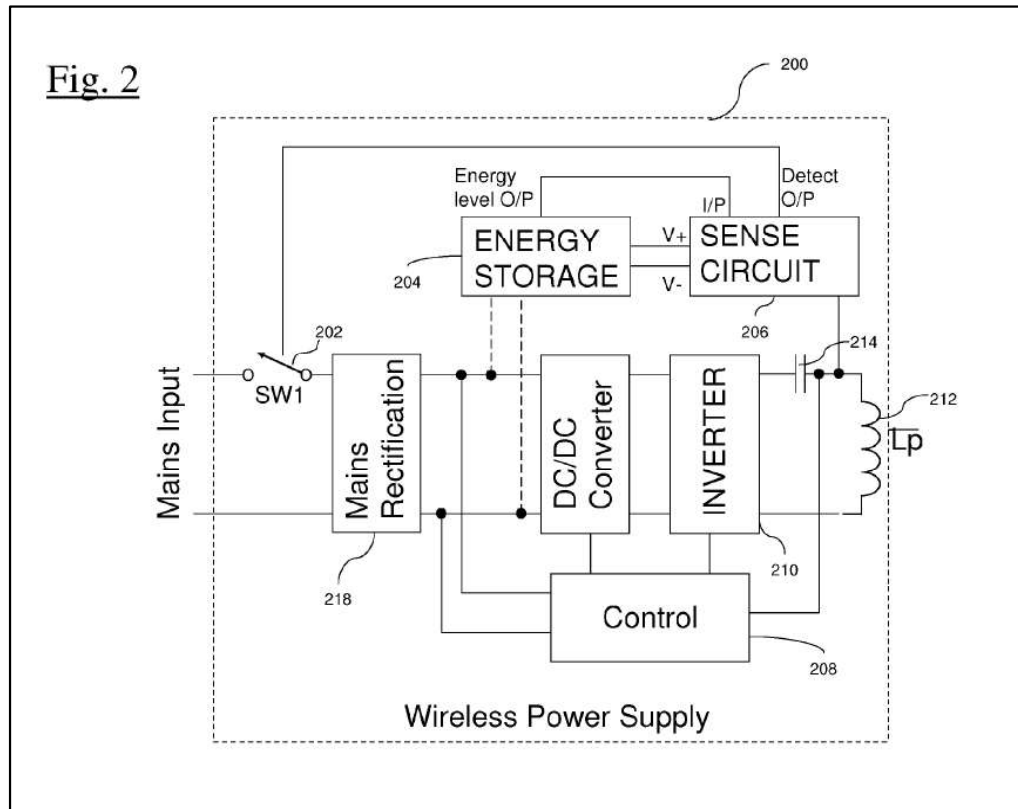
1. Element 1[pre]: Preamble

96. The preamble of Claim 1 recites “[a] wireless energy transfer system with foreign object debris detection, the system comprising.” Fells teaches this.

97. As I discussed in my overview, Fells is titled “Power System,” and discusses a system in which a resonator-based power supply is used to wirelessly transfer to a portable device that also contains a resonant circuit. *See Overview of Fells; Fells* [0189], [0191], Figs. 1-2. This system discloses to a POSA the claimed “wireless energy transfer system with foreign object debris detection.”

98. Specifically, Fells’ system consists of a “wireless power supply” that

“deliver[s] power” to a “portable device,” and also detects whether “a foreign object [is] present.” Fells Title, [0191]. Fells’ wireless power supply has “a capacitor... a primary coil ... and a control unit,” in addition to a “sense circuit,” as the figure below shows. Fells Title, [0191].



Fells Fig. 2.

99. The wireless power supply can enter into a “standby” mode, also known as “ultra low power or ULP mode.” Fells [0191]. In this mode, switch SW1 “is open, so that no power is drawn from the mains. In this mode, the only power drawing element is the sense circuit 206.” Fells [0191].

100. The sense circuit of the wireless power supply “detects when an object

is placed in (or removed from) the proximity of the wireless power supply.” Fells [0191]. The sense circuit is powered by the energy storage element 204. Fells [0191]. If the sense circuit “detects that an object has been placed on (or in proximity to) the wireless power supply 200, then SW1 202 is closed allowing the circuits in the wireless power supply 200 to receive power.”

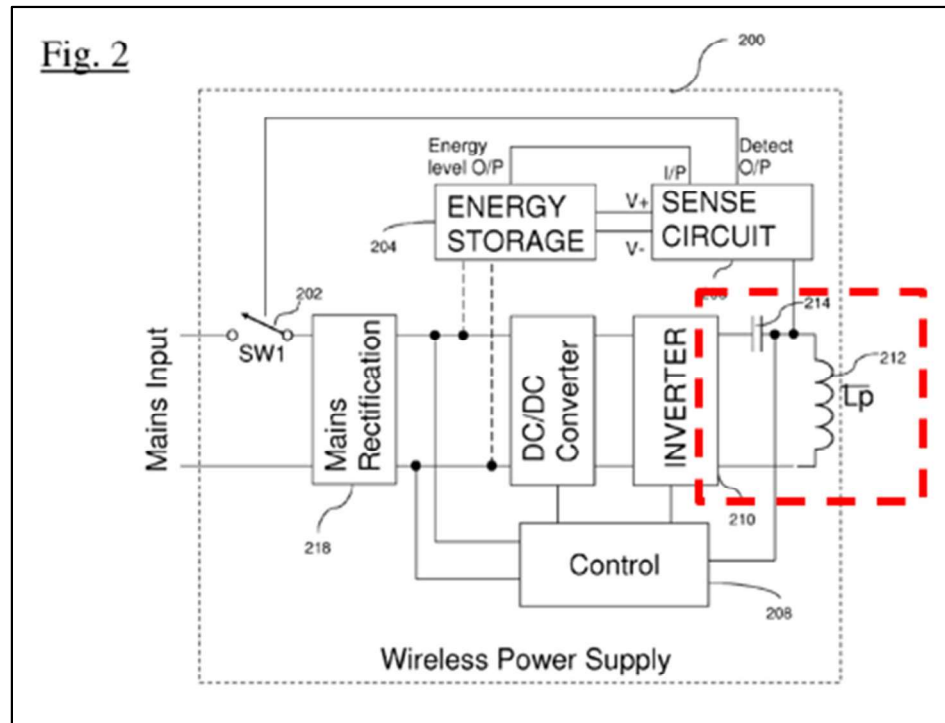
101. When the sense circuit has closed SW1, the control element then “determines i) whether there is a valid device present, ii) if there is a valid device whether it desires power, and iii) whether there is a foreign object present.” Fells [0191]. If “there is a valid device requiring power and no foreign objects present,” the control unit “suppl[ies] current to the tank circuit, which includes the primary coil 212 and capacitor 214,” that in turn wirelessly “deliver[s] power to” a “portable device.” Fells [0191].

2. Element 1[a]: Source Resonator

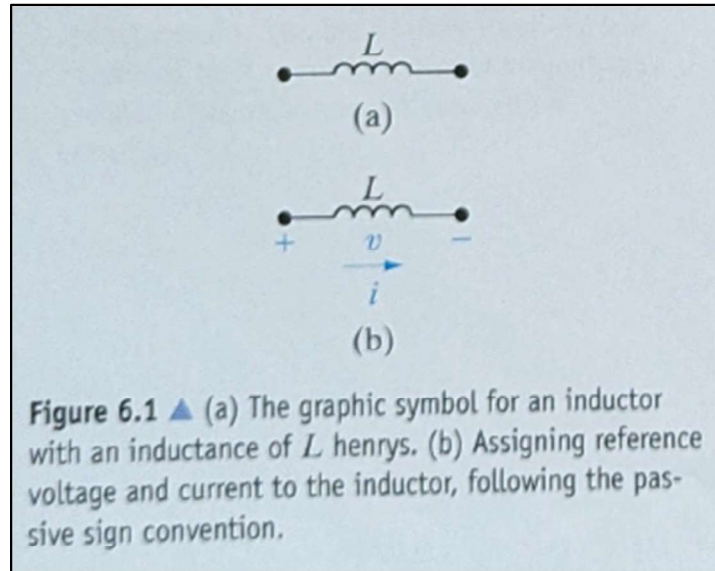
102. Claim 1 next recites “a wireless energy transfer source comprising a source resonator configured to generate an oscillating magnetic field.” Fells teaches this.

103. Specifically, Fells discloses a “wireless power supply 200,” shown below in Fig. 2, that corresponds to the claimed “wireless energy transfer source.” Fells [0191], Fig. 2. As I have annotated in Fig. 2 below, Fells’ wireless power supply has a “capacitor 214” connected to an inductor, “primary coil 212,” that

together form a source resonator. Fells [0191].



104. A POSA would have understood that Fells’ “primary coil 212,” also called L_p , is an inductor because it is described as a “coil,” represented with the symbol L , and shown schematically using a curled line, all of which are common indications of inductors in the electronic arts. For example, the introductory circuits textbook by Nilsson confirms this:



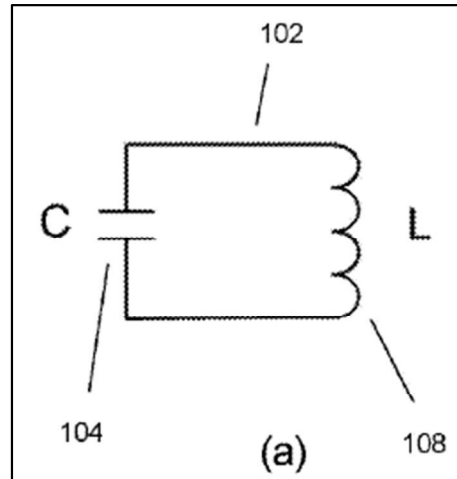
Nilsson 188.

105. A POSA would have understood that “capacitor 214” connected to an inductor, “primary coil 212,” forms a well-known type of resonator known as a “tank circuit,” or “LC tank circuit,” for multiple reasons.

106. First, Fells itself explains that capacitor 214 and inductive primary coil 212 form a “tank circuit.” Fells [0191] (“the tank circuit, which includes the primary coil 212 and capacitor 214...”). A POSA would have understood that a “tank circuit” is a resonator. For example, the *Wiley Electrical and Electronics Engineering Dictionary* defines a “tank circuit” as a “resonant circuit...” Wiley (Ex. 1026) at 771. The *McGraw-Hill Dictionary of Scientific and Technical Terms* similarly defines a “tank circuit” as “A circuit which exhibits resonance at one or more frequencies Also known as electrical resonator”). McGraw-Hill (Ex. 1023) at 2101. Other contemporaneous patents confirm the same. See Pernia (Ex.

1015) 17:66-18:4 (explaining that “inductance in series with a capacitance” is a “resonant LC tank”); McCorquodale (Ex. 1014) at 18:18-35 (describing “an inductor (L) and a capacitor (C) coupled to form an LC-tank” as a “resonator”), 2:51-64 (“a resonator, which may be implemented using one or more inductors or capacitors (as an ‘LC-tank’)”).

107. Second, Fells’ “tank circuit” is the same type of resonator shown in Kurs:



Kurs Fig. 6(a); *see* Kurs [0030] (“Fig. 6(a) shows a circuit diagram of one example of a resonator”). Kurs confirms that the combination of an inductive element and a capacitive element can be an “electromagnetic resonator”:

[0135] Electromagnetic resonators may include an inductive element, a distributed inductance, or a combination of inductances with inductance, L, and a capacitive element, a distributed capacitance, or a combination of capacitances, with capacitance, C. A minimal circuit model of an electromagnetic resonator **102** is shown in FIG. 6a. The resonator

Kurs [0135]. A POSA would have understood that Fells' primary coil 212 is an "inductive element," and its capacitor 214 is a "capacitive element," and so together they form an "electromagnetic resonator" as described in Kurs. A POSA would have understood that these are the same types of resonators described and claimed in the '184 patent, because the '184 patent incorporates Kurs by reference. '184 Patent 1:20-35; *see* Section VI, Overview of the '184 Patent.

108. Third, Fells itself uses the terms "resonant capacitor" and "resonant LC tank" to describe the same type of tank circuit shown in Figure 2, also referring to primary coil Lp 212 and/or capacitor 214. *See* Fells [0198]-[0200] (describing Fig. 5 and explaining that "frequency is determined by the resonant LC tank provided by Lp 212 and C1"), [0273] (describing Fig. 30 and the "resonant frequency of the capacitor-inductor combination"). A POSA would understand the description of these two elements together as a resonator also applies to Figure 2's capacitor 214 and primary coil 212, as well as other figures where those components appear in the same arrangement. Fells confirms this understanding because "[l]ike reference numerals are used throughout [Fells'] figures to designate similar components." Fells [0190].

109. A POSA would understand that Fells' resonant tank circuit is configured to generate an oscillating magnetic field, as the resonant circuit receives alternating current. Specifically, an inverter supplying alternating current drives

Fells' tank circuit resonator. Fells Fig. 2, Fells [0189] ("The inverter 110 generates an AC voltage which is applied to the tank circuit"), [0191] ("the control unit 208 will activate the inverter 210 to supply current to the tank circuit"); Fells [0108] (confirming that "mains" is AC by describing a "power supply for converting alternating current (AC) mains electricity to direct current (DC)"); *see also Wiley* at 391 (defining "inverter" as "chang[ing] a DC voltage to an AC voltage"). If there is a valid device that requires power and if no foreign objects are present, the control unit "will activate the inverter 210 to supply current to the tank circuit, which includes the primary coil 212 and capacitor 214, to deliver power to the portable device." Fells [0191]; *see also* Fells [0192] (describing power provided to portable device, Fells [0195] (describing power supply as a function of time); Fells [0248] (describing operation of a power system).

110. A POSA would have understood that when Fells' tank circuit resonator receives alternating current from the inverter, it generates an oscillating magnetic field, which is what allows the resonator to "deliver[s] power to the portable device." Fells [0191] (describing a wireless power supply where the inverter supplies current to the tank circuit to deliver power to a portable device), Fig. 2, [0295] (Fells' inductive coils "generate[s]" ... "magnetic field"). This is because an inductor such as Fells' primary coil 212 by its nature produces a changing or oscillating 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.

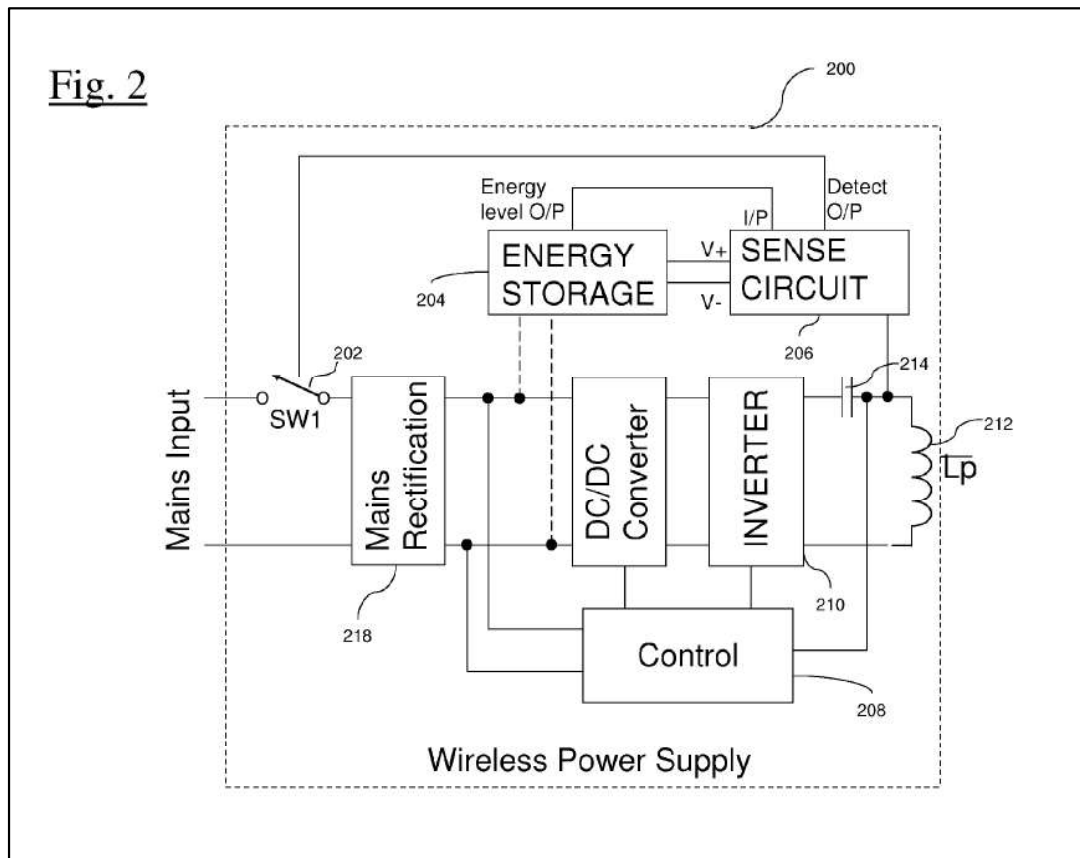
111. An inductor is a passive electronic component capable of storing electrical energy in the form of magnetic energy and traditionally uses a conductor wound into a coil. When electricity flows through the coil, it generates a magnetic field in a certain direction based on the direction of current flow through the coil. When AC current flows through the inductor, it creates an oscillating magnetic field. 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”). This oscillating magnetic field cuts across the windings of the secondary coil, creating an induced voltage in the secondary coil. This principle is what allows Fells’ portable device to wirelessly receive power from the AC-powered tank circuit resonator. Fells [0189]-[0191] (describing wireless power using electromagnetic induction to transmit power to a portable device). The ’184 patent’s “Background” section confirms this understanding, explaining that known “wireless charging systems” between “two coupled resonators” function by using “oscillating magnetic field.” ’184 patent 1:35-41.

3. Element 1[b]: Foreign Object Detection

112. Claim 1 next recites “a foreign object debris detection system.” Fells

teaches this.

113. Specifically, a POSA would have understood that Fells' "sense circuit," "control element," and related circuitry shown in the figure below correspond to the claimed "foreign object debris detection system." Fells [0191] (describing a sense circuit 206 and control element 208 in Figure 2.).



Fells Fig. 2.

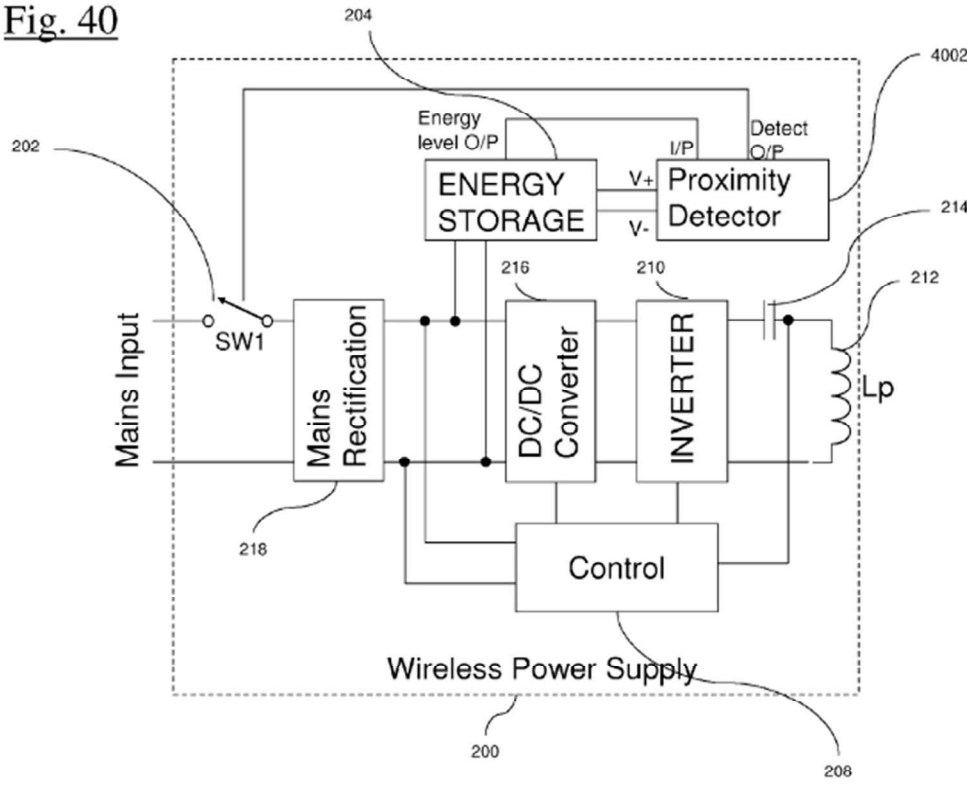
114. Fells' sense circuit "detects when an object is placed in (or removed from) the proximity of the wireless power supply." Fells [0191]. When an object is detected, a switch "is closed allowing the circuits in the wireless power supply 200 to receive power." Fells [0191].

115. When the switch is closed, the remainder of Fells' power supply, including the control element 208, receives power. Fells [0191]. The control element checks for three events. It first determines "whether there is a valid device present". Fells [0191]. If so, it then determines "whether [the device] desires power." Fells [0191]. Finally, it then determines "whether there is a foreign object present." Fells [0191]; *see also* Fells Fig. 18 (first checking whether "device requires power" and then checking whether a "foreign object [is] present"); Fig. 25 (checking whether "device [is] present?", then whether device "needs power?, then whether "foreign object [is present]?"). If "there is a valid device requiring power and no foreign objects present," the control unit "activate[s] the inverter 210 to supply current to the tank circuit ... to deliver power to the portable device." Fells [0191].

4. Element 1[c]: Magnetic Field Sensor

116. Claim 1 next recites that the foreign object debris detection system comprises "at least one magnetic field sensor." Fells teaches this.

117. Specifically, Fells discloses that sense circuit 206 can "act[] as a proximity detector," as further shown below in Fig. 40. Fells [0288] (describing "a sense circuit that acts as a proximity detector 4002").

Fig. 40

Fells Fig. 40. The proximity detector “is used to initially detect that a device or foreign object has been placed in the vicinity of the wireless power supply 200,” and also for detecting “if a device or foreign object is removed from the wireless power supply.” Fells [0288].

118. A POSA would have recognized that the version of Fells’ power supply shown in Fig. 40 is the same as the power supply shown in Fig. 2, merely replacing the label “Sense Circuit” with the label “Proximity Detector” to reflect that the sense circuit is “act[ing] as a proximity detector 4002.” Fells [0288], Fig. 2, Fig. 40. Thus a POSA would have understood that Fig. 40 is the same embodiment of the invention as Fig. 2. *See* Fells [0182] (“Fig. 40 shows an

embodiment of Fig. 2 using a proximity sensor”); [0305] (referring to entire “above description” as a single “current embodiment of the invention”).

119. Fells’ proximity detector can be either “an inductive proximity sensor” or a “Hall Effect sensor,” either of which alone discloses the claimed “magnetic field sensor.” Fells [0289], Fells Claim 11 (requiring that “detecting includes at least one of detecting a change in magnetic field indicative of presence of an object”).

120. First, Fells states that its “proximity detector” may be a “Hall effect sensor,” which measures “a change in voltage in response to a change in magnetic field.” Fells [0289]; *see also* Fells [0290] (“additional sense circuits that act as proximity detectors could include a Hall sensor”). A “Hall effect sensor” or “Hall sensor” was a type of magnetic field sensor well-known to POSAs that detects the presence and magnitude of a magnetic field, and outputs a voltage responsive to a change in that magnetic field. *See* Ferrazzin (Ex. 1018) at 219 (“A Hall effect sensor is essentially a transducer that responds with an output voltage proportional to the local magnetic field”); Wilkinson (Ex. 1027) at 215 (“Hall Effect sensors . . . produce a voltage proportional to the magnetic field through the circuit. They are used in . . . proximity detectors.”); Lenz (Ex. 1022) at 973, 979-980 (listing Hall effect sensor among “the most common technologies used for magnetic field sensing”).

121. Second, Fells’ “proximity detector” can be an “inductive proximity sensor” ... “formed using another coil in the wireless power supply 200 which is independent of the coil used to transfer power.” Fells [0288]-[0289]. Fells also refers to this as an “inductive bridge,” which a POSA would have understood to be a well-known circuit used to measure the unknown inductance of an object. Fells [0291]. A POSA would have understood that as a matter of basic electronics, a coil used as an “inductive proximity sensor” constitutes a “magnetic field sensor” because inductors respond to changes in magnetic fields. *See Nilsson 174* (“The behavior of inductors is based on the phenomena associated with magnetic fields”). The coil is placed “in the vicinity of the wireless power supply,” and when a “device or foreign object has been placed” in that area, the magnetic field will change, resulting in a change to the coil’s own inductance. That inductance can be measured, thereby indicating “that a device or foreign object has been placed” or “removed from the wireless power supply.” Fells [0288]-[0289]. The ’184 patent describes this same type of coil-based magnetic field sensor, describing that sensors for magnetic fields “may comprise loops of wire ... that generate an electrical signal *proportional to the amount of magnetic flux* crossing its surface.” ’184 patent 2:20-42.

5. Element 1[d]: Readout Circuit

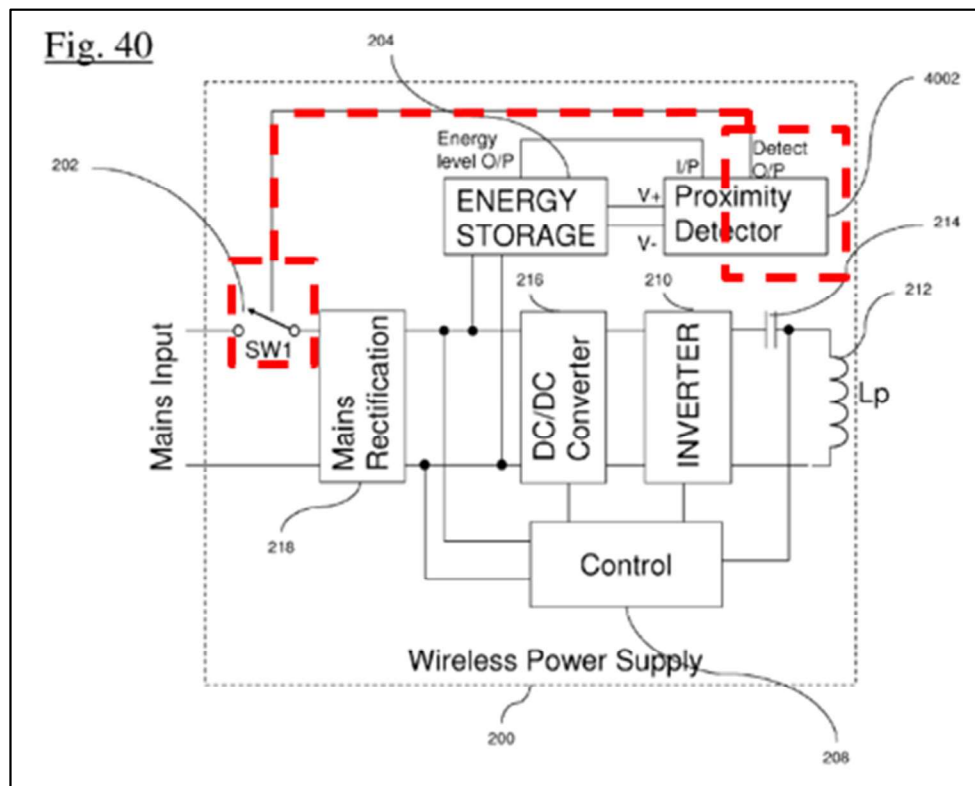
122. Claim 1 next recites “at least one readout circuit configured to

measure one or more electrical parameters of at the at least one magnetic field sensor.” Fells teaches this. In addition, as I explain below, to the extent not taught by Fells it would have been obvious to a POSA to implement Fells with a readout circuit that measures an electrical parameter of the magnetic field sensor.

123. Specifically, when Fells’ sense circuit – either the Hall Effect sensor or inductive proximity sensor – “acts as a proximity detector,” the electrical parameters of the sense circuit change in response to changes in the magnetic field created by the “place[ment]” or “removal” of a “device or foreign object.” Fells [0288]. That placement or removal will result in a “change in voltage” for the Hall Effect sensor and a “change of inductance” for the inductive proximity sensor. Fells [0288]-[0289] (describing a Hall Effect sensor), [0193] (discussing a sense circuit that “determine[s] if a change in inductance has taken place”). A POSA would have understood that the claimed electrical parameter is this change in voltage or inductance, and that the claimed readout circuit is the circuitry that measures this change by using the sensor’s detected voltage or inductance change to “detect” that “an object is placed in (or removed from) the proximity of the wireless power supply.” Fells [0191]; *see also* Fells, Cl. 11 (“detecting includes at least one of detecting a change in magnetic field indicative of presence of an object”), Cl. 56 (same).

124. For example and as shown in the figure below, Fells’ proximity

detector generates an output signal (depicted by the callout “Detect O/P”). Fells Fig. 40; *see* Fig. 2, [0288] (proximity detect “detect[s] that a device or foreign object has been placed in the proximity”). The claimed readout circuit comprises the circuitry within the proximity detector that generates that output signal in response to the Hall Effect sensor or the inductive proximity sensor, and/or the switch (“SW1”) that controls the circuit in response to that output signal. Fells [0288]-[0289] (describing a Hall Effect sensor), [0193] (discussing a sense circuit that “determine[s] if a change in inductance has taken place”); [0191] (describing how switch controls power to circuit based on operation of sense circuit).



Fells Fig. 40 (annotated). I note that Fells' disclosure that is described above is consistent with the '184 patent, where the "readout circuitry" is not described beyond the fact that it "measure[s] the voltages and/or the current" from sensors. '184 patent 2:30-53.

125. I understand that the claims of the '184 patent do not require any particular type of "readout circuit," and therefore it is sufficient that a POSA would understand that the proximity detector, the switch SW1, and/or the circuitry within the proximity detector that generates Detect O/P is sufficient even without further detail. I provide further detail below, however, because it is indicative of how a POSA would understand Fells' disclosure.

126. Because Fells states that its "proximity detector" is merely a version of its "sense circuit," a POSA would have understood that the proximity detector would be built using the same well-known circuitry used for other sense circuits described in Fells. For example, the "comparator" or "microcontroller" that compares the output of the magnetic field sensor to a reference value. Fells [0289] (describing functionality of the proximity sensor), [0258] ("The Fig. 2 embodiment includes ... a sense circuit 206 that includes an integrated microprocessor"), [0182] (Fig. 40 is further "embodiment of Fig. 2"); *see also* Fells Figs. 4-6 (showing circuitry configurations of sense circuit), [0197]-[0202] (describing same, including a "microprocessor unit" and "microcontroller"), [0257]-[0259]

(describing processors and control units, including for the embodiment shown in Figure 2), [0263] (same, using the flow diagram of Fig. 25, to describe circuitry such as switches, memory, and a processor)). A POSA would understand that a comparator, microcontroller, or operational amplifier would be connected to the Hall Effect sensor or inductive proximity sensor, in the same manner described in these other passages of Fells, to generate the “Detect O/P” signal and allow the sense circuit to open and close switch SW1 in response to measured changed in voltage or inductance.

127. All of the above describes how Fells teaches this claim element. Below, I further explain how, even if Fells did not teach this claim element, it would have been obvious to modify Fells to do so.

128. It would have been obvious to a POSA to implement Fells’ “proximity detector” to include an amplifier, comparator, or microprocessor as a readout circuit that measures either the voltage change of the Fells’ Hall Effect proximity sensor or the inductance change of the Fells’ inductive proximity sensor, and outputs the Detect O/P in response. As Fells explains, the sense circuit that detects devices or foreign objects in the vicinity can be adjusted to have “greater sensitivity” by “using amplifiers” or “higher voltage levels.” Fells [0266]; *see* [0289]-[0290], [0191]. A POSA would have desired and known how to obtain this increased sensitivity in proximity detection via “higher voltage levels” by

connecting an operational amplifier, comparator, or microprocessor to the proximity detector's output, in the same manner in which amplifiers, comparators, and microcontrollers were used to generate the "detect" signal in other exemplary sense circuits of Fells. *See also* Fells Figs. 4-6, 11, 24, 26, 28, 29 (showing circuitry configurations of sense circuit), [0197]-[0202] (describing same, including a "microprocessor unit" and "microcontroller"), [0257]-[0259] (describing processors and control units, including for the embodiment shown in Figure 2), [0263] (same, using the flow diagram of Fig. 25, to describe circuitry such as switches, memory, and a processor)). This could be accomplished, for example, with the use of well known 8-bit microcontrollers such as the "PIC12F510" disclosed in Fells. *See* Fells [0231] (implementing sense circuit using PIC12F510 microcontroller), Fig. 11 (same), [0230] (same), Fig. 22 (implementing sense circuit with "ULP processor"); *see also* Figs. 4-6, 11, 24, 26, 28, 29 (showing possible circuitry configurations of sense circuit). The use of amplifiers to increase the voltage of measured signals was a well-known practice to a POSA.

129. By implanting Fells' "detection circuit" to include an amplifier so that the detection circuit monitors the amplifier output, rather than the sensor output itself, the circuit would then be able to detect foreign objects that would have otherwise been too small or far away to create a measurable voltage or inductance

change. Fells [0011] (describing a “detection circuit”); *see also* Fells [0191] (describing that the sense circuit “detects when an object is placed in (or removed from) the proximity of the Wireless power supply”). Connecting amplifiers this way was within the skill of a POSA, and in fact, Fells describes the same arrangement in its other embodiments. Fells [0197]-[0202] (describing Figures 4-6), [0257]-[0259] (describing, among other things, processors used to implement the sense circuit), [0263] (describing the flow diagram in Figure 25), Figs. 4-6.

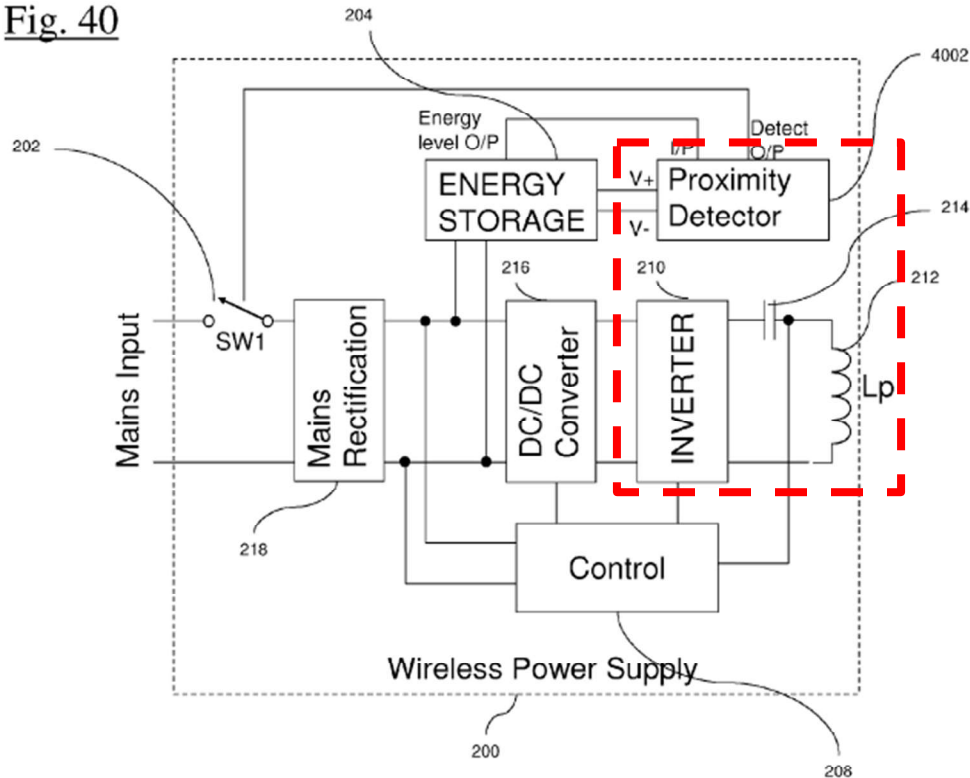
6. Element 1[e]: Position of Magnetic Field Sensor

130. Claim 1 next recites “wherein the at least one magnetic field sensor is positioned within the magnetic field of the wireless energy transfer system.” Fells teaches this. In addition, as I explain below, to the extent not taught by Fells it would have been obvious to a POSA to implement Fells with its magnetic field sensors placed within the magnetic field of the wireless energy transfer system.

131. Fells’ proximity detector works by detecting a “change in voltage [or inductance] in response to a change in magnetic field.” Fells [0289]. The proximity detector is positioned “within the magnetic field” as recited in the claim because, to enable the detector to detect a change in the magnetic field in the manner described in Fells, the detector must be positioned within the region covered by the magnetic field when activated. A POSA would have understood the Hall Effect sensor generates a “change in voltage ... in response to a change in

magnetic field” because the sensor was within the wireless energy transfer system’s magnetic field. *See McGraw-Hill* (defining “Hall effect” as “the development of a transverse electric field in a current-carrying conductor *placed in a magnetic field*”); *ASTM Dictionary* (Hall effect occurs when conductor is “placed in a magnetic field”). Likewise for an inductive proximity sensor, a POSA would have understood that its ability to detect the proximity of foreign objects is because the sensor “coil” was placed within the magnetic field. *See Fells* [0289].

132. A POSAs understanding of this is confirmed by Fells’ diagrams, which show Fells’ proximity detector located near to (and within the same circuit as) primary coil Lp 212. Because primary coil Lp 212 produces a magnetic field that could be negatively impacted by foreign objects, the sensors that make up the proximity detector must be within that magnetic field in order to detect those foreign objects. Fells Fig. 40, Fig. 2 (annotated and reproduced below).

Fig. 40

133. A POSA would further have understood that Fells' proximity detector is placed within the magnetic field generated by the primary coil because if it was not, the proximity detector would not be able to accomplish the goals described in Fells. Fells states that the purpose of the proximity detector is to "initially detect that a device or foreign object has been placed in the vicinity of the wireless power supply," and also "detects if a device or foreign object is removed from the wireless power supply." Fells [0288]. The purpose of this detection, as a POSA would understand, is to 1) charge devices that are nearby and ready to receive charge, and 2) detect metallic foreign objects that "would get hot or hinder power transfer" if they were present within the magnetic field generated by the primary coil. *See*

Fells [0002]. Therefore, a POSA would understand that the proximity detector is also within the magnetic field generated by the primary coil. If it was not within that “proximity,” it would not be close enough to detect the foreign objects in that field that “get hot or hinder power transfer.”

134. All of the above describes how Fells teaches this claim element. Below, I further explain how, even if Fells did not teach this claim element, it would have been obvious to modify Fells to do so.

135. For the same reasons that I describe above, to the extent anyone argues that Fells does not teach placing the proximity detector within the magnetic field of its wireless power supply, it would have been obvious to do so. The purpose of the proximity detector – as with all other sense circuit embodiments – is to detect objects within the nearby “proximity” or “vicinity,” so that they do not interfere with the power transfer. Fells [0002], [0191], [0288]-[0290]. That interference occurs when foreign objects are present within the magnetic field of the primary coil. Fells [0002], [0288]. Thus, when a POSA is deciding where to place the proximity detectors, the obvious solution is to place the proximity detector within the magnetic field of the primary coil, so that the “proximity” over which it detects objects overlaps with the magnetic field of the primary coil. If that were not the case, and the proximity sensor were placed elsewhere, it would not be able to properly ensure that all foreign objects in the concerning region (i.e.,

within the magnetic field of the primary coil) were detected.

7. Element 1[f]: Verification of Foreign Object Debris

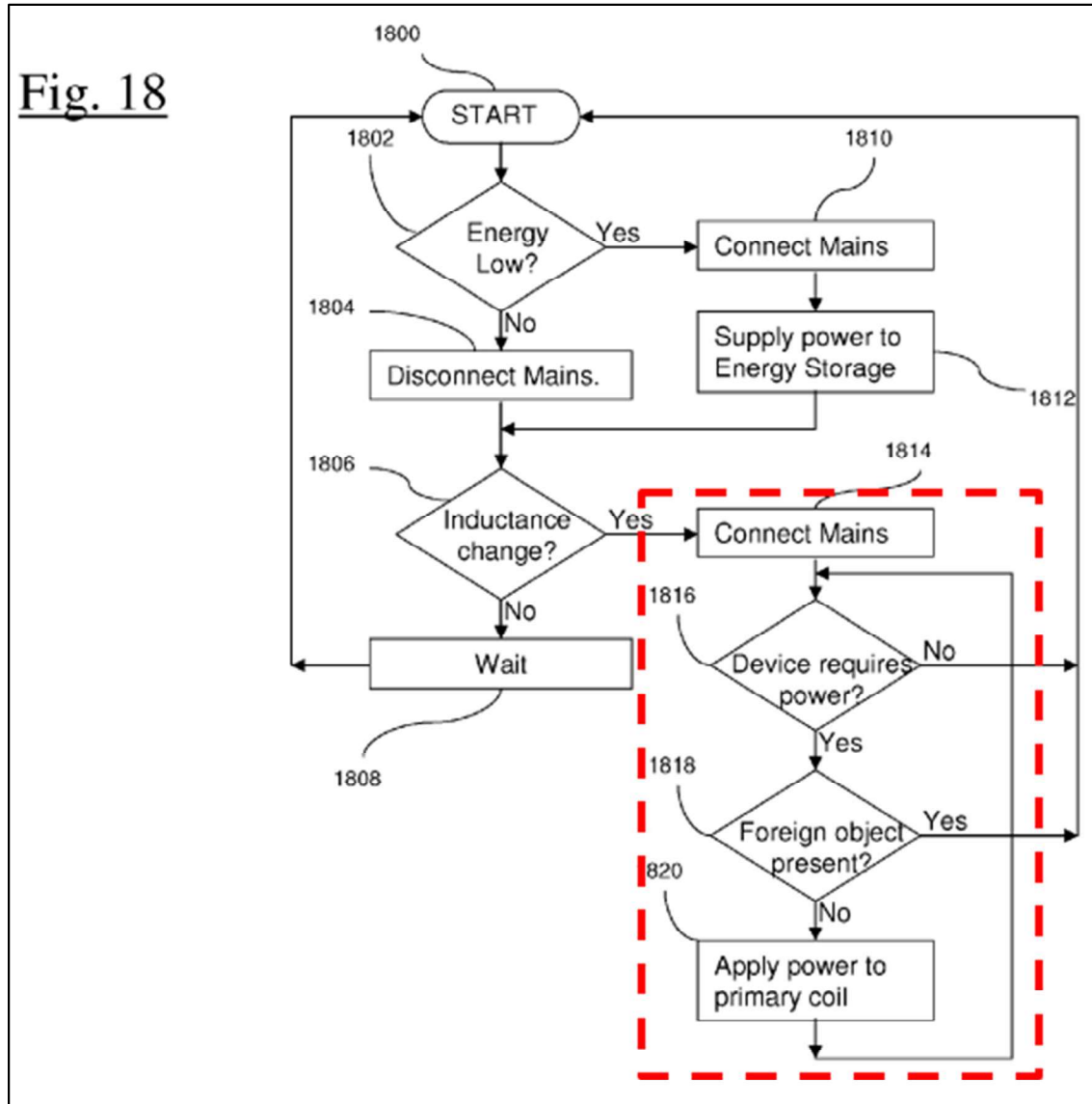
136. Lastly, Claim 1 recites “wherein the foreign object debris detection system is configured to verify that foreign object debris has not moved onto or over the source resonator during generation of the oscillating magnetic field.” Fells teaches this. In addition, as I explain below, to the extent not taught by Fells it would have been obvious to a POSA to implement Fells to verify that no foreign object debris is present in the area of the resonator during charging.

137. As I described above for Element 1[b], Fells’ sense circuit and control circuit check “whether there is a valid device requiring power and no foreign objects present,” and if so, then provide power to the portable device. Fells [0191], *see* Element 1[b]. Notably, the system works “if both a foreign object and a valid device are placed at the same time,” or “if multiple foreign objects are placed at the same time but removed at different times and vice versa.” Fells [0196]. Thus, the system continuously verifies that a foreign object has not been placed onto or near the resonator during “generation of the oscillating magnetic field” while transferring power. Fells [0195].

138. Fells confirm this. For example, Figure 18 shows an “example flow diagram of wireless power supply operation.” Fells [0160], [0248], Fig. 18. During operation, “the system checks,” among other things, “to see if there is a foreign

object present 1818.” Fells [0160], [0248], Fig. 18. If not, “the system delivers power to the primary coil 1820 to supply power to the portable device.” Fells [0160], [0248], Fig. 18. The system then “continues to check that the device is still requiring power 1816 and only goes back to the start 1800 when the device no longer requires power or if a foreign object 1818 is placed on the wireless power supply.” Fells [0248].

139. In other words, a POSA would understand that the system enters a loop as shown below.

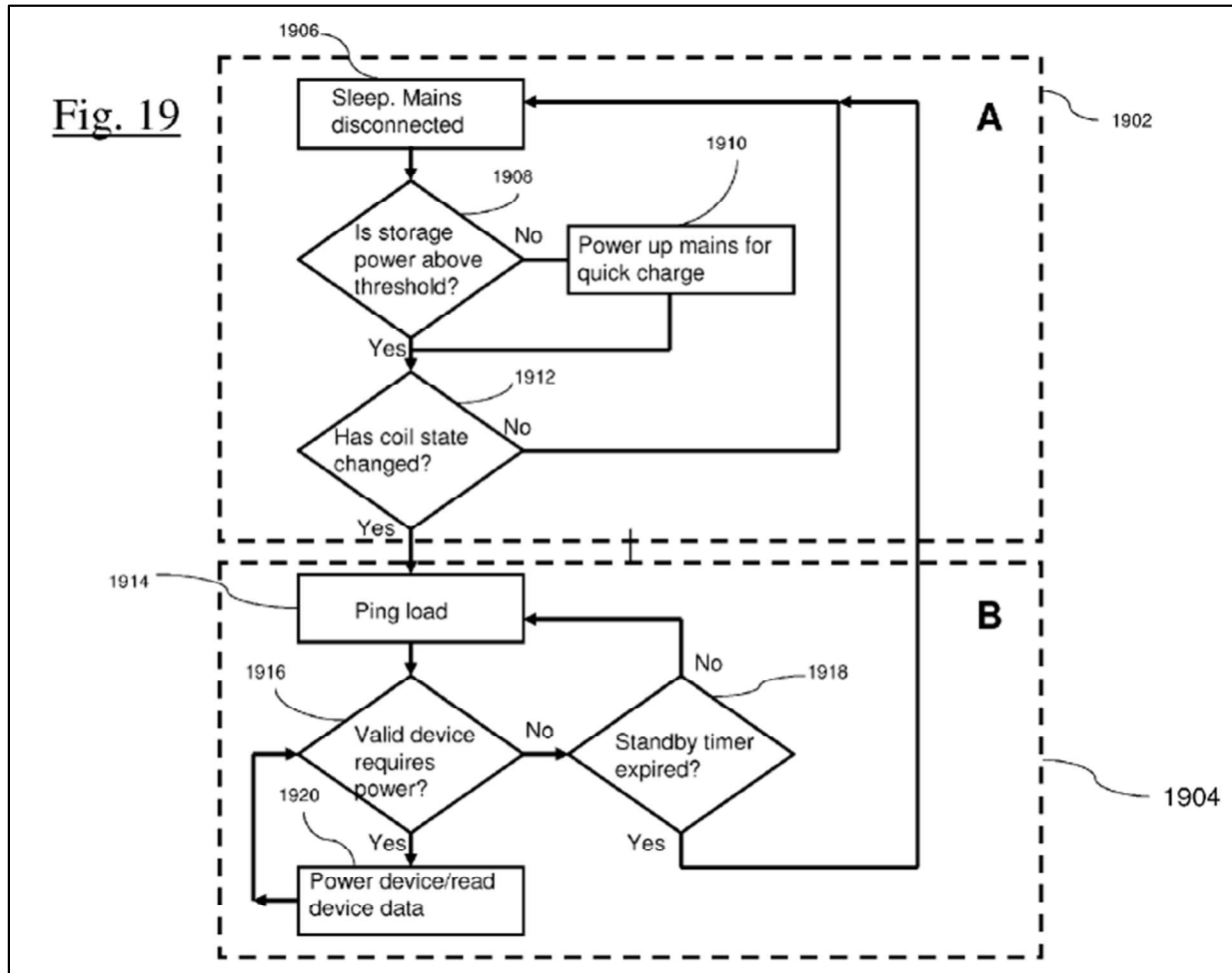
Fig. 18

Fells Fig. 18 (annotated). After first confirming that a device is present and requires power (step 1816), and that no foreign object is present (step 1818), the system provides power to the primary coil which charges the portable device (step 1820). As I explained for Element 1[a], when the primary coil receives AC power from the inverter, it generates an oscillating magnetic field that transfers energy to the portable device. See Element 1[a]; Fells [0191]. After this, and while

continuing to apply power to the primary coil and generating an oscillating magnetic field, the system loops back to steps 1816 and 1818, and again checks whether there is a device that requires power and whether foreign objects are present. If so, power continues to be applied, and the looping checks occur again, indefinitely. This loop continues until either a foreign object is detected or the device no longer requires power. Fells Fig. 18, [0248]. Thus, during the loop, the system verifies that no foreign objects are present as claimed “during generation” of the oscillating magnetic field.

140. This loop specifically checks whether “foreign object debris has not moved onto or over the source resonator,” because as Fells explains, the foreign object detection includes checking whether an object “has been placed on (or in proximity to) the wireless power supply. Fells [0191]; *see* [0191] (“object is placed in (or removed from) the proximity of the wireless power supply”); [0191] (“foreign object present”); [0192] (“foreign objects present”); [0194] (“foreign object has been placed on the wireless power supply”); [0248] (“foreign object present”). Because the foreign object detection check is sensitive enough to determine whether a “foreign object [is] present” at all, a POSA would understand that this includes checking whether foreign objects have moved onto or over the source resonator. As shown in Figure 18, if so, the system ceases power transfer. Fells [0160], [0248], Fig. 18.

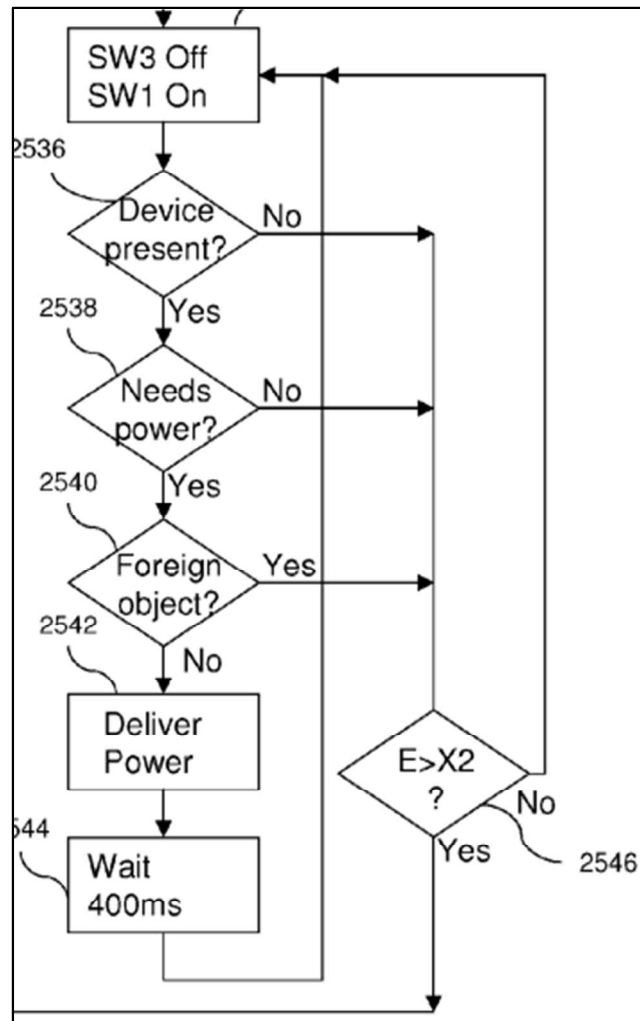
141. Figure 19's "flow diagram of wireless power supply operation" shows the same operation:



Fells Fig. 19, [0161], [0250]-[0253]. Although not expressly shown in the figure, Fells explains that "if the system detects [at step] 1916 that there is a valid device then after checking that there are no foreign objects present, the system will deliver full power to the primary coil." Fells [0251]; Fig. 19. As shown in the figure, after initially beginning power transfer at step 1920, the system will continually check

“that there is a valid device [and].... There are no foreign objects present,” and only in that case will it continue to transfer power. Fells [0251]; Fig. 19.

142. Figure 25 teaches the same again. After an initial series of checks, the system “deliver[s] power.” Fells Fig. 25, [0262]-[0263]. The system then “wait[s] 400ms” before entering a loop in which, again, it checks whether a device is present, whether the device needs power, and whether foreign objects are present. Fells Fig. 25, [0262]-[0263]. If the device is removed, the device is fully charged (i.e. no longer needs power), or foreign objects are present, power transfer is stopped. Otherwise, power continues to be provided and the checking-loop begins again in 400ms. Fells Fig. 25, [0262]-[0263].



Fells Fig. 25 (excerpted).

143. A POSA would have understood that Fells' teaching of continually checking for foreign objects while delivering power would apply to the proximity detector embodiment discussed above and shown in Figure 40. For example, the proximity detector embodiment is one hardware configuration for Fells' "wireless power supply" and Figures 18, 19 and 25 are exemplary flow diagrams of "wireless power supply operation" that a POSA would have understood could be applied to that hardware configuration. Fells [0160]-[0161], [0167], [0248]-[0252], [0262]-

[0263]. In addition, Fells discloses that Figure 18 “illustrates the operation of an ultra low power system,” which a POSA would have understood to be referring to, along other things, the “ultra low power” proximity detector embodiment. Fells [0182] (proximity detector is “an embodiment of Fig. 2”); [0144] (Fig. 2 is “an ultra low power wireless power supply”).

144. A POSA further would have understood that Fells’ teaching of continually checking for foreign objects while delivering power would apply to the proximity detector embodiment, because this is taught in patents incorporated into Fells, and which Fells instructs the reading POSA to look to as a method for detecting foreign objects. Fells states that “foreign objects may be detected by using a method disclosed in GB2414121,” a UK patent that is incorporated by reference. Fells [0192]. The method disclosed in that reference (Stevens (Ex. 1016)), similarly discloses repeated checking for foreign objects while transmitting power, as the figure below shows.

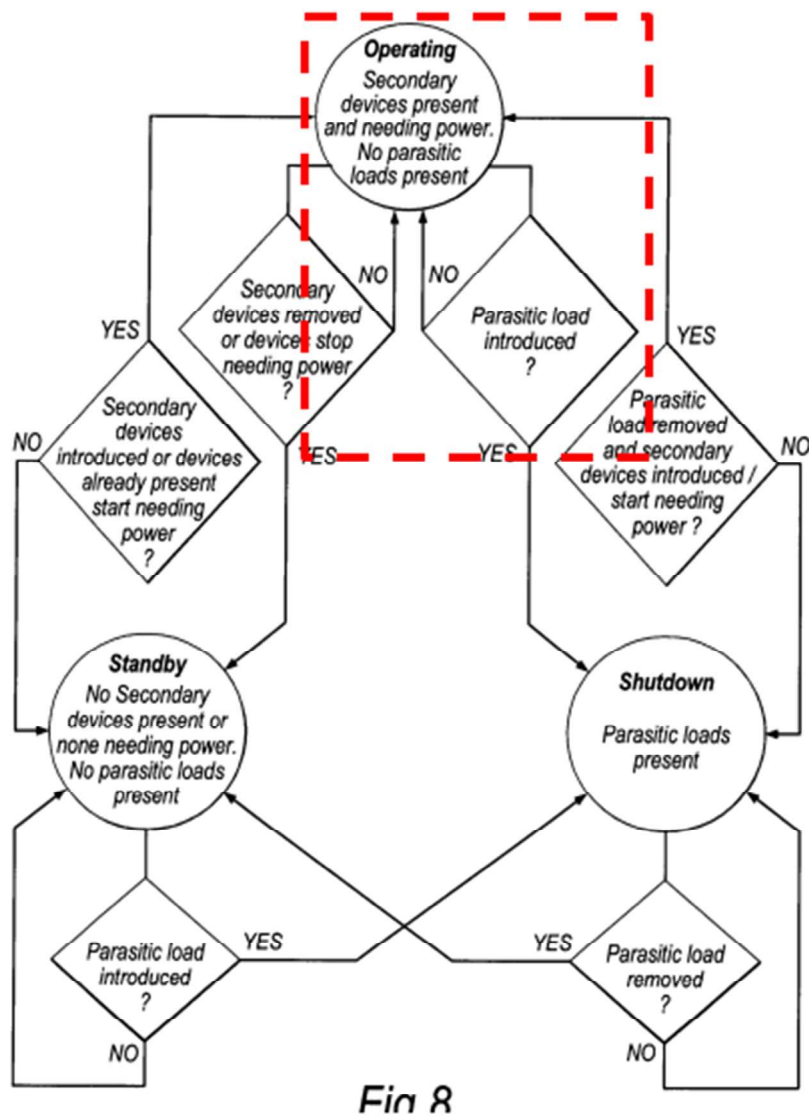


Fig 8

Stevens Fig. 8 (annotated). As Stevens explains, while “[o]perating,” the system provides power to devices that are “present and need[] power,” as long as “[n]o parasitic loads [are] present.” Stevens Fig. 8. A POSA would have understood that “parasitic loads” in Stevens refers to the presence of “foreign objects.” Stevens 2:18-20 (“In the present application, such foreign objects that cause power drain are termed ‘parasitic loads.’ Preferably the primary unit should enter a

‘shutdown mode’ when parasitic loads are present, to avoid heating them.”); 21:13-30 (“a parasitic load 500 on the primary unit, caused for example by a foreign object placed in the vicinity of the primary unit”); 27:27-36 (“parasitic load associated with foreign metal objects”).

145. As shown by the flowchart above, while providing power in the operating mode, Stevens’ system continually checks whether “parasitic load [is] introduced,” or whether a foreign object has been detected, and if so, enters a “[s]hutdown” state. Stevens Fig. 8, 2:18-20; *see* Stevens 5:14-18 (“if there is a substantial parasitic load ... the primary unit can enter a shutdown state”); 18:4-20 (“it is desirable to detect certain conditions and restrict or stop the inductive power supply from the primary unit under those conditions. One such condition is the presence of a substantial parasitic load in the vicinity of the primary unit.”); 25:18-23 (“the primary unit initiates ... power measurements for the purposes of determining ... whether there is a parasitic metal present requiring it to enter the shutdown mode to prevent overheating”); 28:19-25 (“In the operating mode, the primary unit is in the normal state If the result of the measurement sequence is that a significant parasitic load 500 is present, the primary unit goes into a shutdown mode”).

146. All of the above describes how Fells teaches this claim element. Below, I further explain how, even if Fells did not teach this claim element, it

would have been obvious to modify Fells to do so.

147. To the extent that this is not already taught in Fells, it would have been obvious to a POSA to implement Fells' proximity detector embodiment in the way that Fells' flow diagrams and the Stevens reference described: i.e., to check for foreign objects before and during charging of the portable device, and stop charging if a foreign object is detected. It was well within a POSA's knowledge and skill to check for foreign objects—not just at the beginning of the charging sequence, but also while power is generated. Fells' Figures 18, 19, and 25 confirm this. *See* Fells [0248]-[0252], [0262]-[0263], Figs. 18-19, 25; Stevens Fig. 8.

148. Further, a POSA would have found it desirable to do so because foreign objects were known to “get hot or hinder power transfer” and “otherwise interfere with the system.” Fells [0002], [0189] (“foreign objects ... adversely affect operation”). Thus, a POSA would have found it desirable to continue to check for foreign objects to prevent the interference of foreign objects that may have appeared after the generation of power began. In fact, during power generation is when foreign objects present the greatest threat to the system. For example, if the system were *only* to check for foreign objects prior to power transfer, and not during power transfer, the system would not be able to detect a metallic foil gum wrapper, or a soda can, that was wind-blown into the charging

area after startup but while charging. This would be undesirable, as Fells notes, because the metallic debris can “get hot,” possibly combust, and “hinder power transfer” by altering the primary magnetic field. Fells [0002], [0189], [0191]. The obvious way to avoid this, as shown in Fells Figures 18, 19, 25, and Stevens, is to check for foreign objects not just prior to but also during power transfer.

149. In addition, modifying Fells to check for foreign debris during power generation would have been a simple modification, and would not have altered the remaining components of the system, because as Fells explains, the proximity detector can be “completely separate from the primary coil 212,” and thus, there would be no required changes to the control unit. Fells [0288].

150. Thus, implementing Fells’ proximity detector embodiment to check for foreign objects while generating and providing power would have been nothing more than the obvious application of a known method (continuously checking for foreign objects while charging) to known prior art (Fells’ proximity detector embodiment) to obtain a predictable improvement (minimizing system interference caused by foreign objects).

* * *

151. For the reasons provided above, it is my opinion that claim 1 of the ’184 patent is unpatentable over Fells.

B. Claim 8

152. Claim 8 recites: “[t]he system of claim 1, wherein the foreign object

debris detection system is configured to verify that foreign object debris has not moved onto or over the source resonator prior to generation of the oscillating magnetic field.” Fells teaches this.

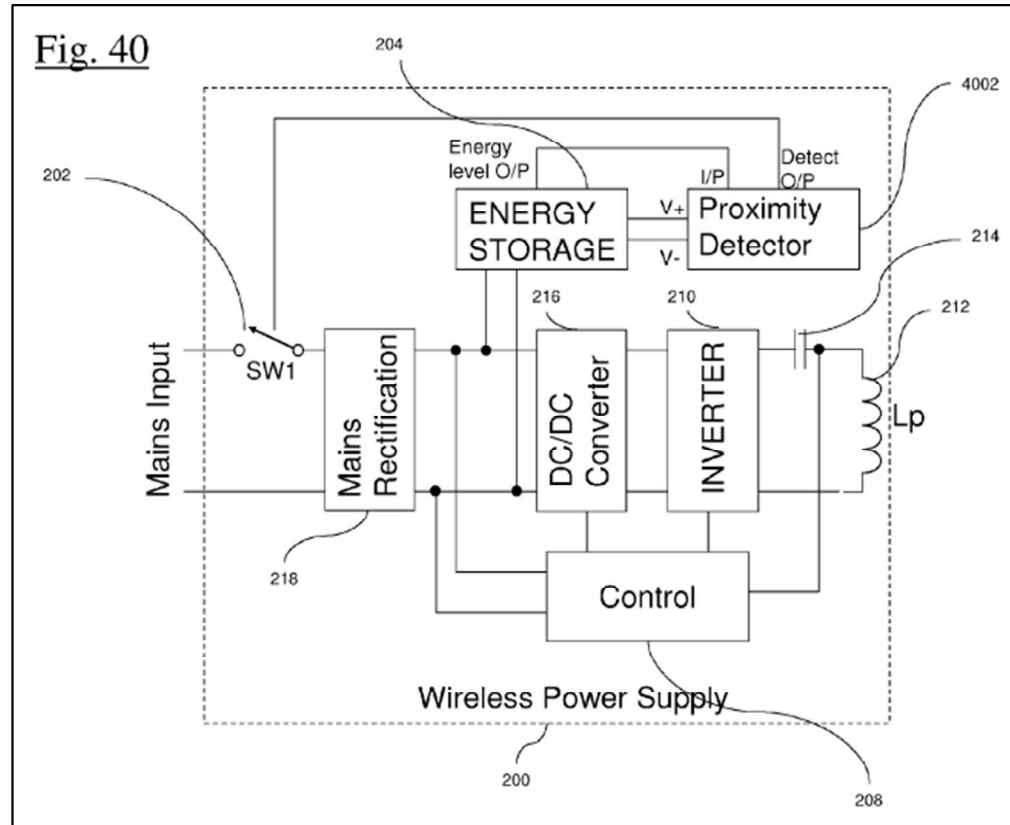
153. Specifically, before “deliver[ing] power to the portable device” by generating an oscillating magnetic field, Fells’ wireless power supply determines “whether there is a foreign object present” on or over the source resonator as claimed. Fells [0191]. Fells expressly states that the determination that there are “no foreign objects present” must occur before “control unit 208 will activate the inverter 210 to supply current to the tank circuit,” which in turn generates the oscillating magnetic field. Fells [0191]. This is confirmed by Fells’ “example timing diagrams,” which state that if “there are foreign objects present ... the system will not power up.” Fells [0194]-[0196], Fig. 3. The sense circuit then “periodically ... powers up” to determine if a “change” has occurred indicating that “the [foreign] object is removed” before initiating power transfer. Fells [0194], Fig. 3, *see also* Fells Fig. 18 (checking whether a foreign object is present before applying power to the primary coil), Fig. 19 (same), Fig. 25 (same); *see* Element 1[f] (generating oscillating magnetic field).

C. Claim 11

154. Claim 11 recites “[t]he system of claim 1, wherein the foreign object debris detection system is integrated into the wireless energy transfer source.”

Fells teaches this.

155. As I explained for Elements 1[a]-[b], Fells' "sense circuit" and "control element 208 in the wireless power supply 200," in addition to the related circuitry, correspond to the claimed "foreign object debris detection system." Fells [0191], [0288], Fig. 2, Fig. 40. As shown below, these components are part of, and therefore integrated into, Fells' "wireless power supply" (the claimed wireless energy transfer source).



Fells Fig. 40; *see* Fells Fig. 2, [0191], [0288] (all confirming that sense circuit, proximity detector, and control element are part of Fells' wireless power supply).

X. Ground 2: Claims 2-7, 9-10, and 16 would have been obvious over Fells in view of Cook

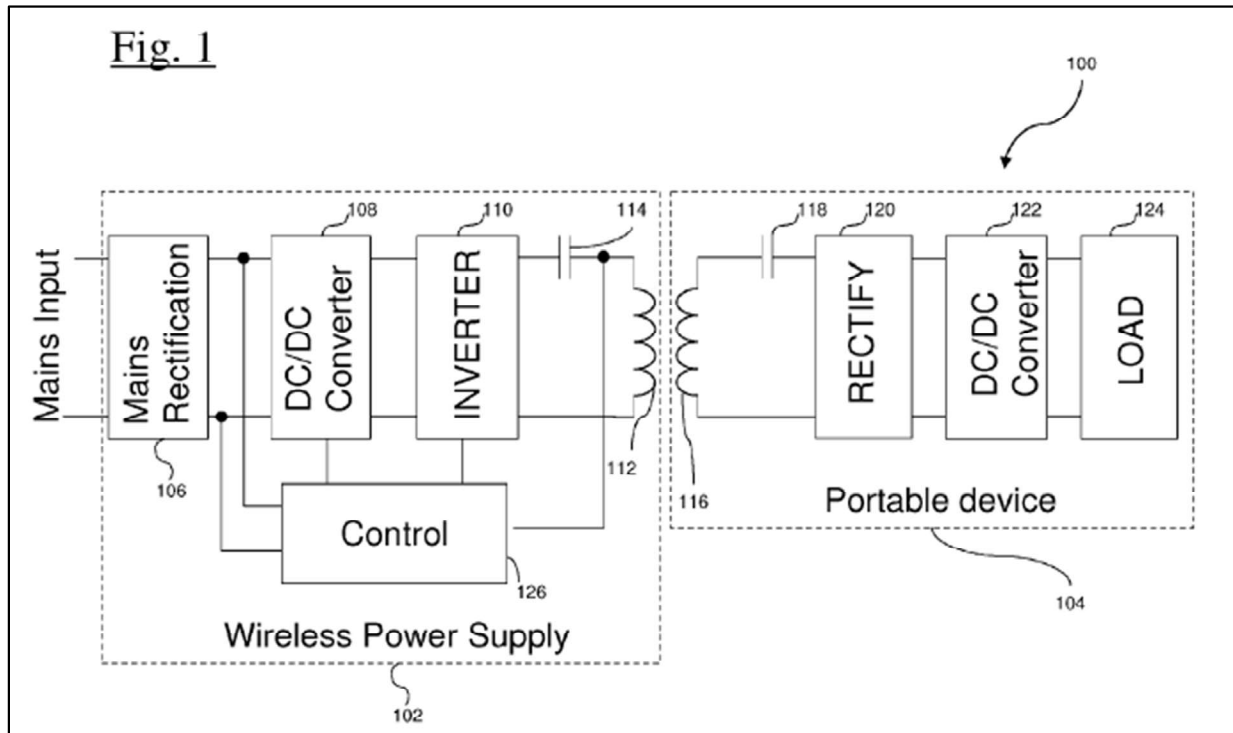
156. For the reasons discussed below, it is my opinion that Fells in combination with Cook renders obvious each claim element as arranged in claims 2-7, 9-10, 12, and 16 of the '184 patent.

A. Motivation to Combine Fells with Cook

157. Fells explains that “it is more convenient to be able to power portable devices without the need to plug in a traditional power cable into the device.” Fells [0001]. A POSA would have understood that this applies not just to “portable” devices, but to any device that needs to be frequently plugged in or unplugged. The more frequently the device needed to be plugged in or unplugged, the more “convenient” and time-saving it would have been for the user to merely place the device in the vicinity of the charger to receive wireless power, rather than to plug in a traditional cable. Thus, a POSA would have known that devices with rechargeable batteries, in particular, would benefit from the convenience of wireless charging, as such devices may need to be plugged or unplugged frequently in order to recharge their batteries.

158. While Fells teaches that its system charges “portable device[s],” and shows that this can be accomplished with the portable device containing a resonant LC circuit, Fells otherwise does not specify, or provide any limitations on, the types of devices that could be charged with its system. Fells [0001], [0189],

[0191], Figs. 1-2. A POSA would have understood this lack of specificity to convey that Fells' wireless power supply could be used to charge any device that could be powered by, or could have its battery recharged by, the resonant circuit shown in Fells' Figure 1, which is the only example of a "portable device" in Fells.



Fells Fig. 1; *see* Fells [0189] (describing portable device).

159. Given Fells' lack of limitation on what devices could be charged, a POSA would have considered it obvious to use an electric vehicle as the "portable device" in Fells, because wireless electric vehicle charging systems were already well-known to POSAs, and electric vehicle charging systems in general were increasing in popularity in the 2010-2011 time frame.

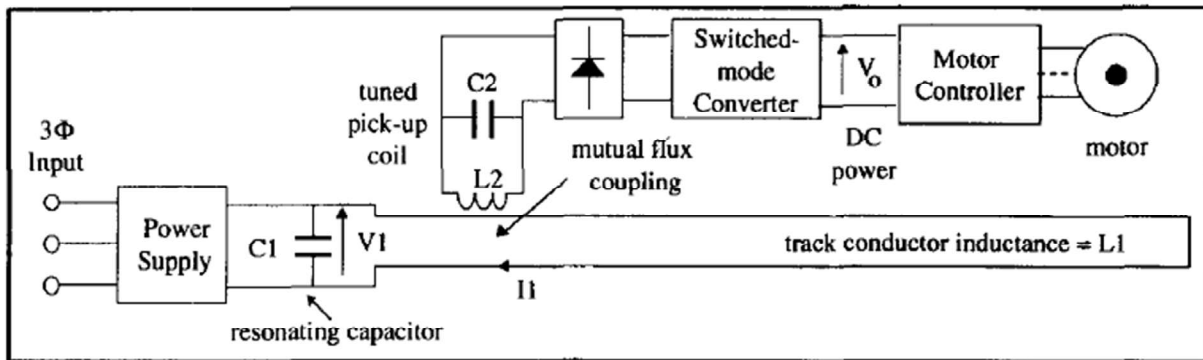
160. For example, Cook described "wireless delivery of power to a mobile

powered device,” and specifically identified “automobile[s]” as an example of a device that can be charged. Cook Title, [0002], [0008], Fig. 1; *see* Section VIII, Overview of Cook. As car manufacturers introduced electric and plug-in hybrid vehicles into the market during the 2008 time frame, it became “desirable to wirelessly deliver power to an electric powered mobile device, such as an automobile.” Cook [0006]-[0008]. Cook-086, an earlier reference that was incorporated into Cook similarly explained that systems for wireless charging can be used for “[m]yriad applications,” from powering or charging “client devices” and “cellular phones” to “powering or charging electric cars.” Cook [0001]; Cook-086 (Ex. 10123), 23:61-24:19.

161. A POSA would have been motivated to implement Fells to charge electric vehicles not only because doing so was known in Cook, but because a POSA would have known that wirelessly charging electric vehicles allowed for higher convenience and reliability, and lower maintenance, as compared to traditional cable charging or track systems.

162. For example, Green, a 1994 article titled “10kHz Inductively Coupled Power Transfer – Concept and Control” explained that while “electric vehicles are used ... because they are low cost, reliable, inoffensive, and simple to control ... conventional methods of power transfer to the vehicle ... have remained less than ideal.” Green (Ex. 1019) 694. A solution, as Green explained in 1994 and a POSA

would have known by 2010, was a wireless “inductively coupled power transmission (IPT) system.” Green 694. By connecting a power supply to a “resonating capacitor” connected to a “coupled track,” power could be transferred to an inductor connected to a capacitor in the vehicle, creating a “magnetic circuit” and transferring energy by “mutual coupling.”



Green 695. Such wireless charging offered benefits over traditional cable charging or electrified contact tracks because it was “clean and spark-free ... robust to dust and water, and ha[d] very low maintenance.” Green 694. Such systems could provide “power transfer of several kilowatts.” Green 694. Even at the time, POSAs recognized that for “moving vehicles,” such as “electric buses and trains, the advantages of a magnetically coupled [charging] system would be considerable.” Green 694. POSAs thus knew, as early as 1994, that “[i]nductively coupled power transmission (IPT) [wa]s set to revolutionize the materials handling and transportation industries” by offering “clean, spark free, environmentally benign, low maintenance power to moving electric vehicles.” Green 694.

163. Similarly, a 2005 paper by Byung-Song Lee and Kyung-Hee Han

titled “Modeling and Analysis of IPT System Used for PRT” explained that “inductive power transfer systems,” in which “electrical power is transferred from a primary winding in the form of a coil or track, to one or more isolated pick-up coils,” had “found application in any fields such as electric vehicles.” Lee (Ex. 1021) 839. “The ability to transmit power without contact enables high reliability and easy maintenance that allows inductive power transfer systems to be implemented [even] in hostile environments.” Lee 839.

164. A July 2004 paper published in *IEEE Transactions on Power Electronics*, titled “Investigating an LCL Load Resonant Inverter for Inductive Power Transfer Applications,” similarly confirmed the benefits of wireless charging for electric vehicles. Wang-IEEE (Ex. 1025) 995. As that paper explains, “inductively coupled power transfer (ICPT) systems [we]re designed to deliver power efficiently from a stationary primary source to one or more movable secondary loads over relatively large air gaps via magnetic coupling.” Wang-IEEE 995. “Modern power electronics have enabled many new applications” for this technology, “such as.... contact-less battery charging across large air-gaps for electric vehicles.” Wang-IEEE 995. As Wang-IEEE explains, “the advantages of such systems are safety, reliability, low maintenance and long product life.” Wang-IEEE 995.

165. A 2001 doctoral thesis, “Selected Resonant Converts for IPT Power

Supplies,” similarly explains the benefits of wireless power transfer systems that use magnetic coupling to transfer energy from a primary loop to a secondary coil. Hu (Ex. 1020) 5-7. Because “there is no direct electrical contact in the path of the power flow,” the system “is spark free,” with “no open live wires.” Thus, “the possibility of accidental electric shock is eliminated,” making wireless charging safer than conventional charging. In addition, because the primary coil and secondary coil are “two independently enclosed parts,” system “operation is not affected by dirt, dust, water, or chemicals,” and “can work in very harsh environments.” Hu 6. As compared to “traditional sliding contact” charging systems, wireless charging systems “do[] not generate carbon residues ... and ha[ve] no harmful effects on surroundings.” Hu 6. Moreover, because “there is no direct friction ... mechanical wear & tear, and electrical erosion are eliminated,” as is “chemical erosion.” Hu 6. “Consequently, the system is very reliable and robust, requiring almost no maintenance.” Hu 6. These systems “can be used for contactless battery charging... to drive an EV (Electric Vehicle),” reducing or eliminating “regular maintenance such as changing the battery electrolytes and cleaning the contact parts.” Hu 7.

166. Each of the above-described systems, like Fells, utilizes a charging system in which a primary coil (possibly with a resonant capacitor) is magnetically coupled to a secondary coil (also with a resonant capacitor), thereby wirelessly

transferring energy to charge the device attached to the secondary coil. Thus, a POSA would have understood that all of the above-described benefits, including improved safety, lack of required maintenance, improved reliability, and resistance to dirt and dust would be realized when using Fells' system to charge an electric vehicle.

167. A POSA would have also recognized that Fells' foreign object detection made its charging scheme particularly well-suited for vehicles. Compared to smaller handheld devices, electric vehicle charging requires (1) a larger battery (often dozens of kWh or more); longer charging times (frequently overnight or longer); and (3) more variation in the charging environment (for example electric vehicles are frequently charged not just at the user's home, but at other charging facilities including store parking lots and public charging stations, many of which are outdoors). Each of these factors increases the likelihood that undesirable foreign objects may enter the magnetic field of the charging system, and therefore would have made a POSA even more likely to want to use a foreign object detection system when charging vehicles. First, larger batteries require larger coils to charge them, creating larger areas that foreign debris could be positioned on or nearby and thus interfere with. Second, longer charge times expose the charging area to foreign object debris for longer time periods. Third, less-controlled environments, such as parking lots, public charging stations, and

garages, pose a higher risk of incoming debris (including road-side trash, rain, dirt, or dust) relative to, for example, charging in the user's home. Thus, a POSA would have been motivated to implement Fells' foreign object monitoring to prevent foreign objects from interfering with the wireless charging of a vehicle that could creating an unsafe environment caused by the heating or burning of the foreign object debris. *See* Fells [0002] (foreign objects "may get hot or otherwise interfere with the system").

168. Further, a POSA would have had a reasonable expectation of success in implementing Fells' system to charge an electric vehicle because Cook and Fells' charging systems both use the same well-known components (resonant circuits) and principles of operation (magnetic induction). For example, Fells' "wireless power system" utilizes "a capacitor," a "primary coil," and a "control unit" for power transfer. Fells [0191]. The "wireless power supply" has a coil and "resonant capacitor" that together form a "tank circuit" resonator used to wirelessly delivers power to a "portable device." Fells [0191], [0189]. The "portable device" includes a "secondary coil 116, and sometimes a resonant capacitor, which couples to the primary coil 112." Fells [0189], Fig. 1.

169. Similarly, Cook describes "wireless delivery of power" from a "charger" consisting of a "coil ... capacitor ... and a charging circuit" to a "magnetic resonant antenna" in an "automobile." Cook [0011]-[0013]. The

antenna is a resonant “LC circuit” formed “from an inductive loop ... in parallel with a capacitor,” and receives power from the resonant charger that “produce[s] a magnetic field. Cook [0011]-[0013]; *see also* Cook [0001], cls. 6, 8, 13 (claiming a charger that is “resonant”); Cook-086, 23:59-24:18.

170. Further, Fells and Cook are analogous both to one another as well as to the ’184 patent, which likewise teaches transferring wireless energy “between two resonators” and detecting foreign object debris. ’184 patent, 1:16-19, 5:5-45.

171. A POSA would have also understood that Fells’ power supply could be used with Cook’s vehicle, despite the fact that Fells’ resonant circuit consists of an inductor and capacitor in series, while Cook’s resonant vehicle antenna placed an inductor and capacitor in parallel. Fells Figs. 2, 40; Cook [0011], Fig. 1. “[S]eries primary and parallel secondary” resonant circuits were one of the “fundamental compensation topologies” well-known to a POSA for coupled wireless power transfer systems. Wang Thesis (Ex. 1018) 24; *see also* Terman 64, Fig. 3-11 (depicting coupled resonators with series primary and parallel secondary); *see also* Fells Figs. 2, 40; Cook [0011].

172. A POSA would have also known that Fells’ teaching of a series LC resonator could be applied to Cook’s parallel LC resonator because “parallel” resonance is “analogous” to “series” resonance. Terman 50-51; *see id.* 52-53 (“working rules” for series resonance “also apply” to “parallel resonance” with

“the only difference is that the signs of the phase angles are now reversed”); Wang Thesis 20-25 (providing circuit diagrams and derived formulas for both series and parallel resonators).

173. Even if that were not the case, it would have been within a POSA’s skill to modify Fells’ power supply to use a parallel resonator configuration, or to modify Cook’s vehicle to use a series configuration, which a POSA would have done if that compensation scheme was preferable for the particular use case. *See* Wang Thesis 21 (describing the benefits of parallel or series compensation that may be preferable, and providing circuit diagrams for each, while noting that “[b]oth series and parallel secondary compensation improve the power transfer capability”).

174. Moreover, a POSA would be able to use Cook’s electric vehicle with a “magnetic resonant antenna” as Fells’ “portable device” to receive resonant magnetic power from Fells’ wireless power supply without having to make changes to the vehicle, as Fells integrates its foreign object detection system directly into its “wireless power supply.” Fells [0191], Fig. 2.

175. Likewise, a POSA would have been able to integrate Fells’ power supply into Cook’s system using Fells’ “retrofit” kit. As Fells explains its “power system” can be “retro-fitted” as an “aftermarket accessory” used to “upgrade” existing “wireless power systems,” including those “from the same manufacturer

or from a different (third-party) manufacturer.” Fells [0233], Fig. 12. In fact, Fells instructs a POSA how to implement its invention in this retrofit fashion, including instructions on adding a “replacement DC Power Supply,” “voltage regulator,” and “thermistor.” *See* Fells [0233]-[0244] (describing “retrofitting third-party systems” to use Fells “sense/control circuit” when “retrofitted to the existing wireless power supply”). A POSA would have been able to apply these teachings to Cook’s system, connecting Fells’ components in retrofit fashion.

176. A POSA would have understood that Fells’ wireless power supply could be used to charge an electric vehicle despite the fact that Fells occasionally refers to its system as “low power.” A POSA would have understood that Fells’ description of its system as “low power” has nothing to do with how much power is transferred when the system is on (which Fells does not even quantify). Rather, what makes Fells’ system “low power” is the fact that, due to the use of the sense circuit, most of the system components remain off, and the system remains in low power standby mode, except when a new foreign object or device to be charged is detected.

177. For example, as Fells explains, its method of “reducing power consumption” is to “detect[] the presence of an object, identify[] whether the object is a valid device, and restrict[] power if it is not a valid device.” Fells Abstract, [0008] (“a method of reducing power consumption includes detecting the presence

of an object within proximity of a primary unit and in response to the determination that a valid secondary device is not present, restricting power supplied to the primary unit”). The Background of the Invention section of Fells makes this clear: “when there is no device on the unit (or when the only devices on the unit are fully charged) it is possible to keep the power consumption at a minimum.” Fells [0001]. Thus, Fells achieves its low power status by having “low standby power.” Fells [0004] (“with careful design it is possible to achieve standby power as low as 0.5 W”).

178. With respect to Fells’ Figure 2 in particular, what makes the device “ultra low power” is its ability to enter “standby” mode. Fells [0191]. In this mode, the switch between the mains power and the rest of the circuit “is open, so that no power is drawn from the mains.” Fells [0191]. Instead, “the only power drawing element is the sense circuit.” Fells [0191]. Thus, a POSA would have understood that what makes Fells’ Figure 2 “low power” is the fact that it largely operates in standby mode, providing power to nothing other than the sense circuit. The remainder of the circuit, and particularly the primary coil that transfers power, is only turned on once it has been determined that “there is a valid device requiring power and no foreign objects present.” Fells [0191]; *see* Fells [0194] (when “foreign” object is present, “the system will not power up, but will remain in ultra low power mode”), Fells [0195] (“when the device is fully charged, the control

unit 208 will determine that no further power is required and place the system in ultra low power mode”). A POSA would have therefore understood that Fells’ wireless power supply remains an “ultra low power” system, as that term is used in Fells, even if it is used to charge an electric vehicle, so long as it remains true that the system enters a standby mode when no devices or foreign objects are detected, and the system only turns on the primary coil to transfer power when a valid device requiring power is present, and no foreign objects are present. *See* Fells [0295] (“[t]he current and/or voltage during the standby sensing would typically be much lower than during power transfer.”) That is true in the combination of Fells and Cook that I discuss in this declaration.

179. A POSA would have recognized that Fells’ “standby” or “ultra low power” mode becomes even more beneficial when used to charge an electric vehicle (or other more powerful device), as compared to a low power device. Without these modes, the charger would remain powered on at all times and waste energy when no vehicle is present to charge. Charging systems that provide more power when turned on, such as those used for charging vehicles, would save even more power by use of standby mode to keep them off (as compared to less power-hungry chargers and devices, where the savings from standby mode would likely be more minimal).

B. Independent Claim 16

180. I address each element of method Claim 16 below. I am informed by counsel that the steps of claim 16 do not necessarily have to be performed in any particular order. As I explain below, however, Fells and Cook render obvious all of the steps in the order written in claim 16. Therefore, even if claim 16 was required to be completed in order, Fells and Cook render the claim obvious.

1. Element 16[pre]: Preamble

181. Claim 16 recites “[a] method of detecting foreign object debris in a wireless energy transfer system.” Fells teaches this.

182. As I explained above for Elements 1[pre], [a], and [b], 1, Fells discloses a “power system” with a “wireless power supply” that detects “foreign objects” and “deliver[s] power to [a] portable device.” *See* Elements 1[pre], 1[a]-1[b].

2. Element 16[a]: Health/Status Check

183. Claim 16 recites “performing a health and/or status check of a source resonator of the wireless energy transfer system.” Fells teaches this.

184. As I explained above for Element 1[a], Fells discloses a resonant tank circuit that corresponds to the claimed “source resonator.” Fells Fig. 2, [0191]; *see* Element 1[a].

185. I address two health and/or status checks of Fells’ source resonator. First, a calibration check that is performed on the resonator. And second, a check

of the energy levels of the “energy storage element.”

A. Calibration Check

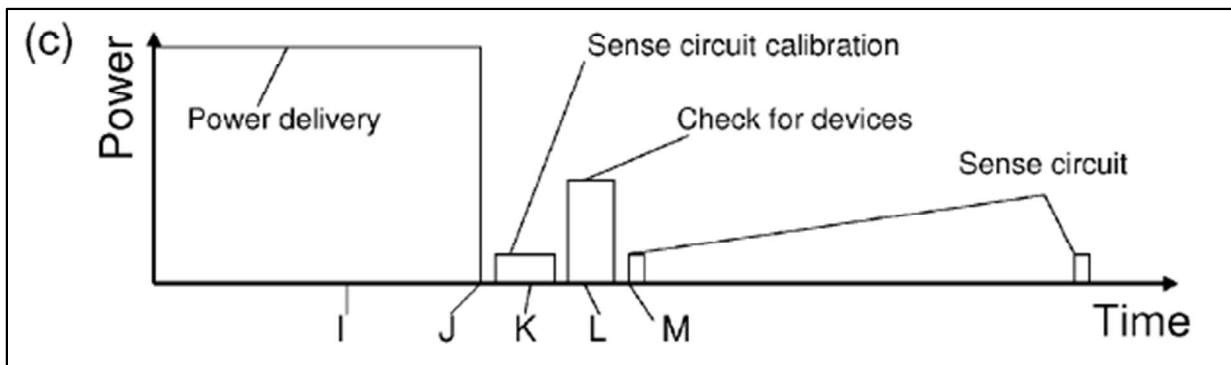
186. When “no devices requiring power” are present and the system is not currently “delivering power,” Fells’ “wireless power supply” performs a “sense circuit calibration” or “calibration inductance measurement” that corresponds to the claimed “health and/or status check” of the source resonator. Fells [0196]. After one device has finished charging, this calibration prepares the system to properly detect the addition or removal of future devices or foreign objects by checking the current induction levels, and establishing a baseline induction measurement that the sense circuit will use to compare with future induction measurements. Fells [0196] (“This is the inductance measurement that subsequent measurements will be compared to in order to trigger the sense circuit”).

187. The system performs additional validation checks on the calibration inductance measurement, such that the calibration “take[s] longer than a normal measurement” because the system “make[s] sure that the calibration measurement is a valid one.” Fells [0196].

188. This calibration check is a status check of Fells’ source resonator, because it prepares for the arrival of a future device by checking the current induction status in the proximity of the resonator, and establishes a baseline induction measurement that will be used to turn the resonator on in the future. Fells

[0196]. Moreover, this calibration can be performed by measuring the inductance across the primary coil 212, which is “the same coil ... used for the transfer of power.” Fells [0259]; *see id.* (describing “numerous ... techniques” that can be used for measuring the baseline inductance).

189. This calibration can be seen, for example, in Fells’ timing diagram of Figure 3(c) below, which a POSA would understand shows a calibration check being made after the prior device has been removed, in preparation for detecting and charging a future-arriving device (rightward on the timeline, not shown).



Fells Fig. 3(c). At the beginning of this figure, a prior device is “receiving power” (point I). Fells [0196]. “[S]ubsequently this device no longer requires power (for example because it has become fully charged or because the device was removed”). At point J, a POSA would have understood that in the case where the prior device has been removed, “the system determines that there are now no devices requiring power and therefore stops delivering power.” Fells [0196] (“it is possible that a device may have been placed on the unit”). At point K, the calibration check occurs, as the system “performs a calibration inductance measurement. This is the

inductance measurement that subsequent measurements will be compared to in order to trigger the sense circuit.” Fells [0196].

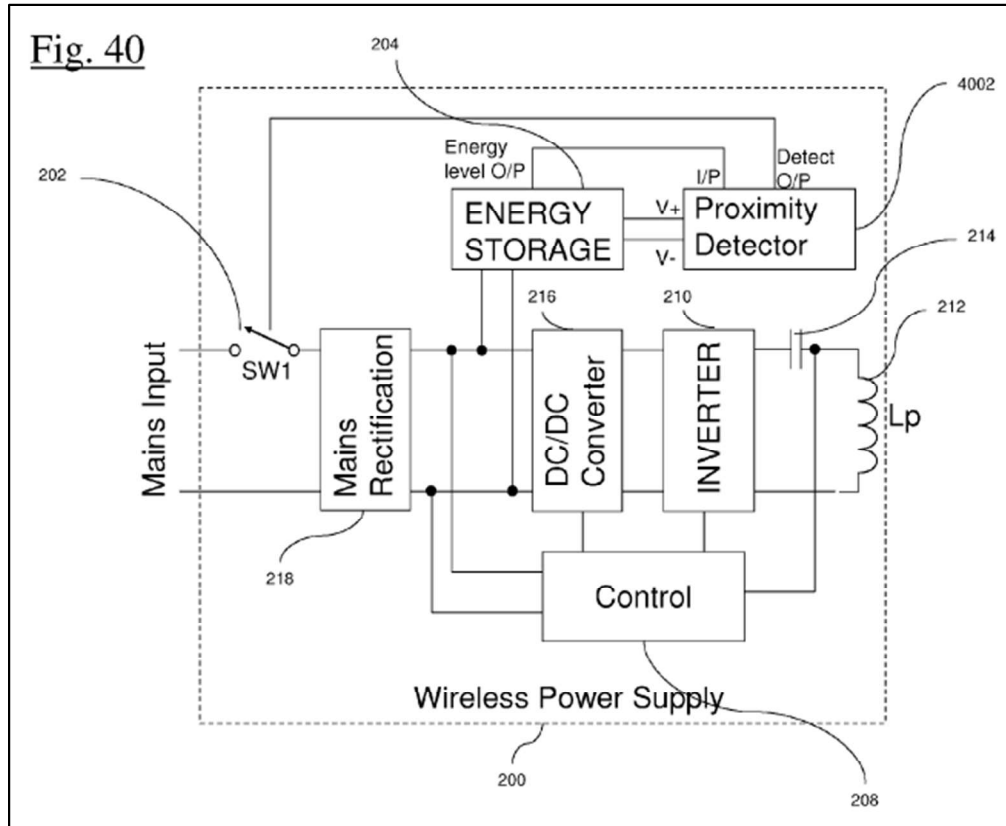
190. At point L, “the system makes another check to determine if there are valid devices present, as it is possible that a device may have been placed on the unit just before the calibration measurement was made.” Fells [0196]. “Assuming no devices were detected” (i.e., assuming that there were no devices on the unit at the time of the calibration check – as would be expected since the prior device had been removed at point J) “at point M the system goes into the ultra low power state.” Fells [0196]. At repeated points “M,” the system that “periodically [is] made to sense for another device being placed in proximity.” Fells [0196].

191. I note that while the ’184 patent does not give any specific examples of what a “health and/or status check” may be, Fells’ calibration check matches the only description of such a check provided in the ’184 patent: a “low-power diagnostic test” that can be “performed without the vehicle present to check [the] health and status of the charging station.” ’184 patent 10:53-55, 11:40-45.

B. Energy Storage Check

192. Separately from the calibration check, Fells discloses an energy storage check that also corresponds to the claimed health and/or status check.

193. As shown below, Fells’ wireless power supply includes an “energy storage element” 204 that powers the sense circuit.



Fells Fig. 40; *see* Fells Fig. 2 (showing same), Fells [0191] (“the sense circuit 206 takes its power from the energy storage element 204”).

194. The “energy storage element” can be a “supercapacitor” or “battery” that “is monitored so that it does not deplete fully, preventing operation of the sense circuit.” Fells [0245]-[0246], Fig. 16 (showing exemplary energy storage element). The sense circuit “periodically monitors the energy in the energy storage element,” and “recharge[s]” the storage element if the energy level falls “below a certain threshold.” Fells [0246]; *see also* Fells [0191]. The system may provide a signal “indicative of the energy level of the energy storage element” as “an output.” Fells [0245]-[0246], Fig. 40 (“Energy level O/P”); Fig. 2 (same).

195. This “monitoring” of the energy storage element to ensure that it is not fully depleted is a diagnostic check that provides the status of the source resonator because the resonator can only be activated from standby mode when there is energy in the storage element. Fells [0191]. If the energy storage unit is depleted, the sense circuit will not function, and the switch SW1 cannot be closed to supply power to the control unit and the resonant tank circuit. Fells [0191]. Thus, if the energy storage element indicates a problem (i.e., depleted), and it is not recharged, the resonator will be inoperable. Fells [0191]; *see* Fells [0201] (unit may not “operate before the energy storage unit is recharged or replaced”).

196. Moreover, the energy storage unit can serve as a “temporary source of power” for the entire circuit, and can “deliver power” to the resonant circuit in order to “supply power from the Energy storage element 1604 to the device.” Fells [0255]. In this embodiment, the energy storage check indicates the status of the resonator even more directly: If the energy storage unit has sufficient power, the resonator can be turned on to transfer power. Fells [0255].

3. Element 16[b]: Foreign Object Verification

197. Claim 16 next recites “verifying that no foreign object debris has moved onto or over the source resonator.” Fells teaches this.

198. As I explained above for claim elements 1[a]-1[b], the sense circuit in Fells’ wireless power supply “detects when an object is placed in ... the proximity

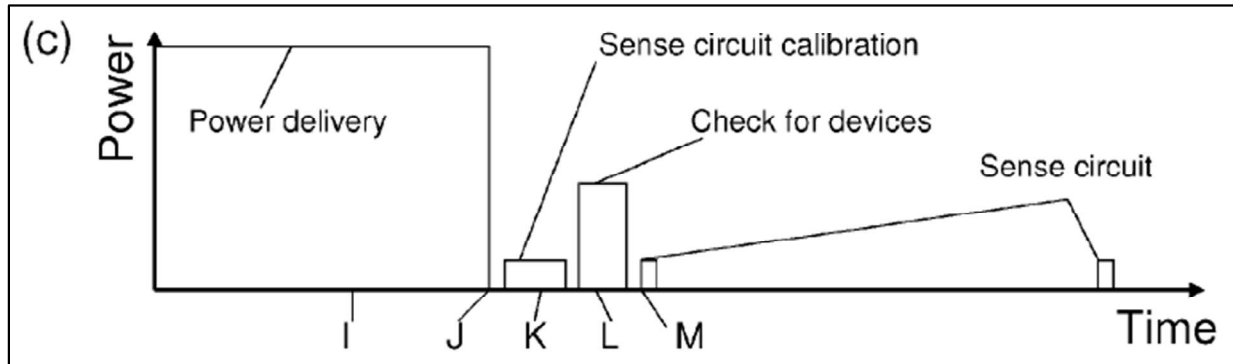
of the wireless power supply.” Fells [0191], *see* Elements 1[a]-1[b]. The sense circuit “periodically ... powers up to see if an inductance change has occurred since the previous measurement.” Fells [0194]. These periodic checks are part of a process to confirm that foreign object debris has not moved onto the resonator. If a “foreign object has been placed on the wireless power supply ... an inductance change will be detected at the next sense point.” Fells [0194]. Fells’ system will then “look to see if [there] is a valid device, whether it requires power and whether there are foreign objects present.” Fells [0194].

199. Only when “there is a valid device requiring power and no foreign objects present” will the system “activate the inverter 210 to supply current to the tank circuit ... to deliver power to the portable device.” Fells [0191]; *see* Elements 1[a]-[b]. If the system determines that the inductance change is caused by a detected object that “is foreign, the system will not power up, but will remain in ultra low power mode.” Fells [0194].

200. To the extent that the steps of this claim must be performed in the order written, this element is met because a foreign object debris check occurs after the health and status check and before a vehicle is positioned over the source resonator. *See* Element 16[a]; Element 16[c].

201. For example, as shown below in Figure 3(c), first the prior device finishes charging and is removed from the resonator (point J). Fells [0196] (“this

device no longer requires power (for example because it has become fully charged or because the device was removed) ... At point J the system determines that there are now no devices requiring power and therefore stops delivering power.”).



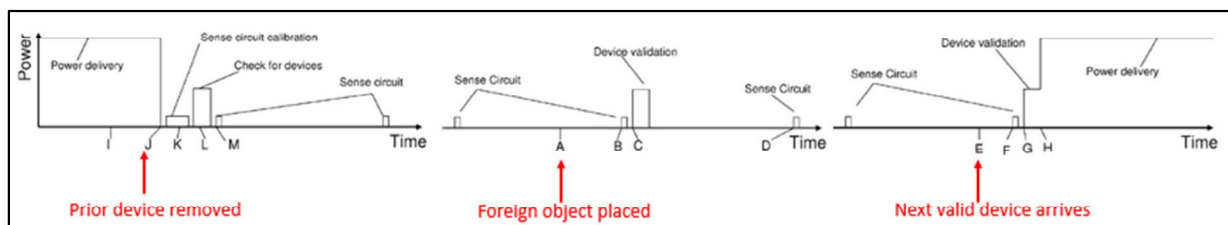
202. After the prior device has been removed, the calibration check occurs (point K, “sense circuit calibration”). Fells [0196] (“at point K, the system performs a calibration inductance measurement”).

203. After the calibration check occurs, the foreign object checks occur by “mak[ing] another check to determine if there are valid devices present” (point L) and by “periodically” “measur[ing] ... to sense for another device being placed in proximity” (point M). Fells [0196]. If these “sense circuit” checks detect “an inductance change ... since the previous measurement,” the system “will look to see if it is a valid device, whether it requires power, and whether there are foreign objects present.” Fells [0194]. If, as shown further in Figure 3(a) for example, a foreign object is present at one of the point M sense checks, “the system [will] connect the mains [power]. Fells [0194]. However, upon realizing that “the object

is foreign, the system will not power up, but will remain in ultra low power mode, and will continue the point M sense circuit checks. Fells [0194], [0196], Fig. 3(a)-3(c).

204. The calibration check occurs before the next device has arrived to be charged, which is not shown in Figure 3(c) but a POSA would understand occurs later (to the right in the figure). Fells [0194], Fells Fig. 3; *see also* Figs. 18, 19, 25 (showing that the system detects an inductance change caused by a foreign object before the arrival of a valid device).

205. This timing can be confirmed, for example, in the scenario in which a fully charged device is removed (as shown in Fig. 3(c)), then a foreign object enters the area of the resonator (as in Fig. 3(a)), and then another device to be charged arrives (Fig. 3(b)). I have arranged Figures 3(c), 3(a), and 3(b) in that order to show this sequence of events below:



Fells Figs. 3(a)-3(c) (annotated). As explained above, the prior device is fully charged and removed at point J, allowing for the sense circuit calibration at point K. Next, the system returns to standby mode in which the device “periodically ... powers up to see if an inductance change has occurred” at each point labeled “sense

circuit.” Fells [0194]. If no foreign object is detected, then no inductance change occurs, and thus, the system remains in a low power state. Fells [0194].

206. When a foreign object becomes present at point A above, the sense circuit check “detect[s]” the “inductance change” caused by the foreign object at point B. Fells [0193]. *Id.* As a result, “the system will look to see ... whether there are foreign objects present” (at point C in the chart above). *Id.* Because foreign objects are present, the system “will not power up.” *Id.* This foreign object detection occurs after the “sense circuit calibration” (point K in the chart above), but before a valid device arrives (by, for example, having the next vehicle pull over the resonator, as detailed in the Motivation to Combine) (point E in the chart above). Fells [0194]. Thus the system checks for foreign objects after performing the status check but before the device to be charged arrives.

207. The same ordering is true of the energy storage check. The verification that no foreign object debris exists also occurs after the energy storage unit status check. The energy storage unit “is monitored so that it does not deplete fully, preventing operation of the sense circuit,” and instead can be “recharged” as necessary. Fells [0246]. Thus, the energy storage status check occurs before the “operation of the sense circuit” to detect foreign objects, a precondition to the system “look[ing] to see ... whether there are foreign objects present.” Fells [0194], Fig. 3. In turn, the periodic operation of the sense circuit happens before

the device to be charged arrives, since the sense circuit detects the arriving device.

Fells [0194], Fig. 3.

4. Element 16[c]: Positioning vehicle over the source resonator

208. Claim 16 next recites “positioning a vehicle over the source resonator.” Fells in combination with Cook renders this obvious.

209. As I explained in my Motivation to Combine, Fells describes a “wireless power system” that generates an oscillating magnetic field to transfer energy to a “portable device,” but Fells does not specify the type of device. Fells [0189]; *see* Element 1[a]. Cook likewise discloses a system for “wirelessly deliver[ing] power to an electric powered mobile device,” and specifies that the device can be “an automobile,” as shown in the figure below. Cook [0008]; Cook [0009] (“electrically powered automobile”).

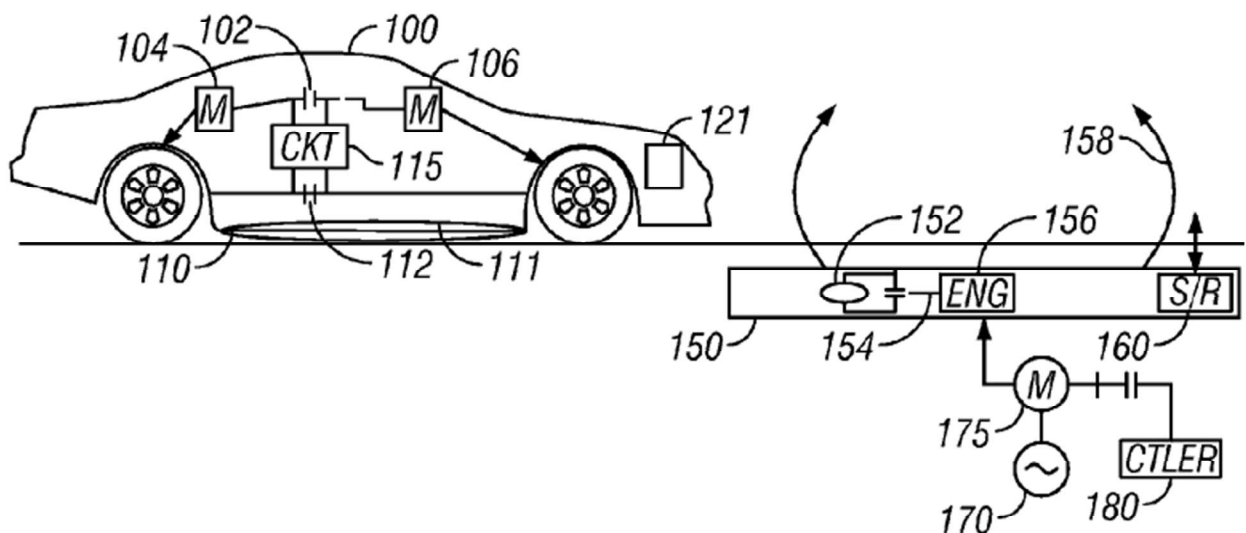


FIG. 1

Cook Fig. 1.

210. As I explained above, it would have been obvious to implement Fells' wireless power supply to charge an electric vehicle as its "portable device," as shown for example in Cook. *See Motivation to Combine.*

211. When Fells is implemented to charge Cook's vehicle, the vehicle has a "magnetic resonant antenna" or "LC circuit" that is formed from "an inductive loop 111 in parallel with a capacitor 112." Cook [0011]. When the vehicle is within "range of the magnetic field" provided by a resonant charger, it "may receive power from that magnetic field, and hence be charged." Cook [0011]-[0013]. The power received by the vehicle can "directly driv[e] the motors" or "charg[e] the battery." Cook [0011]. Cook's vehicle can receive power from Fells' wireless power supply, as this power transfer mechanism (transfer of electromagnetic energy from a primary resonator to a coupled secundar resonator) is the same arrangement described in Fells' to power its portable device. *See Fells* [0189]-[0191]; Cook [0011]-[0013].

212. Fells and Cook both require the device that receives a charge to be physically close to the transmitting coil. Fells [0191] (requiring the device to be in "the proximity of the wireless power supply"); Cook [0013] (requiring the vehicle to be in "range of the magnetic field"). A POSA would have understood that this is a common arrangement of near-field coupling, which both Fells and Cook employ. Since both Fells and Cook require the device receiving charge to be

located near the transmitting coil, a POSA would have (or would have obviously) implemented Fells in the way that Cook describes by placing the charger “within the ground near a parking space,” so that the vehicle is over the coil and within range of the magnetic field of the power supply. Cook [0012], Fig. 1; Fells Fig. 40. Thus, a POSA implementing Fells in view of Cook to charge electric vehicles would position the wireless power supply in the ground near a parking space, and position the vehicle over the source resonator of the power supply.

5. Element 16[d]: Foreign Object Verification

213. Claim 16 next requires “verifying that no foreign object debris has moved onto or over the source resonator”. Fells in combination with Cook renders this obvious.

214. This element is obvious for the same reasons that I explained with respect to identical element 16[b]. *See* Element 16[b]. To the extent Patent Owner argues that this claim step must be performed in the order written (i.e., after the vehicle is positioned over the source resonator, but before generating an oscillating magnetic field), this ordering is met for the reasons I explain below.

215. As explained for above for claim element 16[c], it would have been obvious to place Fells’ wireless power supply with resonant tank circuit in or near a parking spot, and to drive an electric vehicle over the power supply to be charged. Doing so would bring the car “into range of [the] wireless charging circuit.” Cook

[0010]-[0013], Fig. 1; *see* Element 16[c]. Moving the vehicle so that it is over the resonator will activate Fells' proximity-detecting sense circuit, which "detects that an object has been placed on (or in proximity to) the wireless power supply." Fells [0191]. Further, before the vehicle arrives, the sense circuit has been "periodically ... power[ing] up to see if an inductance change has occurred," where the inductance change indicates that either a vehicle or a foreign object has been positioned close to Fells' resonant tank circuit. Fells [0194]; *see* Element 16[b]. If a foreign object is detected, the system "will not power up." Fells [0194]; *see* Element 16[b].

216. When the vehicle is positioned above the resonator and is thus detected by the sense circuit, a switch "is closed allowing the circuits in the wireless power supply 200 to receive power." Fells [0191]. The "control element ... in the wireless power supply 200 then determines i) whether there is a valid device present, ii) if there is a valid device whether it desires power, [and] iii) whether there is a foreign object present." Fells [0191]. Because a vehicle requiring power has arrived, the control element verifies that "no foreign objects [are] present, then activate[s] the inverter 210 to supply current to the tank circuit ... to deliver power to the portable device." Fells [0191]. Thus, after the vehicle arrives, which in turn triggers the sense circuit and closes the power-allowing switch, the control element confirms that no foreign object debris has moved onto

or over the resonant tank. *See* Element 1[f], Fells [0248], Fig. 18 (showing that foreign object detection occurs after the initial sense circuit detection, but before charging); Fig. 19 (same); Fig. 25 (same). Only after this confirmation does power begin to flow.

6. Element 16[e]: Generating an Oscillating Magnetic Field

217. Claim 16 next recites “generating an oscillating magnetic field using the source resonator to transfer energy wirelessly to the vehicle to charge a battery of the vehicle.” Fells in combination with Cook renders this obvious.

218. As I explained above for claim element 1[a], Fells’ wireless power supply transfers power to a device by generating an oscillating magnetic field. *See* Element 1[a]. This is true even when Fells is implemented to use Cook’s electric vehicle as the “portable device” that receives energy. *See* Element 16[c], Motivation to Combine. Cook’s electric vehicle has a “receiving circuit” that “converts” the power received through electromagnetic resonance from the charger “into output current.” Cook [0011]. This remains true when receiving power from Fells’ wireless power supply. *See* Fells [0189] (explaining that the “portable device” contains “battery and charging circuit” for charging). A POSA would have understood that Fells’ power supply that transmits power to Cook’s electric vehicle through an oscillating magnetic field “can be used ... for charging the battery” of the vehicle. Cook [0011]; Fells cl. 9 (describing charging battery).

7. Element 16[f]: Foreign Object Verification

219. Lastly, Claim 16 recites “verifying that no foreign object debris has moved onto or over the source resonator during the transfer of energy.” Fells in combination with Cook renders this obvious.

220. As I described for Element 1[f], Fells teaches (or at least renders obvious) checking to verify that no foreign objects are present while transferring energy from the wireless power supply to the portable device. *See* Element 1[f]; Fells [0194]-[0195], [0248]-[0251], [0262]-[0263], Figs. 18, 19, 25. This would remain true when Fells is implemented to charge Cook’s electric vehicle, for the same reasons.

C. Claims Dependent From Claim 1

1. Claim 2

221. Claim 2 recites “[t]he system of claim 1, wherein the wireless energy transfer source is configured to generate the oscillating magnetic field to transfer energy to a vehicle.” Fells in combination with Cook renders this obvious.

222. As I explained above for claim element 16[c], it would have been obvious to implement Fells’ wireless charging system to charge an electric vehicle, such as the vehicle with mounted resonant antenna described in Cook. *See* Element 16[c], Motivation to Combine. In doing so, Fells’ resonant tank circuit would generate an oscillating magnetic field that transfers energy to the vehicle, in the same manner that Fells’ resonant tank circuit generates an oscillating magnetic

field to charge any other portable device. *See* Element 16[e] (Fells generating oscillating magnetic field), Element 1[a] (same).

2. Claim 3

223. Claim 3 recites “[t]he system of claim 2, wherein the foreign object debris detection system is configured to verify that foreign object debris has not moved onto or over the source resonator prior to a transfer of energy from the source resonator to the vehicle.” Fells in combination with Cook renders this obvious.

224. As I explained above for claim elements 16[b] and 16[d], Fells’ “sense circuit” and “control element” verify that “no foreign objects [are] present” prior to “deliver[ing] power to the portable device.” Fells [0191]; *see* Elements 1[a], 16[b], 16[d]. This would remain true if Fells was implemented with Cook to charge an electric vehicle. Fells’ power supply would determine that “no foreign objects [are] present” before “the inverter 210 ... suppl[ies] current to the tank circuit ... to deliver power to” the vehicle, just as in the unmodified version of Fells. Fells [0191].

3. Claim 4

225. Claim 4 recites “[t]he system of claim 3, wherein the foreign object debris detection system is configured to perform a health and/or status check of the wireless energy transfer source before the vehicle is positioned over the source

resonator.” Fells in combination with Cook renders this obvious.

226. As I explained above for Element 16[a], Fells performs two status checks of the resonator: a calibration check and an energy storage check. *See* Element 16[a]. Both the sense circuit calibration check and the energy storage element status check happen before the vehicle that needs to be charged is positioned over the source resonator. Specifically, the sense circuit calibration check happens before the vehicle that needs charging arrives, while the energy storage check happens periodically before any vehicle or foreign object being detected. I addressed this timing in more detail with respect to Element 16[b]. *See* Element 16[b]; Fells [0194]-[0196], Figs. 3, 18, 19, 25.

227. Further, Fells states that “it is possible that a device may have been placed on the unit just before the calibration measurement was made.” Fells [0196]. Because of the term “possible,” a POSA would have understood that this statement also means that the opposite is true; namely, that it is *possible that no device* was placed on the unit until after the calibration measurement was made. In that case, no vehicle was “placed on the unit ... before the calibration measurement was made,” and the status check thus is made “before the vehicle is positioned over the source resonator” as claim 4 requires. Fells [0196 (“the device was removed ... there are now no devices requiring power”). I note that this is what is shown in Figure 3(c), which “assum[es] that no devices were detected”

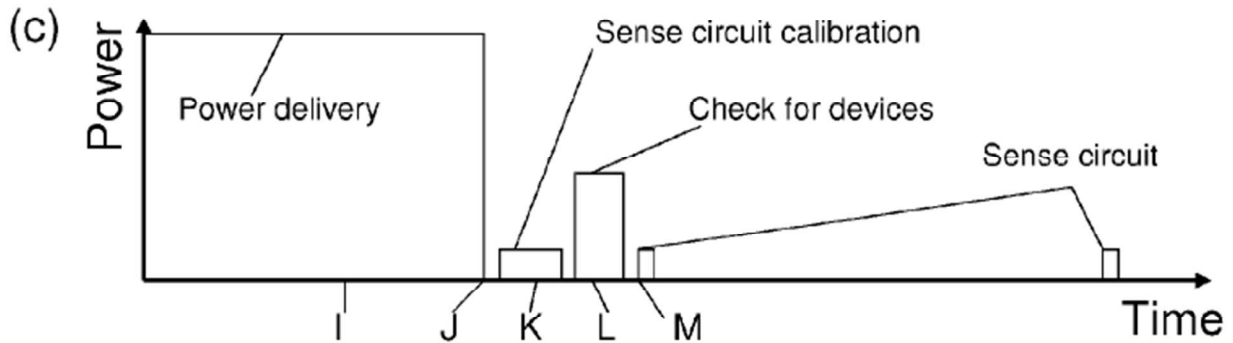
during or after the calibration measurement, allowing the system to enter the low power stats. Fells [0196].

4. Claim 5

228. Claim 5 recites “[t]he system of claim 4, wherein the foreign object debris detection system is configured to perform the health and/or status check less frequently than the verification that foreign object debris has not moved onto or over the source resonator prior to a transfer of energy from the source resonator to the vehicle.” Fells in combination with Cook renders this obvious.

229. A POSA would have understood that Fells’ calibration check occurs less frequently than the “periodic” checks to “sense for another device being placed in proximity,” which triggers or includes a foreign object check. As shown in Figure 3, for example, the calibration status check occurs once after a previous charging is complete, while the sense circuit checks for newly arrived devices or foreign objects are performed repeatedly until a new device arrives to be charged. Fells [0191]-[0196], Fig. 3.

230. Figure 3(c) shown below, for example, confirms this. The system performs a calibration check only once (at point K), while checking for changes in inductance that may correlate to new devices or foreign objects at least twice during the same period (two separate points M). Fells [0196], [0191].



Fells Fig. 3; *see* Fells [0194] (explaining that if “foreign object has been placed on the wireless power supply 200, an inductance change will be detected” at the next point labeled “sense circuit”); *id.* (“at point M the system goes into the ultra low power state in which low power inductance measurements are periodically made to sense for another device being placed in proximity”). Combining Fells with Cook to specifically charge electric vehicles would not change this.

5. Claim 6

231. Claim 6 recites “[t]he system of claim 4, wherein the foreign object debris detection system is configured to periodically perform the health and/or status check and the verification that foreign object debris has not moved onto or over the source resonator prior to a transfer of energy from the source resonator to the vehicle.” Fells in view of Cook and/or a POSA’s knowledge renders this obvious.

232. This element is obvious for two different reasons. First, Fells teaches that its status checks (calibration check and energy storage check) and foreign object debris detection check occur periodically. Second, even if that were not the

case, it would have been obvious to implement each of those checks periodically, as periodic checks were a well-known solution to monitoring for ongoing events.

A. Fells Teaches Periodic Checks

233. Fells' status checks are each performed periodically. Fells' calibration check occurs each time after the system has finished charging a device, whether because the device is fully charged, or because it was removed, thus setting the appropriate calibration level for the next detected object. Fells [0196] (explaining that a check is made once "there are now no devices requiring power"). Meanwhile, the energy storage element "is monitored" at intervals that allows for recharging, and also "periodically monitor[ed]" by the sense circuit. Fells [0246].

234. Fells' verification that no foreign objects exist also occurs "periodically" since Fells taught that "low power inductance measurements ... to sense for another device being placed in proximity" are made "periodically." Fells [0194]-[0196]; Fig.3(a)-3(c); Combining Fells with Cook to specifically charge electric vehicles would not change this.

B. Periodic Checks Would Have Been Obvious

235. To the extent that it is not already disclosed in Fells, it would have been obvious to a POSA to implement Fells such that the calibration check, the energy storage element check, and the foreign object debris check before transferring energy were all performed periodically. A POSA would have known

to perform each of these checks periodically to ensure that the system continues to detect objects correctly (for the calibration check), that the system continues to work safely (for the foreign object debris check) and that the system continues to work at all (for the energy storage element check – without which the foreign object detection and primary coil are inoperable).

236. Each of Fells' status and foreign object checks provide monitoring against disruptive occurrences, namely, miscalibration of the resonator for the calibration check, depletion of the energy storage element for the energy storage check, and the arrival of a foreign object or vehicle to be charged for the foreign object check. *See* Element 16[a], Claims 4-5. A POSA would have understood that, along with performing checks sporadically, or continuously, performing checks "periodically" was one of a finite number of known, predictable solutions for ongoing monitoring against disruptions.

237. Further, a POSA would have known how to implement these checks periodically, and a POSA would have also been motivated to implement them periodically because Fells, for example, discloses nearly a dozen separate examples of "periodically" monitoring for disruptions. *See, e.g.*, Fells [0194] ("[p]eriodically, the sense circuit 206 powers up to see if an inductance change has occurred ..."), [0196] ("low power inductance measurements are periodically made to sense for another device"), [0200] ("periodically take measurements..."),

[0222] (“periodically check to see if the counter has overflowed”), [0238] (“the false trigger counter is periodically reinitialised”), [0246] (“the sense circuit 206 periodically monitors the energy in the energy storage element”), [0250] (“sense circuit 206 periodically looks for a change”), [0251] (“system periodically ‘pings’ ... the system by modulating the primary coil”), [0260] (“[microprocessor] periodically reads the value of the peak detector”), [0279] (“the devices are detected by periodically applying power”), [0293] (“periodically send out short pings of energy...” and “periodically listen for pings of information”), Fig. 25 (checking every “400ms”). As these examples confirm, performing monitoring checks “periodically” was a well-known method of performing status checks, compatible with the system disclosed in Fells.

238. I note that the ’184 patent does not explain why performing status checks or foreign object checks periodically would have been inventive or novel in 2011, and a POSA would have recognized periodic checks were not inventive or novel. The ’184 patent specification does not describe or explain status checks or object detection checks occurring periodically, much less describe how or why it would be beneficial or inventive for them to be periodic. *See generally* ’184 patent. At bottom, the alleged novelty of the ’184 patent is not related to periodic checks, the specification fails to disclose how or why to implement periodic checks, and performing periodic checks was well known in the art. Thus, it would

have been obvious to a POSA to implement periodic status checks and foreign object detection checks in Fells as one of a limited number of finite, predictable solutions for solving the same problem.

6. Claim 7

239. Claim 7 recites “[t]he system of claim 2, wherein the foreign object debris detection system is configured to verify that foreign object debris has not moved onto or over the source resonator after the vehicle is positioned over the source resonator and prior to a transfer of energy from the source resonator to the vehicle.” Fells in combination with Cook renders this obvious.

240. This element is taught for the reasons I explained above for claim elements 16[d] and 1[f]. Namely, when Fells is implemented to charge an electric vehicle as in Cook, Fells checks that no foreign objects are present after the vehicle is in position (triggering the sense circuit and control unit) but before the inverter activates the primary coil to transfer energy from the source resonator to the vehicle. *See* Elements 16[d], 1[f]; Fells [0194], [0248], Fig. 18 (showing that foreign object detection occurs after the first sense circuit detection but before charging), Fig. 19 (same), Fig. 25 (same).

7. Claim 9

241. Claim 9 recites “[t]he system of claim 1, wherein the wireless energy transfer source is a component of a vehicle charging station.” Fells in combination

with Cook renders this obvious

242. As explained above for Element 16[c] and Claim 2, it would have been obvious to a POSA to implement Fells to charge an electric vehicle like the vehicle described in Cook. *See* Element 16[c]; Claim 2; Motivation to Combine. In that implementation, a POSA would have understood that Fells' wireless power supply serves as a vehicle charging station. I note that the '184 patent provides no limitations on, or explanation of, what a "vehicle charging station" is beyond requiring that it provides power to an "electric vehicle." '184 patent 10:61-67, 11:40-45. Thus, when Fells' wireless power supply is used to charge the battery of Cook's electric vehicle, a POSA would consider that to constitute a "vehicle charging station," as it is a station that charges the vehicle. That is especially true when, as I described above, Fells' power supply could be placed under the ground of a parking space, with the vehicle parked above in the parking space to be charged. *See* Motivation to Combine; Element 16[c].

8. Claim 10

243. Claim 10 recites "[t]he system of claim 9, further comprising a device module configured to be mounted on an electric vehicle." Fells in combination with Cook renders this obvious.

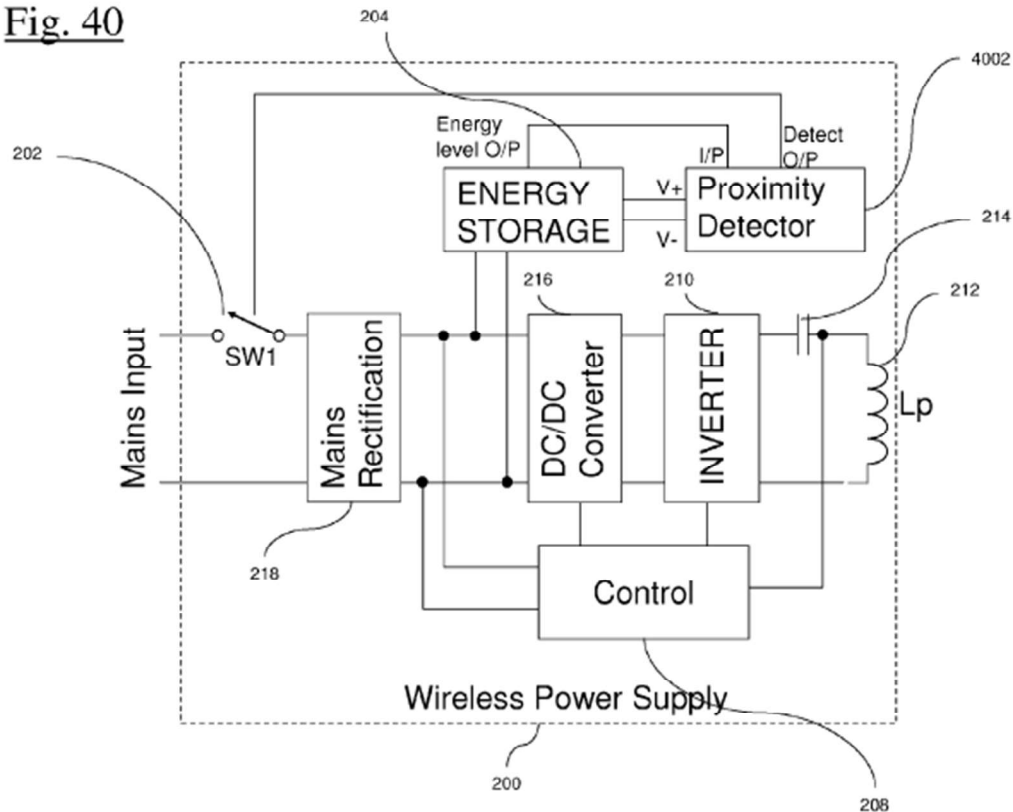
244. As I explained above, Cook's "automobile" "includes at least one magnetic resonant antenna ... formed from an inductive loop 111 in parallel with

a capacitor.” Cook [0011], Fig. 1 (showing a coil mounted on the vehicle). Cook’s automobile-mounted antenna has a “receiving circuit” which “receives a magnetic signal” from the charger and “converts that power into output current.” Cook [0011]. A POSA would understand that the antenna with receiving circuit constitutes a device module, as it is the circuitry module that assists in powering the device (vehicle). When Fells is implemented to charge electric vehicles, as I described above, a POSA would use this same arrangement. *See* Element 16[c], Claim 2, Motivation to Combine.

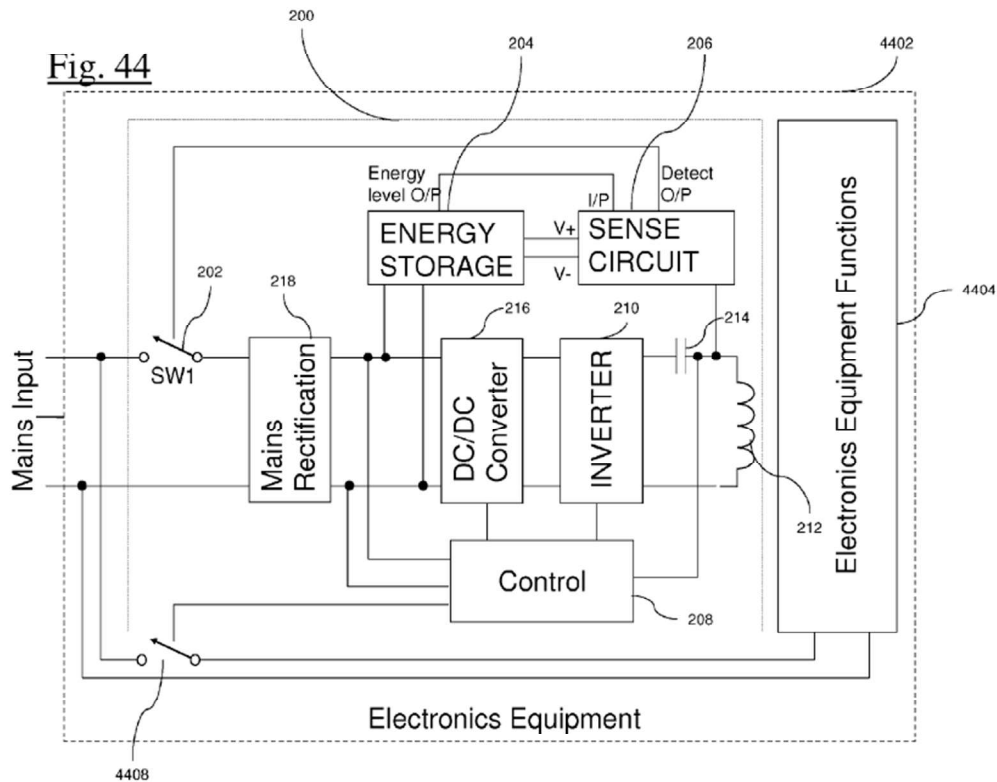
XI. Ground 3: Claim 12 Would Have Been Obvious Over Fells Alone or In View of Ono

245. Claim 12, which recites “[t]he system of claim 1, further comprising an enclosure housing at least a portion of the wireless energy transfer source, wherein the foreign object debris detection system is integrated into the enclosure.” Fells, alone or in view of Ono, teaches or renders obvious this element.

246. Fells teaches that its resonant tank circuit as well as its control unit and proximity detector (the claimed foreign object debris detection system) are integrated into a “wireless power supply” enclosure, as shown by the dotted line in the figure below.

Fig. 40

Fells Fig. 40. Further, Fells teaches the importance of “shielding” components. Fells [0295] (explaining that the “coils may” have shielding). A POSA would have understood that the dotted lines in Fells’ diagrams indicate an “integrated” system that a POSA would have understood to be logically implemented within a single enclosure encompassing the components within those dotted lines. For example, when Fells describes the “embodiment of Fig. 2 integrated into another device,” it depicts this “integration” by showing all components within dotted lines, as shown in Figure 45 below.



Fells Figs. 44; *see* Fells Fig. 45, [0186]-[0187] (describing dotted lines of Figs. 44-45 as showing the “embodiment of Fig. 2 integrated into another device”), [0301] (describing components shown within dotted lines as “wireless power supply ... integrated with another piece of electronic equipment”).

247. To the extent that Fells does not teach an enclosure, a POSA would have considered it obvious to place Fells’ wireless power supply, including the proximity detector (or sense circuit), control unit, and tank circuit, within a primary enclosure as taught by Ono. Ono Fig. 2, 3:64-4:26 (showing and describing “primary enclosure” containing “primary coil 21” and “detector coil 26,” and being separate from “secondary enclosure 25” containing the secondary coil).

248. A POSA would have understood that an enclosure was a well-known way to cover and protect electronic components to prevent them from malfunctioning, including for wireless charging systems and foreign object detection systems. *See, e.g.* Ono Fig. 2, 4:3-50 (describing a “primary enclosure” containing “primary coil” and “detector coil” for “detection of foreign objects”); Cook-086 16:59-62 (describing that a “shield ... disposed around the antenna” would “mitigat[e]” interference caused by “close-by objects or humans” due to their “stray capacitance”); Boys (Ex. 1011) 8:19-42 (describing “charging pad” for charging a “vehicle” that is inside an “outer housing”), Figs. 2-3.

249. Using an enclosure or housing would protect the primary coil and other sensitive components of Fells’ wireless power supply from the environment, such as dirt, lint, debris, and any other contaminants. It would also shield the coil and circuitry from the environment, leading to a more robust product lifespan due to the decreased risk of electrical shorts. Such an enclosure also increases safety, as users will no longer be exposed to live electrical current. When placing Fells’ wireless power supply in an enclosure, the proximity detector, control unit, and primary coil would be placed in the same enclosure since they are part of the same circuit and are hardwired together. *See, e.g.*, Fells Figs. 2, 40.

XII. Ground 4: Claim 13 Would Have Been Obvious Over Fells In View of Cook and/or Wang Thesis

250. Claim 14 recites “[t]he system of claim 1, wherein the wireless energy

transfer source is configured to deliver a power of more than 3.3 kW to a wireless power receiving device.” Fells in combination with Cook and/or Wang Thesis renders this obvious.

251. As I described above for Claims 2 and 16, a POSA would have found it obvious to use Fells’ wireless power supply to charge an electric vehicle, as Cook discloses. *See* Motivation to Combine Fells with Cook, Element 16[c], Claim 2. Although Fells and Cook do not quantify the power provided by their systems, it would have been obvious to a POSA to design Fells’ system to provide power in excess of 3.3kW (as described, for example, in Wang Thesis) in order to fully charge the battery of an electric vehicle in a reasonable amount of time.

252. Wang Thesis discloses a “design procedure” for wireless resonator-based charging systems “with the aim of achieving a controllable power transfer capability over a specified operating range with minimum total cost.” Wang Thesis 77. In this design procedure, Wang Thesis shows a POSA how to “achieve the desired power” in a resonator-based wireless charging system by adjusting “four major design factors: the operating frequency (ω_0), the primary current (I_p), the magnetic design factor ($k^2 L_p = M^2 / L_s$) and the secondary quality factor (Q_{s0})” according to the provided formula:

$$P = V_{oc} I_{sc} Q_{s0} = \omega_0 I_p^2 (k^2 L_p) Q_{s0} = \omega_0 I_p^2 \left(\frac{M^2}{L_s} \right) Q_{s0}$$

Wang Thesis 77-78; *see id.* 79-86.

253. As shown in the figure below, a POSA starting with the “electromagnetic structure” and “compensation topology” of the Fells/Cook system, could and would have used Wang’s “design procedure” to select the remaining variables like the operating frequency and primary current, to “achieve” their “desired” power level. Wang Thesis 77.

254. A POSA would have “desired” to implement Fells’ power supply using Wang’s design procedure to obtain power at least in excess of 3.3kW (or higher) because these power ratings were common for vehicle chargers at the time. For example, an IEEE article on electric car and battery technologies (Dickerman, Ex. 1028) explained that in the 2010 timeframe, a POSA would have known that “Level 2” electric vehicle chargers could provide relatively quick charge times by providing power in excess of 3.3 kW, while systems with higher “charge power” provided even quicker charging times.

table 3. Typical set of charging options developed for an EV.				
EVSE	Utility Service	Usage	Charge Power (kW)	Time to Charge
Level 1	110 V, 15 A	Opportunity	1.4	18 hours
Level 2	220 V, 15 A	Home	3.3	8 hours
Level 2	220 V, 30 A	Home/Public	6.6	4 hours
Level 3	480 V, 167 A	Public/Private	50–70	20–50 min

Dickerman 59 (explaining that charging systems with less than 3.3kW of power “may not be the customer’s preferred charging method” because of their slow charging, which meant a lengthy wait for a full charge). Other contemporaneous articles on electric vehicle batteries similarly confirmed that charging speeds in excess of 4kW were known, and known to be useful. *See, e.g.* Weiller (Ex. 1033) 3767 (2011 article disclosing “Fast-charging a vehicle battery at 4 kW on a low voltage grid”)

255. Moreover, in January 2010 the Society of Automotive Engineers revised their “J1772 ... surface vehicle recommended practice,” a technical standard for “electric vehicle and plug in hybrid electric vehicle conductive charge coupl[ing].” SAE Standards (Ex. 1031) 1. These standards “redefine[] AC Level 1 and Level 2 charge levels,” as shown below. SAE Standards 1.

TABLE 1 - CHARGE METHOD ELECTRICAL RATINGS (NORTH AMERICA)			
Charge Method	Nominal Supply Voltage (Volts)	Maximum Current (Amps-continuous)	Branch Circuit Breaker rating (Amps)
AC Level 1	120 V AC, 1-phase	12 A	15 A (minimum)
	120 V AC, 1-phase	16 A	20 A
AC Level 2	208 to 240 V AC, 1-phase	≤ 80 A	Per NEC 625
DC Charging	Under Development		

SAE Standards 9. A POSA would have understood this table to convey that “AC Level 2” standard electric vehicle charging could occur at powers as high as 19.2 kW (240 volts multiplied by 80 amps).

256. In addition to charging powers in excess of 3.3 kW being well-known for electric vehicles, a POSA would have desired to transmit power above a rate of 3.3kW in order to charge an electric vehicle in a reasonable time frame, such as overnight, which electric vehicle consumers would expect. Hall (Ex. 1029) [0531] (“plugging in at night” is “traditional non-wireless recharging practice[]”). As shown below, commercially available electric vehicles in the 2010-2011 timeframe had battery capacities as high as 28 or 53 kilowatt-hours.

table 2. Sample of vehicle production plans as of November 2009.						
Manufacturer	Model	EV Type	Consumer Availability	Electric Range (miles)	Total Range (miles)	Battery Size (kWh)
Buick		PHEV	2011	10	300	8
Chevrolet	Volt	EREV	Late 2010	40	300	16
Cooper (BMW)	Mini E	EV	Now	156		28
Fisker	Karma	PHEV	2010	50	300	22
Nissan	LEAF	EV	Late 2010	100		24
Tesla	Roadster	EV	Now	220		53

Dickerman 57. In order to fully charge these vehicles overnight, a POSA would have understood that they would need to be charged at more than 3.3 kW. For example, Dickerman states that the Tesla Roadster is listed to have a 53 kWh battery size. At 3.3 kW of power, charging would take more than 16 hours. A POSA would have sought to charge at even higher speeds to ensure that the car could be charged overnight, and thus used every day. Charging in 8 hours, for example, would require charging power of 6.6 kW or higher. The same is true for the 28 kWh BMW Mini E, which would need to be charged at least 3.5 kW in order to charge in an 8 hour overnight timeframe.

257. Thus, a POSA would have been motivated to implement Fells' power supply to charge an electric vehicle at power levels in excess of 3.3 kW to charge the vehicle in an overnight timeframe, and could have done so using the design methodology for contact-less electric vehicle battery charging systems that Wang Thesis described.

258. For the same reasons that I explained with respect to Fells and Cook above, the fact that Fells' describes itself as "low power" would not stop a POSA

from implementing Fells to transfer power in excess of 3.3kW. As Fells makes clear, “low power” is not a reflection of how much power is transferred when charging is ongoing. Rather, the system is low power because it spends most of its time in a “standby” state, with only the sense circuit drawing power. This would remain true when Fells’ power supply is implemented to charge an electric vehicle at powers greater than 3.3 kW. *See Motivation to Combine Fells and Cook*

XIII. CONCLUSION

259. All statements made here 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 10/23/2023 (date), in Philadelphia, PA (city, state).


Mark Allen