

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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TRANSMISSION

DECLARATION OF DR. GARY L. WOODS

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I, Gary L. Woods, Ph.D., declare as follows:

I. INTRODUCTION

1. I have been retained as a technical expert by counsel on behalf of Anker Innovations Ltd. (“Anker” or “Petitioner”). I understand that Anker is requesting that the Patent Trial and Appeal Board (“PTAB”) institute an *inter partes* review (“IPR”) proceeding with respect to U.S. Patent No. 8,626,461 (“the ’461 patent”) (EX1001).

2. I have been asked to provide my independent analysis of the ’461 patent in light of certain prior art publications, and I have done so based on my personal knowledge and experience. As detailed below (and demonstrated in my CV attached here), I am familiar with the technology described in the ’461 patent, and I am also familiar with the knowledge of a person of ordinary skill in the art with respect to this technology both as of the filing date of the ’461 Patent (November 29, 2011) and as of the earliest alleged priority date of the ’461 patent (March 22, 2007).

3. I am not, and never have been, an employee of Anker. I received no compensation for this declaration beyond my normal hourly compensation based on my time actually spent analyzing the ’461 patent, the prior art publications cited below, and various issues related thereto. I will not receive any added compensation based on the outcome of any IPR or other proceeding involving the ’461 patent.

II. QUALIFICATIONS

4. In formulating my independent analysis of the '461 patent, I have relied on my knowledge, training, and experience in the relevant field, which I have summarized below.

5. I have over 25 years of professional experience working with electronic circuit design, battery technology, and mobile electronic devices. I have applied these technologies in a variety of contexts, including among others, the design of wireless electrical charger devices and rechargeable mobile devices. Further, I have authored numerous published technical papers, and I am a named inventor on at least 16 U.S. patents.

6. Since 2008, I have been employed as a Professor in the Practice in the Department of Electrical and Computer Engineering at Rice University in Houston, Texas. Since 2020, my title has been Distinguished Professor in the Practice. Before that, I worked as a postdoctoral fellow at the University of California, Santa Barbara (1996-1998); at Intel Corporation (1998-2000); at Spectralane Inc. (2000-2002); at Optonics (later Credence Systems Corp.) (2003-2006); and as an independent consultant (2006-present). In the summers of 1988 and 1989 I worked at Texas Instruments.

7. My educational background includes undergraduate degrees in Physics and Electrical Engineering from Rice University in 1988 and an MS (1991) and

Ph.D. (1997) in Applied Physics from Stanford University.

8. I am familiar with patents both as an inventor and as Chief Technology Officer in charge of the patent portfolio of a company I co-founded, Spectralane. I am an inventor on at least 16 issued patents in the U.S., of which most are related to design, testing, and manufacture of electronic circuits. My CV attached to this declaration contains a list of patents on which I am a named inventor or co-inventor.

9. With regard to wireless electronic charger devices specifically, I have worked on a number of design projects at Rice in this field. Many of them were year-long capstone design projects, where I was the technical mentor on the project. I have worked on projects involving charging cellphones with supercapacitors and with human-powered generators, and harvesting energy from a shock absorber. Additionally, other projects focused on the design of wireless charging devices, including wireless power delivery for transcutaneous charging of biomedical implants, wirelessly powering a CO₂ sensor for the International Space Station, and others.

10. I have supervised a number of capstone projects involving significant wireless aspects, including wirelessly powering a multi-element pacemaker; an 11 GHz real-time 4x4 imaging radar array; sending video over cellphone links for ambulance telemedicine; ultra-low power wireless EEG transmission; several off grid internet-of-things (IOT) systems; and several wirelessly transmitting medical

devices.

11. Outside of capstone projects, I have been involved in research activities related to this case including developing an experimental setup with the highest magnetic field in Texas, developing a solar-powered, IOT flood-sensor network to be deployed by the City of Houston, and developing a terahertz generation and detection system. I have also been involved in research activities related to wireless charging technology, including collaborations with Prof. Joseph Cavallaro in Electrical and Computer Engineering at Rice University and with Dr. Mehdi Razavi, a cardiologist at the Texas Heart Institute.

12. In my educational activities at Rice University, I regularly teach a laboratory course that includes the design of circuits for rechargeable battery technology, wireless electronic charger devices, and protection circuits for such batteries and/or devices. I also mentor the Rice Electric Vehicle Team, whose project includes wireless telemetry, and the Rice Wind Power Team, whose project includes charging a battery.

13. For these reasons, I believe that I have a detailed understanding of the state of the art during the relevant period, as well as a sound basis for opining how persons of skill in the art at that time would understand the technical issues in this proceeding related to the '461 patent.

14. Additional details about my employment history, fields of expertise, and publications are included in my curriculum vitae (attached as Appendix A).

III. LEGAL PRINCIPLES

15. In forming my analysis and conclusions expressed in this declaration, I have applied the legal principles described in the following paragraphs, which were provided to me by counsel for the Petitioner.

A. Anticipation

16. I have been informed that a patent claim is unpatentable as anticipated under 35 U.S.C. § 102 if each and every element of a claim is found either explicitly or inherently in a single prior art reference. Under the principles of inherency, if the prior art necessarily functions in accordance with, or necessarily includes the claimed elements, it anticipates.

B. Obviousness

17. I have been informed that a patent claim is invalid as “obvious” in light of one or more prior art references if it would have been obvious to a person of ordinary skill in the art at the time of the alleged invention (“POSITA”), taking into account (1) the scope and content of the prior art, (2) the differences between the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any so called “secondary considerations” of non-obviousness, which include: (i) “long felt need” for the claimed invention, (ii) commercial success attributable to the claimed

invention, (iii) unexpected results of the claimed invention, and (iv) “copying” of the claimed invention by others.

18. While I do not know the exact date that the alleged invention of the ’461 patent was made, I do know that the ’461 patent’s earliest claimed priority date is March 22, 2007. For purposes of my obviousness analysis in Grounds 1A-3 (Sections VIII-XI), I have applied a date of March 22, 2007 as the date of the alleged invention, although in many cases the same analysis would hold true even if the date of the alleged invention were earlier.

19. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references. To be obvious in light of a single prior art reference or multiple prior art references, there must be a reason that would have prompted a POSITA to modify or supplement the single prior art reference, or to combine two or more references, in a manner that provides the elements of the claimed invention. This reason may come from a teaching, suggestion, or motivation to combine, or may come from the reference(s) themselves, the knowledge or “common sense” of a POSITA, or from the nature of the problem to be solved, and this reason may be explicit or implicit from the prior art as a whole. I have been informed that, under the law, the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield

predictable results. I also understand it is improper to rely on hindsight in making the obviousness determination.

IV. PERSON OF ORDINARY SKILL IN THE ART

20. Based on my knowledge and experience in the field and my review of the '461 patent and its file history, I believe that a POSITA would have had a bachelor's degree or higher in electrical engineering, at least three years of experience designing or researching electronic circuits, and familiarity with power electronics and inductive power transfer circuits. I base this opinion on my experience collaborating with, consulting, and managing technical teams of engineers and technicians working on the design and development of electronic circuits, including power electronics and inductive power transfer circuits (e.g., wireless charging devices). Accordingly, my analysis and conclusions expressed herein are based on the perspective of a POSITA having this level of knowledge and skill. My education, technical expertise and personal knowledge discussed in Section II demonstrate that I meet the qualifications of a POSITA.

V. MATERIALS CONSIDERED

21. My analysis in this declaration is based on my understanding of a POSITA's knowledge and experience with the design and development of electronic circuits, including power electronics and inductive power transfer circuits (e.g., wireless charging devices). Based on my above-described qualifications in Section

II, I am an expert in the field of technology of the '461 patent. Also, based on my experiences detailed above, I understand and know of the capabilities of persons of ordinary skill in this field. While the designs of wireless chargers and other electronic circuits to which I have contributed were substantially more sophisticated than the technology described in the '461 patent, many of the underlying circuit components and design principles are the same.

22. As part of my independent analysis for this declaration, I have considered the following: the '461 patent (EX1001) and its prosecution history (EX1002); the background knowledge/technologies that were commonly known to a POSITA; my own knowledge and experience gained from my work in the field; my experience in teaching and advising others in this field; and my experience working with others involved in this field. In addition, I have analyzed the following publications and materials:

EX1004	U.S. Publication No. 2005/0075699 ("Olson")
EX1005	PCT Publication No. WO2005/109597 ("Stevens")
EX1006	US Publication No. 2002/0057164 ("Jin")
EX1013	U.S. Patent No. 7,605,496 ("Stevens496")
EX1014	U.S. Patent No. 7,791,312 ("Kook")

23. Note that my citations to patent literature in this declaration refer to the column/line numbers or paragraph numbers in those documents. Note also that all emphasis (bold/italics/underline) in any quoted text has been added unless indicated otherwise.

24. Although this declaration refers to selected portions of the cited references, it should be understood that these are examples, and that a POSITA would have viewed the references cited herein in their entirety and in combination with other references cited herein or cited within the references themselves. The references used in this declaration, therefore, should be viewed as being incorporated herein in their entireties.

VI. THE '461 PATENT

A. Overview of the '461 Patent (EX1001)

25. The '461 patent is titled "Efficiency Monitor for Inductive Power Transmission." EX1001, cover. The "efficiency monitor" is used for an inductive power outlet, which can be used to wirelessly charge another device. EX1001, 12:60-15:60, FIGS. 5-7, Abstract. The '461 patent explains that the "efficiency monitor 4300 consists of an input power monitor 4122 incorporated within the power outlet 4210 and an output power monitor 4124 incorporated within the electric device 4290, both in communication with a processor 4162." EX1001, 13:10-14. As shown in FIG. 5 (below), the "input power monitor 4122" measures the input power

provided by the “primary coil 4220” and the “output power monitor 4124” measures the output power received by the “secondary coil 4260”:

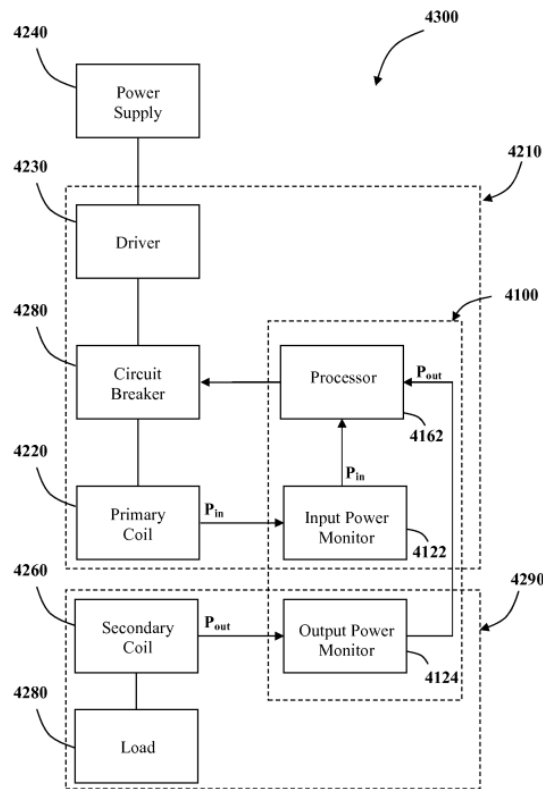


Fig. 5

EX1001, FIG. 5, 13:4-20.

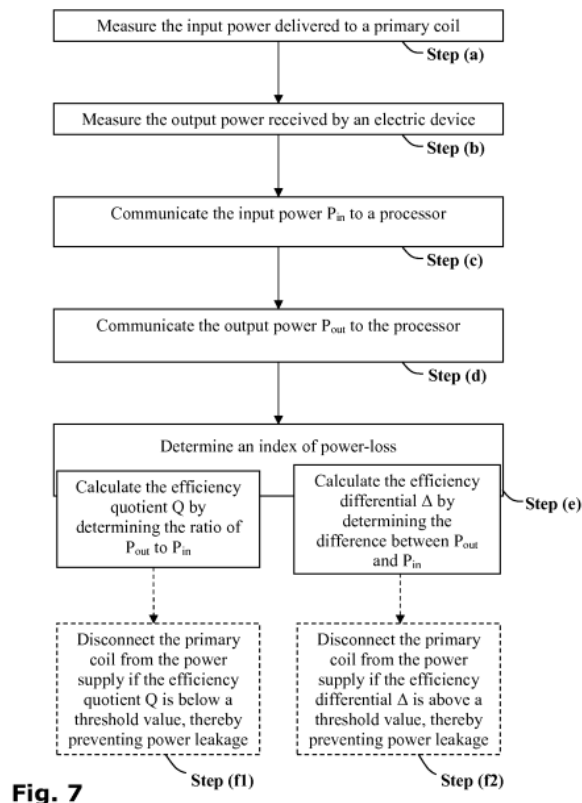
26. In the example depicted above, a processor 4162 of the power outlet 4210 is in communication with both the input power monitor 4122 and the output power monitor 4142 for purposes of receiving the values of “input power P_{in} ” and “output power P_{out} ,” which the processor uses to calculate “an index of power-loss.”

EX1001, 13:21-37; FIGS. 5, 7. The specification explains that:

The index of power-loss may be the efficiency quotient Q which is the

ratio between them, P_{out}/P_{in} , which is an indication of the efficiency of the inductive coupling. Alternatively the index of power loss may be the efficiency differential Δ which is the difference between P_{out} and P_{in} .

EX 1001, 13:24-29. As described below, the explanation is relevant to the independent claims of the '461 patent. The method shown in FIG. 7 also describes the same alternatives for the “index of power-loss”:



EX1001, FIG. 7, 15:34-39; *see also id.*, FIGs. 6(a)-(d) and 13:38-15:33 (describing an embodiment that “then calculates the efficiency quotient Q”).

B. The Prosecution History of the '461 Patent

27. The '461 patent was filed November 29, 2011, and claims priority to several earlier-filed applications, the earliest filed March 22, 2007. EX1001, 1.

28. Based on my review of the file history (EX1002), I understand that the Examiner issued two Office actions during prosecution of the application that would later issue as the '461 patent. Claim 13 of the '461 patent started as application claim 14, which was initially rejected in a first Office action dated August 29, 2012, as being anticipated by U.S. Pat. 7,605,496 (EX1013). EX1002, 91-93. In response, the applicant argued that the cited patent did not “describe any signal detector configured to detect signals carrying data pertaining to output power received by the secondary coil” and did not describe “any alternative way to determine an index of power loss.” EX1002, 180, 186-187. In a second Office action dated March 21, 2013, the Examiner was “not persua[ded]” by the arguments and explained why the cited patent taught all elements of the independent claim. EX1002, 200-203.

29. The file history shows that the applicant and the Examiner had two interviews after the second Office action issued—once in May 2013 and then in June 2013. In the first interview, no agreement was reached. EX1002, 220. In the second interview, the Examiner suggested amending each independent claim to overcome the cited patent—including an amendment to add the “wherein” clause of a dependent claim (application claim 10) into each independent claim. EX1002, 220.

The applicant made these suggested amendments, which resulted in application claim 14 (now issued as claim 13) being amended as follows:

14. An inductive power outlet comprising at least one primary coil, for inductively coupling with a secondary coil wired to an electric load, the inductive power outlet further comprising an efficiency monitor comprising:

at least one input power monitor configured to measure input power received by the primary coil from the power supply ~~delivered to the primary coil~~;

at least one signal detector configured to detect signals carrying data pertaining to output power received by the secondary coil;

at least one processor configured to receive data pertaining to the input power and the output power, the processor further configured to determine an index of power-loss indicative of the efficiency of an inductive coupling between the primary coil and the secondary coil;

wherein the index of power-loss comprises at least one of:

an efficiency quotient Q , defined as the ratio of the output power to the input power; and

an efficiency differential Δ , defined as the difference between the output power and the input power.

EX1002, 218, 224 (“However, in order to expedite prosecution, and following the Examiner suggestions”).

30. The examiner mailed a notice of allowance expressly identified the reasons for allowance. EX1002, 240-248. Relevant to application claim 14 (issued claim 13), the Examiner concluded that US7,605,496 was “the reference closest to the claimed invention” because it discloses all of the claim elements except the functional recitation of the processor element:

Stevens et al. do not teach the processor further configured to determine an index of power-loss indicative of the efficiency of an inductive coupling between the primary coil and the secondary coil; wherein the index of power-loss comprises at least one of: an efficiency quotient Q , defined as the ratio of the output power to the input power; and an efficiency differential A , defined as the difference between the output power and the input power.

EX1002, 247-248.

31. As demonstrated by Grounds 1A-3 below, and based on my knowledge and experience in this field and my analysis of the publications cited herein, it is clear that more pertinent prior art was never presented to the Examiner during examination. As shown below, publications such as Olson and Jin show prior art examples of what the Examiner mistakenly believed to be missing from the prior art.

C. The Issued Claims of the '461 Patent

32. Counsel has asked me to consider the validity of claims 13-18 (the “Challenged Claims”) of the '461 patent. The following chart provides a listing of

the elements in each of the Challenged Claims, which I refer to throughout my analysis herein:

Claim Element	Language
[13.P]	An inductive power outlet comprising at least one primary coil, for inductively coupling with a secondary coil wired to an electric load, the inductive power outlet further comprising an efficiency monitor comprising:
[13.1]	at least one input power monitor configured to measure input power received by the primary coil from the power supply;
[13.2]	at least one signal detector configured to detect signals carrying data pertaining to output power received by the secondary coil;
[13.3]	at least one processor configured to receive data pertaining to the input power and the output power, the processor further configured to determine an index of power-loss indicative of the efficiency of an inductive coupling between the primary coil and the secondary coil;
[13.4]	wherein the index of power-loss comprises at least one of: an efficiency quotient Q , defined as the ratio of the output power to the input power; and an efficiency differential Δ , defined as the difference between the output power and the input power.
[14]	The inductive power outlet of claim 13 additionally comprising at least one circuit-breaker configured to disconnect the primary coil from the power supply.
[15.1]	An inductive power receiver comprising at least one secondary coil for inductively coupling to a primary coil and supplying power to an electric load,
[15.2]	the inductive power receiver further comprising: at least one output power monitor for measuring output power received inductively by the secondary coil from the primary coil, and
[15.3]	at least one signal transmitter configured to transmit signals carrying data pertaining to the output power to the inductive power outlet of claim 13.
[16]	The inductive power receiver of claim 15 wherein the signal transmitter is selected from a group consisting of: light

	emitting diodes, radio transmitters, optocouplers, and transmitter circuits.
[17.1]	The inductive power receiver of claim 15 wherein the transmitter comprises: an ancillary load selectively connectable to the secondary inductive coil, a modulator for modulating a bit-rate signal with an input signal to create a modulated signal, and
[17.2]	a switch for intermittently connecting the ancillary load to the secondary inductive coil according to the modulated signal.
[18]	The inductive power receiver of claim 15 wherein the output power monitor is incorporated into an electric device.

D. The '461 Patent's Priority Date

33. The '461 patent was filed November 29, 2011, and claims priority to several earlier-filed applications, the earliest filed March 22, 2007. EX1001, 1. I have been instructed by counsel for Anker to treat the earliest alleged date—March 22, 2007—as the priority date of the Challenged Claims, and I have done so throughout my analysis in this declaration. To be clear, I have not independently assessed the priority date of any of the Challenged Claims and I have not formed an opinion as to the correct priority date of any claim of the '461 patent. Regardless, I note that each of the references cited in Grounds 1A-3 (i.e., Olson, Stevens, and Jin) were published long before the alleged March 22, 2007 date.

VII. CLAIM CONSTRUCTION

34. I understand that, in an IPR proceeding, the terms appearing in patent claims are interpreted according to their “ordinary and customary meaning,” which

is often referred to as the *Phillips* standard. In determining the ordinary and customary meaning, I understand that the words of a claim are first given their plain meaning that those words would have had to a POSITA. I also understand that the structure of the claims, the specification and file history may be used to better construe a claim. Moreover, I understand that even treatises and dictionaries may be used, albeit under limited circumstances, to determine the meaning attributed by a person of ordinary skill in the art to a claim term.

VIII. ANALYSIS – ANTICIPATION BASED ON OLSON (GROUND 1A)

A. Olson (EX1004)

35. The Olson reference has a teaching that is similar to the '461 patent. For instance, Olson describes a power outlet device (Olson uses the term “external charging device”) having a “primary coil” for inductively coupling with a “secondary coil” of a battery-powered electric device:

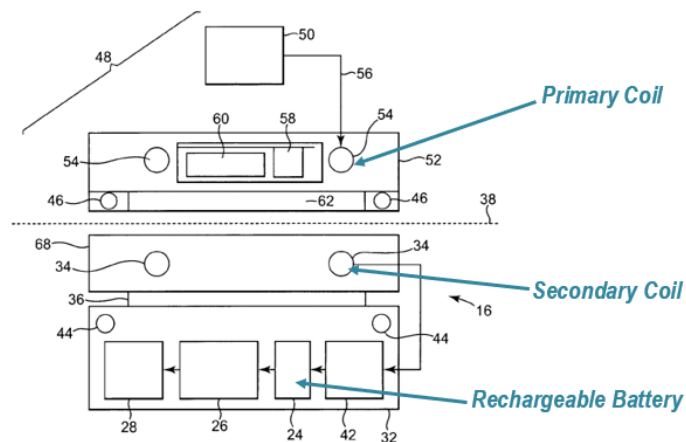


Fig. 3

EX1004, [0019], [0046]-[0054], [0072]-0078], FIGS. 3 (annotated above) and 14.

Olson illustrates that the power outlet device can be implemented in the form of wireless charger for transmitting power to an implanted medical device. EX1004, [0046]-[0054], [0072]-[0078], [0111]-[0116]. Olson explains that “[f]or implanted medical devices, the efficiency at which energy is transcutaneously transferred is crucial” because a high efficiency beneficially reduces the heating of surrounding components and tissues as well as reduces the amount of time to recharge the wireless device. EX1004, [0017]. Accordingly, Olson’s charging device measures and calculates an efficiency of power transfer between the external charging device and the implantable medical device. EX1004, [0074], [0075], [0076], [0112]. This efficiency of power transfer is displayed to a user to assist with repositioning/alignment for improved power transfer from the external charging device to the implantable medical device. EX1004, [0076]-[0078].

36. Olson expressly teaches that the charging device “contains the electronics necessary to drive primary coil 54 with an oscillating current in order to induce current in secondary coil 34” contained in the implantable device. EX1004, [0054]. The “[s]econdary charging coil 34 is operatively coupled through electronics 26 to rechargeable power source 24.” EX1004, [0050].

37. Olson monitors the efficiency of power transfer from the primary coil to the secondary coil using a microprocessor 212, a telemetry antenna 218, and a current measure block 226, which are all shown in the circuit diagram of FIG. 14:

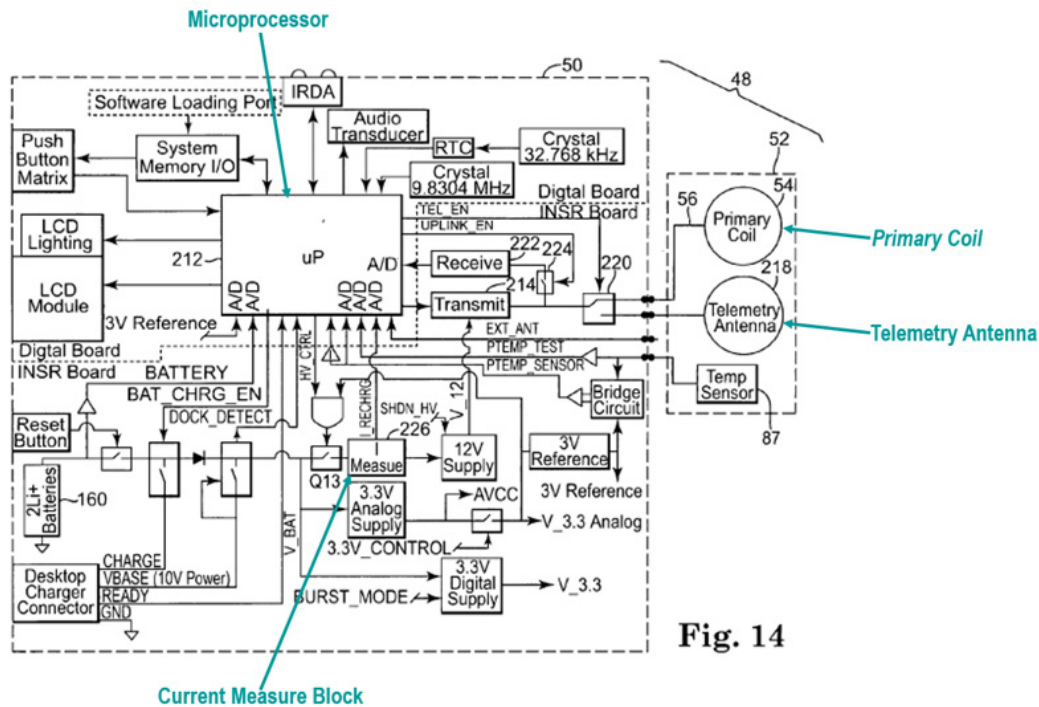


Fig. 14

EX1004, FIG. 14 (annotated), [0072], [0074]-[0078]. The “[c]urrent measured by current measure block 226 is used in the calculation of power,” which as depicted in FIG. 14, measures the “power in” provided to transmit block 214/primary coil 54 and communicates this “power in” measure to the microprocessor 212. EX1004, [0074]-[0075] (“by the current driving external antenna 52”), FIG. 14. From there, this **“power in” measure** is “used in the calculation of efficiency of power transfer and/or charging efficiency.” EX1004 [0074]. The charging device 48 also includes a “telemetry antenna 218.” *Id.*, [0072]. The charging device receives “by telemetry” (e.g., the telemetry antenna 218) the data pertaining to the “power induced in the implantable medical device 16”—a **“power out” measure** indicating the recharging power received by the secondary coil. EX1004, [0075] (“by the charging current in

the implantable medical device 16”), *see also* [0073].

38. Olson also explains that the microprocessor 212 receives data pertaining to the “power in” and “power out” measures and then calculates the efficiency of power transfer from the primary coil to the secondary coil. EX1004, [0073]-[0076], [0112] FIG. 14. In particular, Olson teaches the conventional option of using an index of power loss in the form of an **efficiency quotient**—which is described as a “calculation” where the “power out” measure is “divided by” the “power in” measure. EX1004, [0075]-[0076], [0112] (“efficiency is measured by dividing the power in, i.e., the power received by secondary coil 34, by the power out, i.e., the power transmitted by primary coil 54”). For at least these reasons, Olson teaches that which the Examiner believed to be missing from the prior art during examination of the ’461 patent. *Supra*, ¶¶30-31.

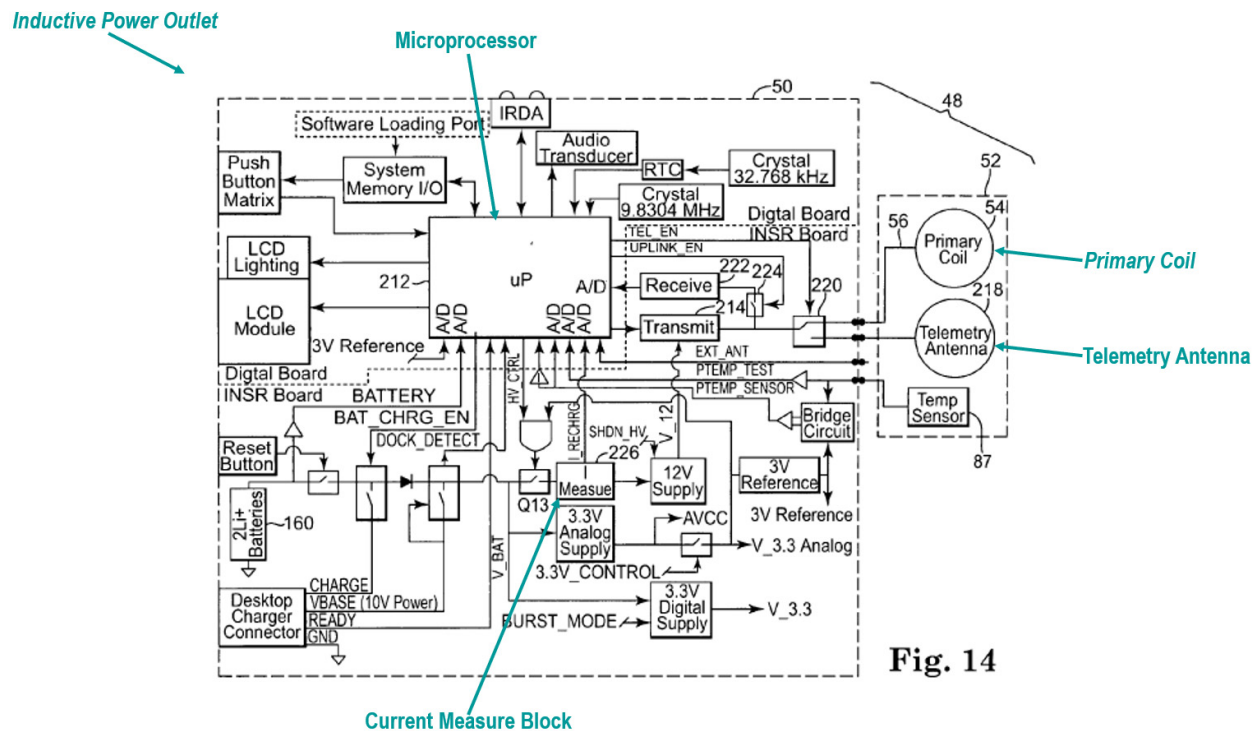
B. Application of Olson

Claim 13

Element [13.P]: An inductive power outlet comprising at least one primary coil, for inductively coupling with a secondary coil wired to an electric load, the inductive power outlet further comprising an efficiency monitor comprising:

39. Olson discloses element [13.P]. For example, Olson teaches a “charging device 48” (e.g., the claimed **inductive power outlet**) comprising a “**primary coil 54**.” EX1004, [0072], [0075], FIG. 14, *see also* [0050]-[0054], FIGS.

2-3, 13. The charging device 48 “contains the electronics necessary to drive primary coil 54 with an oscillating current in order to induce current in secondary coil 34 when primary coil 54 is placed in the proximity of secondary coil 34.” EX1004, [0054], *see also* [0072]. These structures are also shown in FIG. 14:

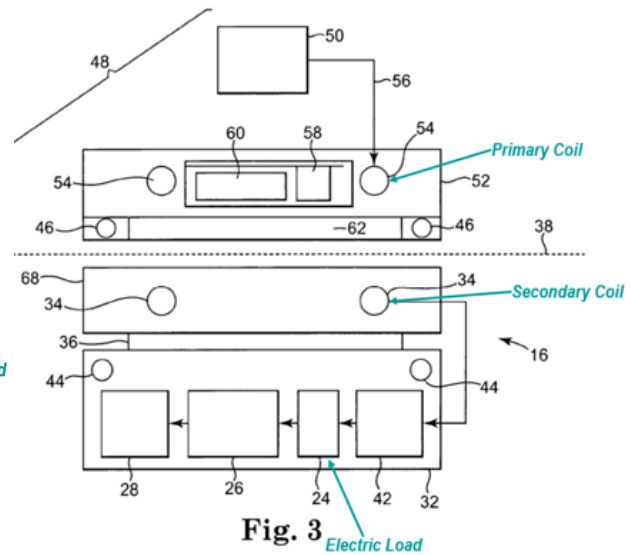
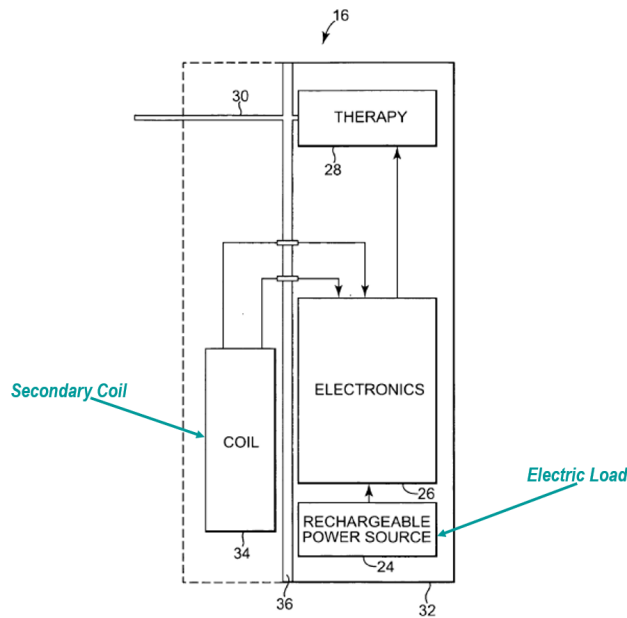


EX1004, FIG. 14 (annotated).

40. Further, Olson explains that the charging device 48 wirelessly recharges an electric device, which is an implanted medical device in Olson’s embodiments illustrated in FIGS. 2-3 (below) and which includes a “rechargeable power source 24” (e.g., the claimed electric load) wired to the “secondary charging coil 34.” EX1004, [0050]-[0054], FIGS. 2-3. The “[s]econdary charging coil 34 is

operatively coupled through electronics 26 to rechargeable power source 24.”

EX1004, [0050], [0054], [0075], FIGS. 2-3.



EX1004, FIGS. 2-3 (annotated).

41. Olson teaches that the charging device 48 includes “a microprocessor 212,” “telemetry antenna 218,” and “current measure block 226” that operates as part of the claimed **efficiency monitor**. EX1004, [0072]-[0076], FIG. 14; *see also* EX1004, [0112]. In particular, the microprocessor 212 is configured to determine an efficiency index calculation by receiving (e.g., via the “current measure block 226”) data pertaining to the “power in” at the primary coil 54 and by receiving (e.g., via the telemetry antenna 218) data pertaining to the “power out” for the amount of power induced at the secondary charging coil 34. EX1004, [0072], [0074]-[0076]. Olson explains that the microprocessor 212 uses these measured values to determine

an efficiency quotient indicative of power loss during the wireless power transfer. EX1004, [0074]-[0076] (“divided by”), [0112] (“by dividing”).

Element [13.1]: at least one input power monitor configured to measure input power received by the primary coil from the power supply;

42. Olson discloses Element [13.1]. Olson discloses the use of a current measure block 26 that, in connection with microprocessor 212, provides the claimed **input power monitor**. For example, Olson’s “[c]urrent measure block 226” measures current to the “primary coil 54” from the **power supply** 216 EX1004, [0071]-[0078]. FIG. 13, FIG. 14; *above*, Element [13.P]. Olson teaches that the “current measure block 226” measures current to “12 volt power supply 216,” which is used in the calculation of the “power in” measure. EX1004, [0074]. This is the current driving the external antenna 52, via the transmit block 214 and to the primary coil 54 (as depicted in FIG. 14 (reproduced below)). EX1004, FIG. 14, [0074]-[0075] (“by the current driving external antenna 52”), *see also* [0112] (“efficiency is measured coil-to-coil, i.e., **from primary coil 54** to secondary coil 34.”). Olson also states that the “power in” measure can be “used in the calculation of efficiency of power transfer and/or charging efficiency to determine, in part, the best location of external antenna 52 and/or rotating core cup assembly 92.” EX1004, [0074].

43. Olson’s circuit diagram in FIG. 14 also teaches that the current measure

block 226 produces a signal that is provided as input to an analogue-to-digital (“A/D”) converter of the microprocessor 212 so that the microprocessor 212 receives a value for the measured current from the power supply to drive the primary coil 54 of the external antenna 52:

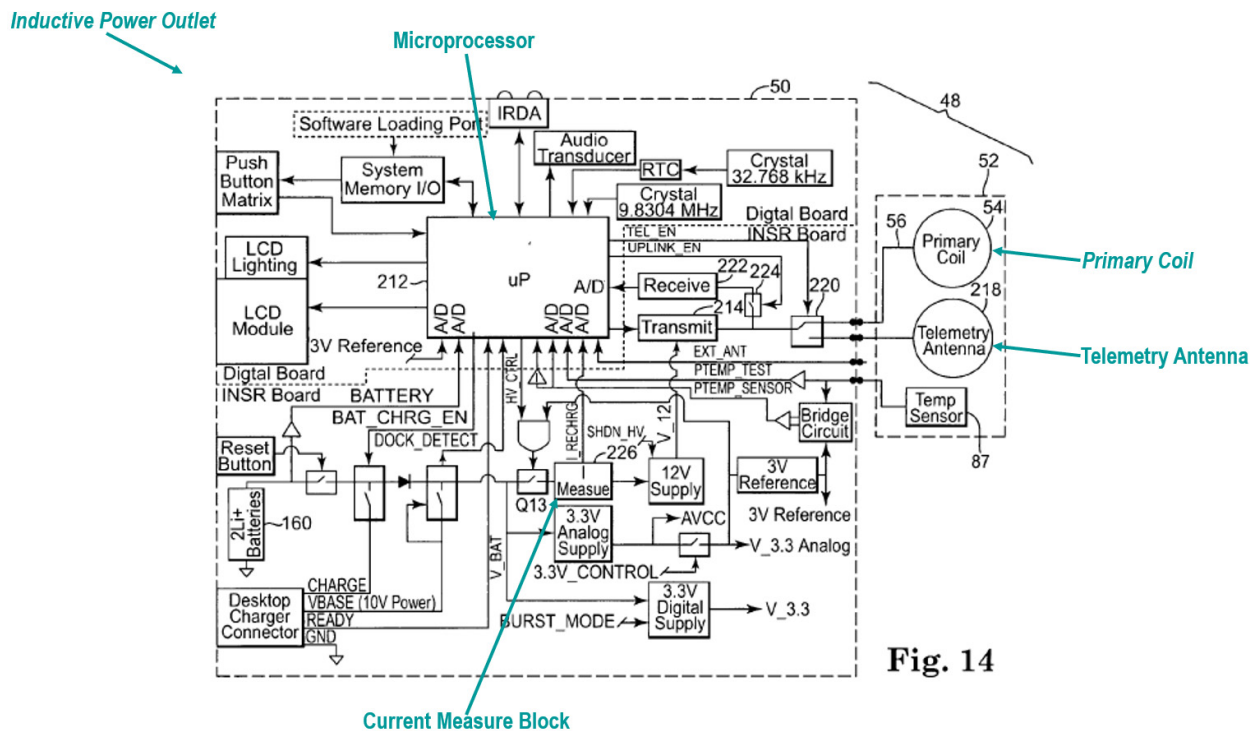


Fig. 14

EX1004, FIG. 14 (annotated), [0074].

44. Olson also explains that the microprocessor 212 receives the input voltage of the charging device 48 (e.g., from the batteries 160 and/or the desktop charging device 162). EX1004, FIG. 14. According to Olson, the microprocessor 212 can calculate the “power in” by “multiplying the internal voltage of the charging unit 50 ... by the current driving the external antenna 52 [provided to the primary coil 54].” EX1004, [0075]; *see also* EX1004, [0071]-[0078], FIGS. 13-14, 17; and

[0112] (“efficiency is measured by dividing the power in, i.e., the power received by secondary coil 34, by the power out, i.e., the power transmitted by primary coil 54. While energy efficiency can be measured at other locations in external antenna 52 and/or implantable medical device 16, for purposes of some embodiments of the present invention **it is preferred that efficiency is measured coil-to-coil, i.e., from primary coil 54 to secondary coil 34**”) (emphasis added).

Element [13.2]: at least one signal detector configured to detect signals carrying data pertaining to output power received by the secondary coil;

45. Olson discloses Element [13.2]. For example, Olson teaches a signal detector that operates like the signal detector of the '461 patent. For example, Olson describes a “telemetry antenna 218” (e.g., a **signal detector**) that is configured to detect data signals from the wireless electric device 16. EX1004, [0072]-[0075] (“by telemetry”), FIG. 14, *see also* [0052] (“to obtain information from implantable medical device 16”). As such, the microprocessor 212 receives “by telemetry” measurement data pertaining to “the power induced in implantable device 16” (e.g., via the telemetry antenna 218). EX1004, [0072], [0075], FIG. 14, *see also* EX1004 [0052].

Element [13.3]: at least one processor configured to receive data pertaining to the input power and the output power, the processor further configured to determine an index of power-loss indicative of the efficiency of an inductive coupling between the primary coil and the secondary coil;

46. Olson discloses Element [13.3]. For example, Olson describes (and illustrates) a processor and also teaches the functionality of the processor as recited in this claim element. As I previously noted, Olson describes the “microprocessor 212” (e.g., a **processor**) that receives data pertaining to the input power and the output power. EX1004, [0071]-[0078], [0112], FIG. 14. And as I explained above in Elements [13.P]-[13.1], the microprocessor 212 is configured to determine an efficiency index calculation by receiving (e.g., via the “current measure block 226”) data pertaining to the “power in” at the primary coil 54 and by receiving (e.g., via the telemetry antenna 218) data pertaining to the “power out” for the amount of power induced at the secondary charging coil 34. EX1004, [0072], [0074]-[0076]. Notably, Olson’s FIG. 14 depicts the “I_RECHRG” output from current measure block 226, which is connected to an analog-digital input (“A/D”) of the microprocessor 212, thereby providing the microprocessor with data pertaining to the “power in” measure. EX1004, [0072]-[0075] (“the current driving the external antenna”), [0112] (“efficiency is measured coil-to-coil”), FIG. 14. Also, as I described above in Element [13.2], the microprocessor 212 receives “by telemetry”

(e.g., the telemetry antenna 218 and the receive block 222) data pertaining to the “power out” measure indicative to the power induced in the implanted medical device. EX1004, [0072]-[0075] (“the charging current”), [0112] (“coil-to-coil”), FIG. 14.

47. Further, consistent with my analysis above in Elements [13.P]-[13.1], the microprocessor 212 is configured to determine “a measure of the efficiency of external charging device 48,” which is an index of power-loss indicative of the efficiency of an inductive coupling between the primary coil and the secondary coil. EX1004, [0075] (“divided by”), [0112] (“by dividing”), *see also* EX1004, [0072] (explaining that the external charging device 48 is “controlled by microprocessor 212”), FIG. 14.

Element [13.4]: wherein the index of power-loss comprises at least one of: an efficiency quotient Q , defined as the ratio of the output power to the input power; and an efficiency differential Δ , defined as the difference between the output power and the input power.

48. Olson discloses Element [13.4]. For example, Olson teaches a particular type of calculation for the index of power-loss, namely, an efficiency quotient. EX1004, [0074], [0075], [0076], and [0112]. In particular, Olson describes calculating “a ratio of power out divided by power in,” which provides the claimed **efficiency quotient** as the **index of power-loss**. EX1004, [0076], *see also*

[0074]-[0075] (“divided by”), [0112] (“efficiency is measured by dividing the power in, i.e., the power received by secondary coil 34, by the power out, i.e., the power transmitted by primary coil 54.”), *see above* Element [13.3]. And Olson also explains that this efficiency quotient can be advantageously “displayed to patient 18, or a medical professional or other person adjusting rotatable core cup assembly 92 or positioning external antenna 52,” which is consistent with Olson’s explanation that this index value is useful “to determine, in part, the “best location of external antenna 52.” EX1004, [0076], [0074], *see also* [0112] (“measured coil-to-coil”).

49. I note that Olson’s paragraphs [0074]-[0076] consistently uses the terms “power in” and “power out,” but in one subsequent paragraph (paragraph [0112]) this terminology is flipped in a self-evident (and readily noticeable) instance. The inadvertent flip of these two terms in that sentence of is readily identifiable because paragraph [0112] is still consistent with the earlier paragraphs [0074]-[0076] in that they describe the same dividend and divisor for the efficiency quotient. In particular, paragraph [0112] plainly clarifies that “the power *received by secondary coil 34*” (the “power out” measure according to paragraphs [0074]-[0076]) should be divided by “the power *transmitted by primary coil 54*” (the “power in” measure according to paragraphs [0074]-[0076]), thereby confirming that the calculation for the efficiency quotient is consistent in all of these paragraphs. Also, I note here that this conventional practice in Olson is also consistent with the

preferred embodiment of the efficiency quotient Q in the '461 patent (*supra*, ¶26).

Claim 14

Element [14]: *The inductive power outlet of claim 13 additionally comprising at least one circuit-breaker configured to disconnect the primary coil from the power supply.*

50. Olson discloses Element [14]. For example, Olson teaches two examples of a circuit breaker that is configured to disconnect the primary coil from the power supply. In a first example, Olson teaches that an “electronically controllable switch 220” serves as a circuit-breaker configured to disconnect the primary coil 54 from the 12V power supply:

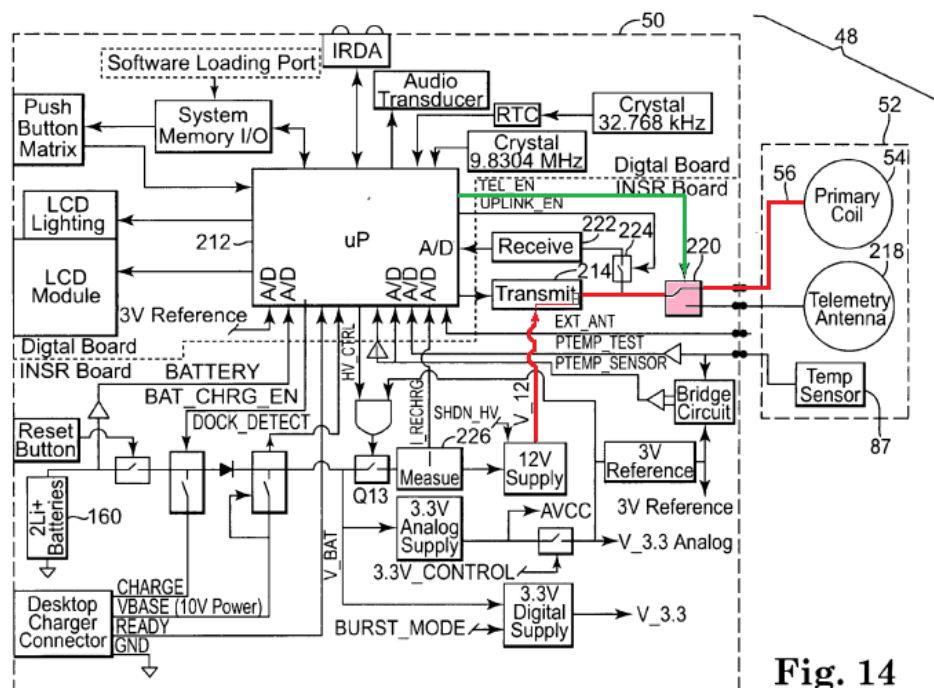


Fig. 14

EX1004, FIG. 14 (color added), [0072] (“Drive selection is done by electronically controllable switch 220”).

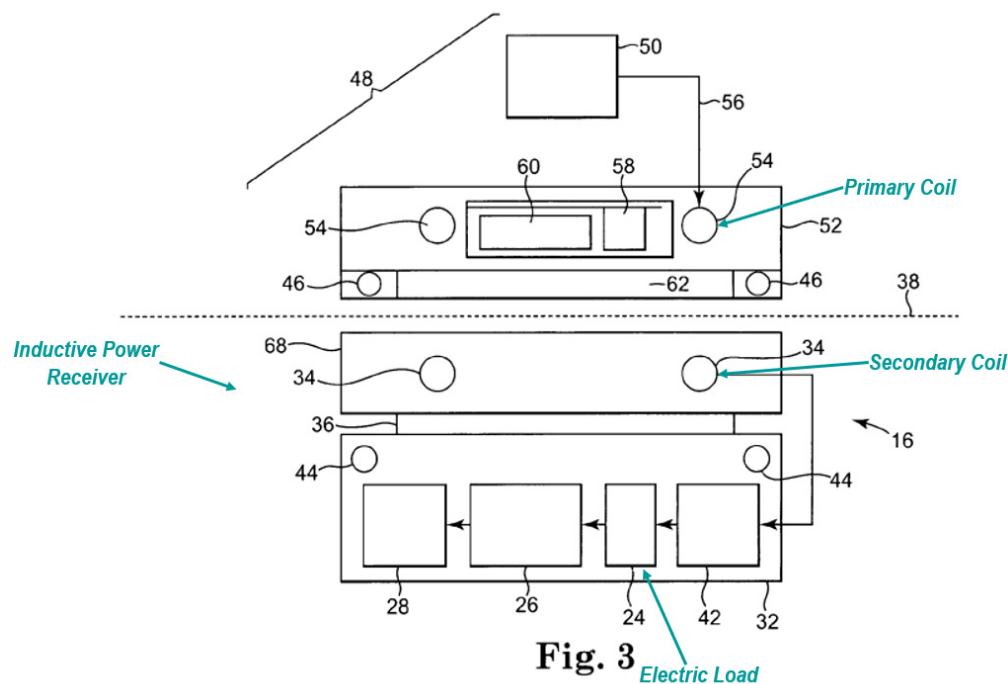
51. The microprocessor 212 provides a control signal to the switch 220, which can selectively disconnect the primary coil 54 and thereby break the connection between the power supply and the primary coil 54. EX1004, [0072]. In a second example, Olson describes control circuitry/control logic that switches off energy transfer from the primary coil 54 in the event too much heat is generated (e.g., due to inefficient power transfer). EX1004, [0085], [0105], [0110]. This disconnection of the primary coil 54 is disclosed in the context of Olson teaching that “heat may be generated” as energy is transferred from primary coil 54 to secondary coil 34. EX1004, [0105], [0110]. Olson explains that a temperature sensor 87 (feeding back a sensor signal to the microprocessor 212, as shown in FIG. 14) can trigger control circuitry to “curtail energy transfer” from the primary coil 54. EX1004, [0105], [0110] (“Control logic in charging unit 50 can then take appropriate action ... by ceasing ... further energy transfer”).

52. In each of these two examples, FIG. 14 is pertinent. In particular, a POSITA would have understood the “SHDN_HV” signal shown in FIG. 14, as teaching a mechanism to shut down the “12V supply” when it is beneficial to prevent power transfer to the primary coil. EX1004, FIG. 14.

Claim 15

Element [15.1]: An inductive power receiver comprising at least one secondary coil for inductively coupling to a primary coil and supplying power to an electric load,

53. Olson discloses Element [15.1]. For example, Olson teaches the claimed inductive power receiver, as recited in element 15, including the signal transmitter to transmit signals to the inductive power outlet of claim 13. Regarding the structure recited in Element [15.1] and as detailed in Elements [13.P]-[13.2], Olson discloses an inductive power receiver (the implantable medical device 16 in the depicted embodiments) that includes a “rechargeable power source 24” and a “secondary charging coil 34”:



EX1004, FIG. 3 (annotated), [0050], FIG. 2. Olson states that the “[s]econdary

charging coil 34 is operatively coupled through electronics 26 to rechargeable power source 24.” EX1004, [0050]-[0054], [0075], FIG. 2.

Element [15.2]: the inductive power receiver further comprising: at least one output power monitor for measuring output power received inductively by the secondary coil from the primary coil, and

54. Olson discloses Element [15.1] including the claimed output power monitor. As I have described in Elements [13.P] and [13.4], Olson discloses that “efficiency is measured coil-to-coil, i.e., from the primary coil 54 to the secondary coil 34”—and in particular “by dividing the power in, i.e., **the power received by secondary coil 34**, by the power out, i.e., the power transmitted by primary coil 54.” EX1004, [0112]. Accordingly, Olson describes that an output power monitor at implantable medical device 16 measures both “the charging current” induced at the secondary coil and “the voltage of the rechargeable power source 24,” that are multiplied to provide a measurement of power at the secondary coil. EX1004, [0075] (“by multiplying the voltage of rechargeable power source 24 by the charging current in implantable medical device 16”), *see also* [0112]. This measurement information would be provided at the “powering electronics 26,” to control “the charging rate of the rechargeable power source 24”—or, optionally, a separate “charging regulation module 42” shown in FIG. 3—and then a “telemetry coil 44” would communicate this “information from implantable medical device 16.” *See*

EX1004, [0050]-[0054], FIGS. 2-3. Olson teaches communicating the power information to the power outlet device (charging device 48) “by telemetry” so that the microprocessor can measure the efficiency “coil-to-coil, i.e., from the primary coil 54 to the secondary coil 34.” EX1004, [0075], [0112].

Element [15.3]: at least one signal transmitter configured to transmit signals carrying data pertaining to the output power to the inductive power outlet of claim 13.

55. Olson discloses Element [15.3] including the claimed signal transmitter. For example, as discussed above in Element [15.2], Olson teaches an inductive power receiver implemented within the “implantable medical device 16” that includes an “internal telemetry coil 44 configured in conventional manner to communicate [with]... charging unit 50.” EX1004, [0052], FIG. 3. Olson teaches the implantable medical device as providing the measured power information to the charging device “by telemetry.” EX1004, [0075].

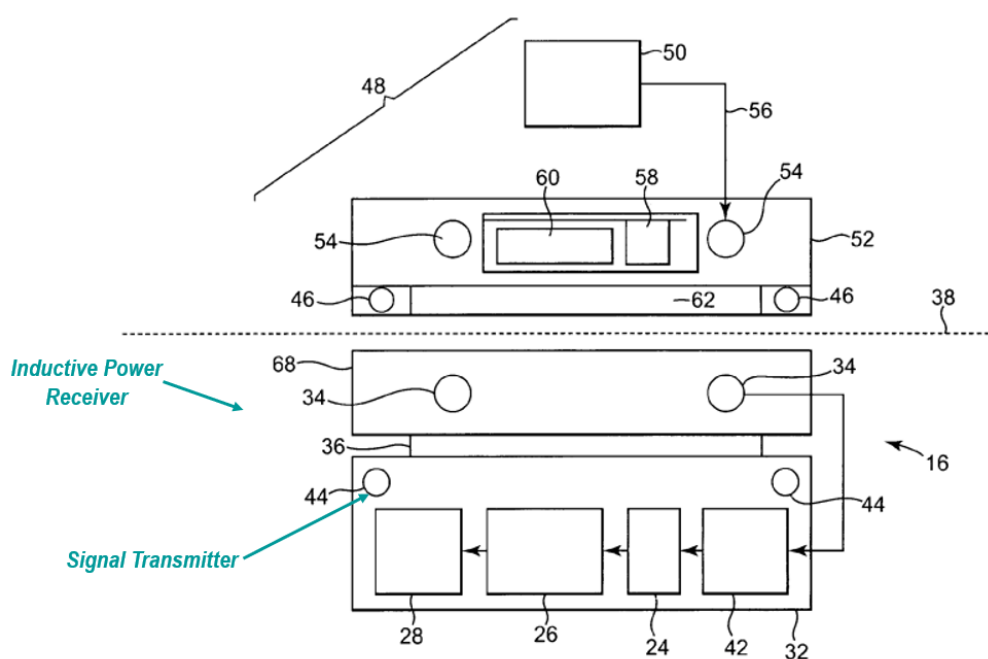


Fig. 3

EX1004, FIG. 3 (annotated).

Claim 16

Element [16]: *The inductive power receiver of claim 15 wherein the signal transmitter is selected from a group consisting of: light emitting diodes, radio transmitters, optocouplers, and transmitter circuits.*

56. Olson discloses Element [16] including the claimed signal transmitter as recited in claim 16. For example, Olson's implantable medical device includes an "internal telemetry coil 44 configured in conventional manner to communicate through external telemetry coil 46 to ... charging unit 50." EX1004, [0052], [0075]. A POSITA would have recognized Olson's internal telemetry coil 44 to be both a radio transmitter and a component of a transmitter circuit.

Claim 18

Element [18]: *The inductive power receiver of claim 15 wherein the output power monitor is incorporated into an electric device.*

57. Olson discloses Element [18]. As I describe in Elements [13.P] and [15.1]-[15.2], Olson's implantable medical device 16 is an "electronic device" that incorporates the output power monitor. EX1004, [0052], [0075], FIGS. 2-3; *above*, Elements [13.P] and [15.1]-[15.2].

IX. ANALYSIS – OBVIOUSNESS BASED ON OLSON AND STEVENS (GROUND 1B)

A. Stevens (EX1005)

58. Stevens describes an inductive power transfer system. EX1005, 1:3-4, 17:7-15; 38:5-39:35- FIGS. 1, 4, 12. The system includes “a primary unit 10” that has a “primary coil 12” and a “secondary device 30” that has a “secondary coil 30” wired to an “actual load”:

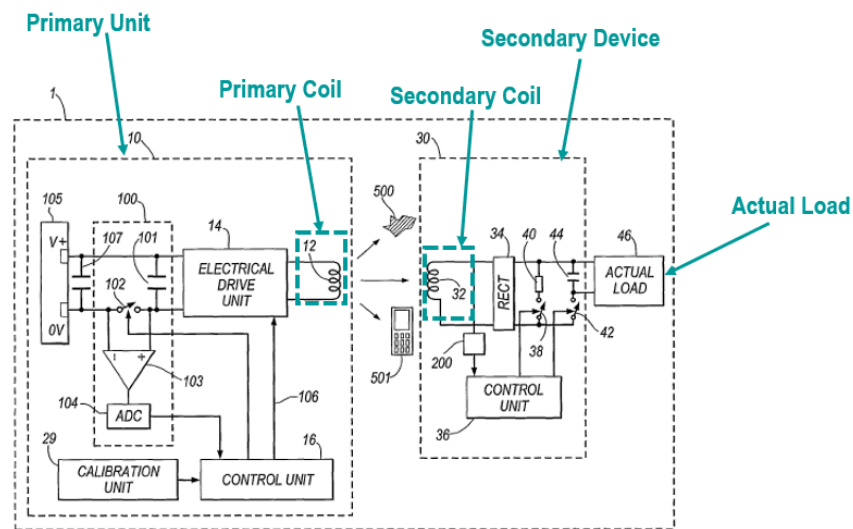


Fig.4

EX1005, FIG. 4 (annotated), 17:7-26, 21:17-35; 23:31-33; 38:5-23.

59. The primary unit 10 includes an “electrical drive unit 14” that is connected to a “power supply 105,” via a “power measurement unit 100.” EX1005, 21:16-27. The electrical drive unit “takes the AC voltage signal 106 and converts it to an AC current signal in the primary coil 12, so as to generate an induced electromagnetic field in the proximity of the 15 primary coil 12.” EX1005, 17:7-15. The “secondary coil 30” couples with “the electromagnetic field generated by the primary unit 10 when the secondary device 30 is in proximity to the primary unit 10” to inductively transfer power from the primary unit 10 to the secondary device 30. EX1005, 17:22-26.

60. The primary unit further includes the control unit 16/720 and a power measurement unit 100/730. EX1005, 21:22-23, FIG. 1, FIG. 12. The power measurement unit “provides an output representative of the electrical power drawn by the electrical drive unit 14 to the control unit 16.” EX1005, 18:7-9. “The power drawn by the electrical drive unit 14 is representative of the power drawn by the primary coil 12.” EX1005, 18:9-10.

61. Stevens describes using “any suitable communication link” to permit the secondary device to communicate its power requirement information to the primary unit. *See* EX1005, 38:25-26 and 39:24-35, FIG. 12 and FIG. 4 (reference numbers 40 and 38). In some examples Stevens teaches that the secondary device

“may transmit its power requirement information to the primary unit by varying a load imposed by the secondary device on the primary unit.” EX1005, 5:23-28.

62. The control unit receives both the power drawn by the driving circuit and the power requirement information of the secondary device. EX1005, 18:7-9, FIG. 4, FIG. 12. The control unit determines, “if the measured power from the power measurement unit 730 exceeds the sum of the load measures from the secondary devices by more than a shutdown threshold then the control unit 720 concludes that a substantial parasitic load must be present and places the primary unit in the shutdown mode.” EX1005, 38:34-39:6. Stevens plainly suggests that the control unit 720 should determine **an index of power-loss** (an efficiency differential in this example) for purposes of comparing to Steven’s shutdown threshold value. EX1005, 38:34-39:6. For example, in the implementation in which there is one secondary device (600₁), Stevens would determine a difference between the power received by the secondary device 600₁ and the power transmitted by the primary unit 700 (an efficiency differential Δ), which is then compared to Steven’s threshold value to identify when the primary unit 700 should be shut down. EX1005, 38:34-39:6.

63. I was informed that this pertinent portion of Stevens (pp. 38-39, suggesting the use of an efficiency differential), specifically the corresponding sections in the counterpart U.S. Pat. 7,605,496 cited during prosecution of the ’461

patent, was never acknowledged by the examiner nor the applicant at the time. *See, e.g.,* EX1002, 202 and 223 (referring to columns 12-13 of US7,605,496 rather than columns 25-26). Regardless, the Stevens reference here is employed *in combination with Olson* (Ground 2) or *in combination with Jin* (Ground 3). *Below*, Sections X-XI.

B. Predictable Combination of Olson and Stevens

64. Based upon my knowledge and experience in the field of the ‘461 patent and my review of Olson and Stevens, a POSITA would have been motivated to implement Olson’s charging unit (e.g., charging unit 50) according to Stevens’ suggestion for communicating power information to the primary unit by varying the imposed load using a dummy load, thereby modulating a bit-rate signal, to achieve known benefits at the time. As I described above in my analysis of Ground 1A, Olson discloses all elements of independent claim 13. To the extent Olson does not expressly disclose the elements of dependent claim 17, such features were commonly implemented in similar wireless charging systems to provide known benefits—as demonstrated by the Stevens reference.

65. Stevens and Olson are similar to one another. For example, both illustrate concepts related to power outlet devices having a “primary coil” for inductively coupling with a “secondary coil” of a wireless electric device for recharging a battery. EX1005, 17:7-18:28, 21:13-24:16, 38:5-39:35, 33:1934:15,

FIGS. 1, 4, 9 and 12; EX1004, [0050]-[0054], [0072]-[0078], FIGS. 2-3 and 14. Stevens provides additional details regarding a number of conventional options used in such wireless charging devices. Stevens provides details regarding such a conventional transmitter for an inductive power receiver, and also teaches that “each secondary device could vary the load it imposes on the primary unit to communicate the power requirement information.” EX1005, 39:27-35. Stevens teaches the conventional practice of the secondary device using “a dummy load” (e.g., an ancillary load) representing the amount of power required by its actual load, and Stevens teaches dynamically altering the load to provide information of the secondary device to the primary unit including using a number of “bits.” EX1005, 30:34-31:6.

66. There are several rationales that would have prompted a POSITA to implement Olson’s charging unit (e.g., charging unit 50) with Stevens’ suggestion for communicating power information to the primary unit by varying the imposed load using a dummy load, thereby modulating a bit-rate signal, to achieve known benefits. For example, these reasons would have led a POSITA to use Stevens’ load-modulation scheme in lieu of Olson’s telemetry-based communication to achieve known benefits for various predictable designs.

67. As a first reason, a POSITA would have been motivated to implement communication according to Stevens’ suggested load modulation scheme to reduce

the size and complexity of Olson's charging devices. Olson's original communication technique relies on an "[i]nternal telemetry coil 44" that has "a larger diameter than secondary coil 34" so as not to be "completely covered by magnetic shield 36." EX1004, [0053], FIG. 3. In contrast, in Stevens' load-modulation scheme the secondary coil 34 itself would be predictably used to signal load variations to the charger device 48 via primary coil 54. This is beneficial in eliminating the need for the large internal telemetry coil 44 separate from the secondary coil 34 itself. *Id.* In fact, implementing the teachings of Stevens with Olson's system would advantageously permit Olson's implanted device to use Olson's existing secondary coil to transmit power information back to the charging device (without requiring the separate telemetry coil). This advantageously provides a more compact device with fewer communication coils. A smaller device also allows for easier alignment, especially in transcutaneous applications. Removing the telemetry antenna could also provide space for multiple Tx/Rx coils to provide multi-source and/or multi Rx parallel charging system.

68. As a second reason, a POSITA would have been motivated to implement communication according to Stevens' suggested load modulation scheme to reduce component costs. Windings and coils were relatively expensive electronic circuit components. Stevens' suggested use of the secondary coil itself for load modulation and communication of power information would yield cost savings by

not requiring a separate telemetry coil.

69. As a third reason, Stevens expressly suggests a known technique to address a conventional problem of communicating information (e.g., power information) from a secondary unit to a primary unit of a wireless charging system similar to Olson's. The Olson-Stevens combination simply involves applying a known technique (e.g., Stevens' suggested load-modulation scheme) to address this known problem using the prior art elements of Olson and Stevens according to their established functions.

70. Based upon my knowledge and experience in this field and my review of the straightforward teachings of Olson and Stevens, a POSITA would have possessed the level of skill necessary to implement this combination and would have had a reasonable expectation of success doing so, especially given the similar technologies at issue in each of Olson and Stevens. Olson and Stevens are both directed to wireless charging systems whose designs were concerned with power transfer efficiency and the communication of power information from a secondary unit to a primary unit.

C. Application of the Predictable Olson-Stevens Combination

Claim 17

Element [17.1]: The inductive power receiver of claim 15 wherein the transmitter comprises: an ancillary load selectively connectable to the secondary inductive coil, a modulator for modulating a bit-rate signal with an input signal to create a modulated signal, and

71. The Olson-Stevens combination provides Element [17.1]. Stevens discloses an inductive power receiver (the secondary device 30) that includes a “secondary coil 32, a dummy load switch 38”, and “a dummy load 40” (e.g., ancillary load):

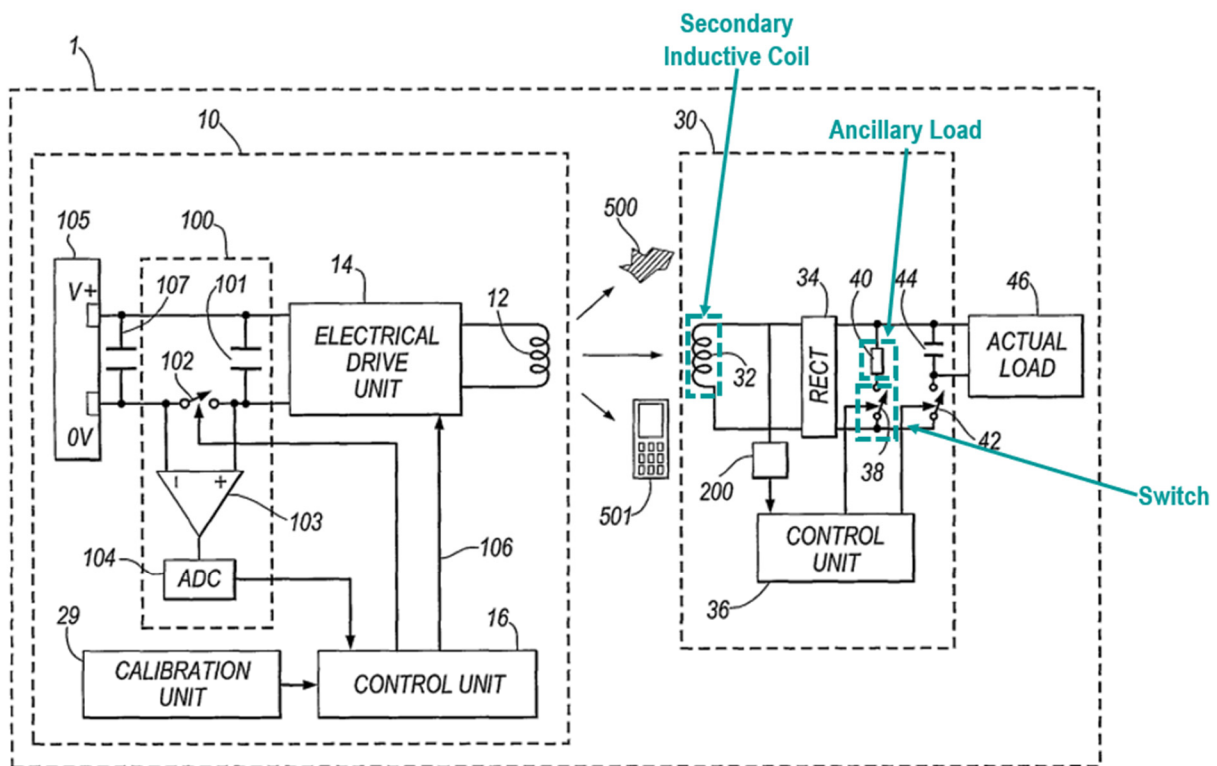


Fig.4

EX1005, FIG. 4 (annotated), 23:31-24:2. The dummy load 40 is selectively connectable to the secondary coil 32 using the dummy load switch 38. *See* EX1005, FIG. 4, 23:31-24:2, 30:13–22.

72. Stevens teaches that a “way of dynamically changing the load is to modulate switch 40” to provide “information about the load requirements and parasitic information of the secondary device 30.” EX1005, 30:13-31:6. This information can include “information about the serial number, model number, power requirements or other information stored in the secondary device” by dynamically altering either “synchronously or asynchronously” and “a number of ‘bits’ ... may be used.” EX1005, 31:1-6. Stevens also teaches that “each secondary device could vary the load it imposes on the primary unit to communicate the power requirement information.” EX1005, 39:27-35; *see also* 5:23-28, 6:1-18, 19:13-20, 30:13-22, 30:34-31:6, 32:1-10, 33:10-17. For each of the reasons I discussed above in the overview of the Olson-Stevens combination, it would have been obvious to implement in Olson’s electric device using Stevens’ load modulation transmitter that includes a modulator for modulating a bit-rate signal with an input signal to create a modulated signal in order to communicate power requirement information to the primary device using “bits.” *See* EX1005, FIG. 4, 5:23-28, 6:1-18, 19:13-22-20, 23:31-24:2, 30:13-31:6, 32:1-10, 39:27-35.

Element [17.2]: *a switch for intermittently connecting the ancillary load to the secondary inductive coil according to the modulated signal.*

73. The Olson-Stevens combination provides Element [17.2]. Stevens teaches a dummy load switch 38 that is provided to selectively connect the dummy load 40 to the secondary coil 32:

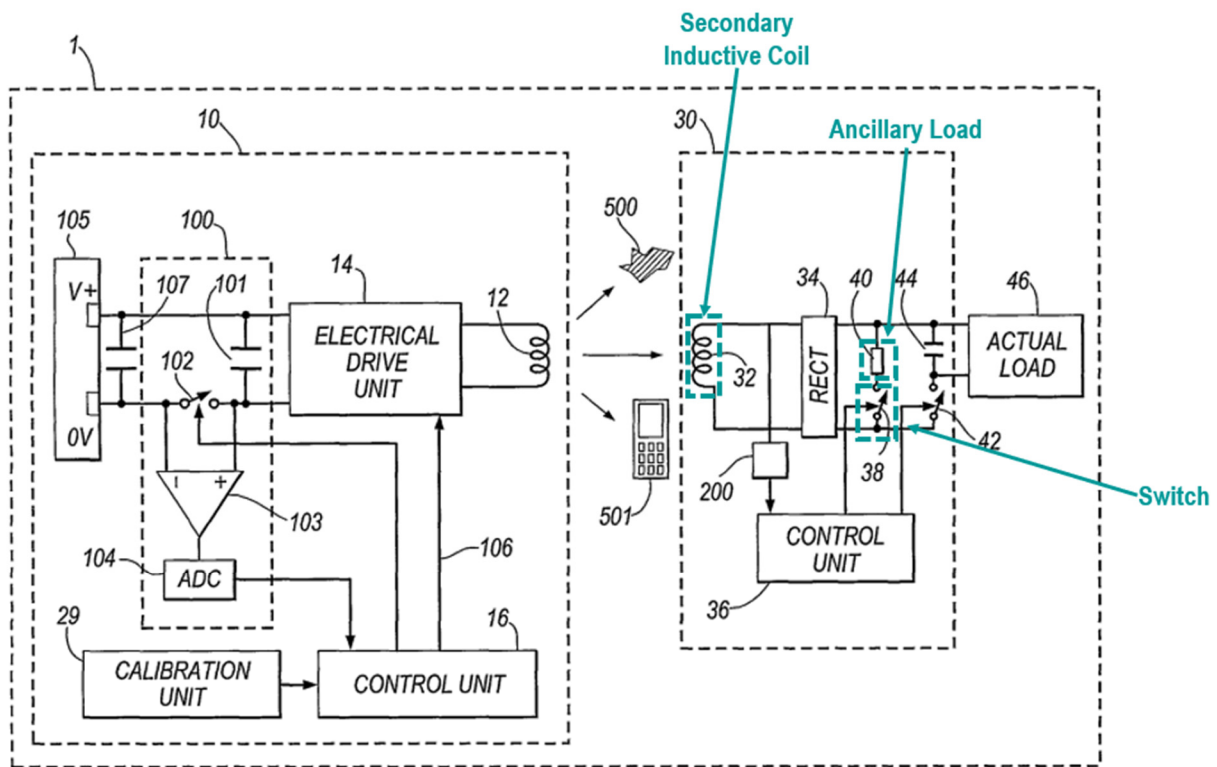


Fig.4

EX1005, FIG. 4, 23:31-24:2, 30:13-22, above Element [17.1].

74. As I discussed in element [17.1], Stevens describes a “way of dynamically changing the load is to modulate switch 40” to provide “information about the load requirements and parasitic information of the secondary device 30.”

EX1005, 30:13-31:6, *above* Element [17.1]. For each of the reasons I discussed above in the overview of the Olson-Stevens combination, it would have been obvious to implement, in Olson's electric device, Stevens' suggestions of a dummy load switch to intermittently connect a dummy load to the secondary coil according to the modulated signal to transmit information to the primary device using load modulation. *See* EX1005, FIG. 4, 5:23-28, 6:1-18, 19:13-20, 23:31-24:2, 30:13-31:6, 32:1-10, 39:27-35.

**X. ANALYSIS – OBVIOUSNESS BASED ON STEVENS AND OLSON
(GROUND 2)**

A. Predictable Combination of Stevens and Olson

75. Based upon my knowledge and experience in the field of the '461 patent and my review of Stevens and Olson, a POSITA would have been motivated to implement Stevens' inductive power transfer system according to Olson's suggestion for calculating a power transfer efficiency ratio, to achieve known benefits at the time. While Stevens suggests an index of power-loss (*see above*, Section IX.A and EX1005, 38:34-39:6), Olson expressly discloses more details for the conventional practice of calculating an index of power-loss according to an advantageous efficiency quotient. EX1004, [0072]-[0078], [0112]. As I noted above (Section VIII.A), Olson describes calculating "a ratio of power out divided by power in." EX1004, [0074], [0075], [0076], and [0112] ("efficiency is measured

coil-to-coil”).

76. There are several rationales that would have prompted a POSITA to implement Olson’s suggestion (calculating a power transfer efficiency ratio) in Stevens’ system to achieve known benefits. .

77. As a first reason, a POSITA would have been motivated to implement Olson’s suggestion (determining the index of power-loss using an efficiency quotient, as described above) in Stevens’ system because Olson’s efficiency measure (“[t]he ratio of power out divided by power in”) advantageously “works not only at high charging or power transfer levels but also at reduced charging levels, as for example, when charging at reduced levels toward the end or beginning of a charging cycle.” EX1004 [0076]-[0077]. A POSITA would have readily recognized that using this efficiency measure provides a similar benefit to Stevens’ system, which would also seek to monitor the efficiency even when charging at reduced levels toward the end or beginning of a cycle.

78. As a second reason, a POSITA would have been motivated to implement Olson’s suggestion for determining the index of power-loss using an efficiency quotient in Stevens’ system because Olson expressly suggests it was “an important measure of effectiveness,” especially where the efficiency is measured “coil-to-coil.” EX1004, [0111]-[0112]. Based on my review, a POSITA would have recognized practical, real life benefits from Olson’s suggestion to maximize energy

transfer efficiency in this manner, such as advantageously improving charging times and reducing overall heat generation. EX1004 [0017].

79. As a third reason, a POSITA would have been motivated to modify Stevens' system to include Olson's suggestion (determining an index of power loss between a primary and secondary coil that includes a ratio of the output power and input power) for purposes of improved detection of a parasitic load, especially in instances where the magnitude of the power transferred is relatively low, by comparing this quotient value with a threshold value. EX1005, 2:8-20, 38:34-39:6. Calculating a ratio between input power (to the primary coil) and output power (received by the secondary coil(s)) can be advantageous over merely calculating the difference between the two powers. In some cases, the overall power level transmitted to the secondary coil(s) could be low, even though a parasitic load was present. For example, suppose the transmitter is capable of delivering 10 Watts to desired loads, and has a threshold set to detect if 2 Watts or more (20% of the max) are being absorbed by a parasitic load. Suppose the transmitter is only transmitting 1 Watt to the desired loads, because they are nearly fully charged already. The same parasitic load brought into the same proximity to the system would only absorb 0.2 Watts and would not be detected by a protection circuit that relied solely on power differences. However, a circuit that measured transfer efficiency would detect the presence of a parasitic load that was consuming 20% of the transmitted power. To

the extent that it is important to prevent parasitic loads from receiving power, the ratio-based measurement would be more effective than the difference-based measurement in identifying a parasitic load in such cases.

80. Based upon my knowledge and experience in this field and my review of the straightforward teachings of Stevens and Olson, a POSITA would have possessed the level of skill necessary to implement this combination and would have had a reasonable expectation of success doing so, especially given the similar technologies at issue in each of Stevens and Olson. This is especially apparent considering Stevens' and Olson's related desires to use conventional indices of power loss to improve power transfer efficiency according to conventional techniques.

B. Application of the Predictable Stevens-Olson Combination

Claim 13

Element [13.P]: An inductive power outlet comprising at least one primary coil, for inductively coupling with a secondary coil wired to an electric load, the inductive power outlet further comprising an efficiency monitor comprising:

81. Stevens discloses Element [13.P]. Stevens describes a system with “a primary unit 10 and a secondary device 30”:

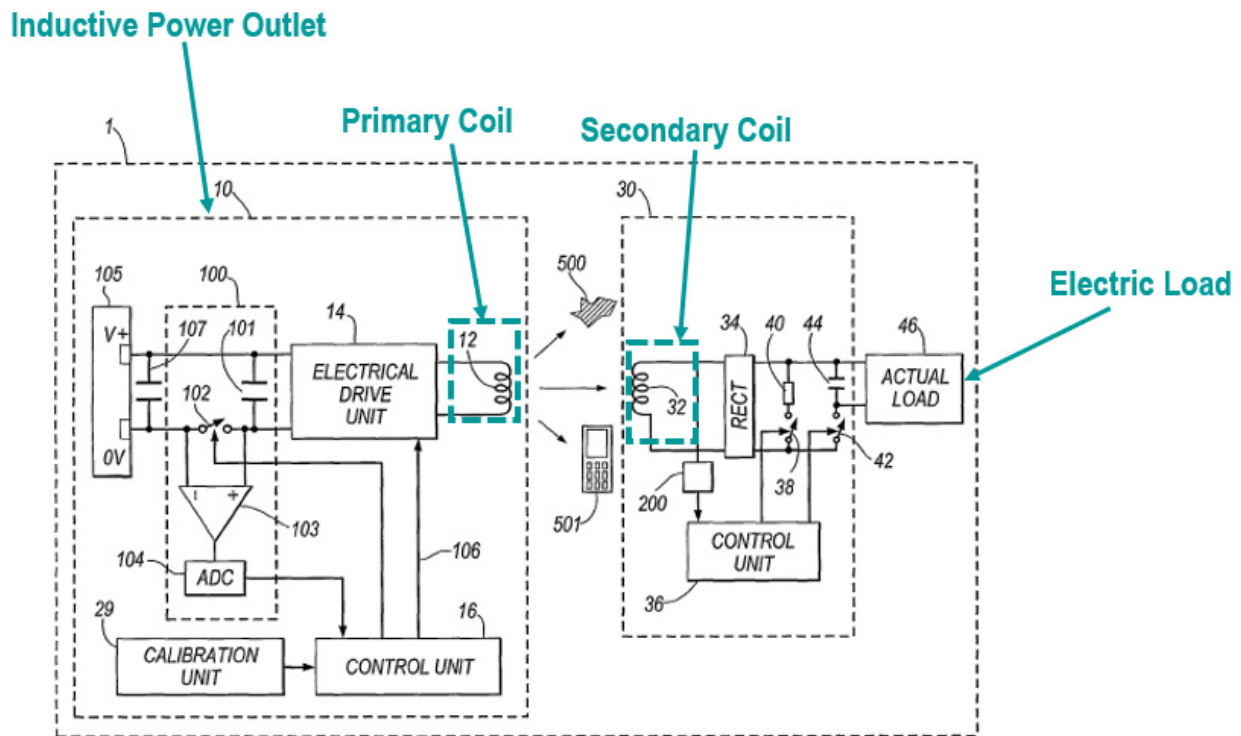


Fig.4

EX1005, FIG. 4 (annotated), 21:13-15, FIG. 4, *see also* EX1005, FIG. 1, *Abstract*, 1:10-18, 18:7-15.

82. “[T]he primary unit 10 comprises a primary coil 12, an electrical drive unit 14, a control unit 16 and a power measurement unit 100.” EX1005, 21:22-23, FIG. 4. As illustrated in FIG. 4, the secondary device includes a secondary coil. EX1005, 1:16-19, FIG. 1, *see also* EX1005, 17:7-15, FIG. 4. The primary unit drives an alternating current through the primary coil to create a time-varying magnetic flux and “[w]hen the secondary coil is placed in proximity to the time-varying flux created by the primary coil, the varying flux induces an alternating current in the secondary coil, and thus power may be transferred inductively from the primary unit

to the secondary device.” EX1005, 1:10-18, 4:27-5:3, 10:22-11:9, 17:9-26, 21:22-30, FIG. 1, FIG. 4. The secondary device includes the “secondary coil 32” of the secondary device 30 is wired to an “actual load 46” (e.g., the claimed *electric load*) *Id.*, 23:31-33, FIG. 1, FIG. 4.

83. The primary unit includes the control unit 16/720 and a power measurement unit 100/730 (e.g., collectively the claimed efficiency monitor)¹. EX1005, 18:5-11, 19:10-28, 21:22-35, 38:5-39:35, FIGs. 4,12, *see also* EX1005 4:27-5:3, 10:22-11:9, 11:29-12:4. For example Stevens states “[t]he control unit 720 corresponds generally to the control unit 16 described previously with reference to Fig. 1, and the power measurement unit 730 corresponds generally to the power measurement unit 100 described in reference to Fig. 1.” EX1005, 38:5-39:35. The power measurement unit “provides an output representative of the electrical power drawn by the electrical drive unit 14 to the control unit 16.” EX1005, 18:4-11. “The power drawn by the electrical drive unit 14 is representative of the power drawn by the primary coil 12.” EX1005, 18:9-10.

84. Stevens teaches that the operation of the primary unit 700 (having the control unit 720 and power measurement unit 730) corresponds to the earlier embodiment “in reference to Fig. 1.” EX1005, 38:9-14. Similarly, Stevens states that

the features of the secondary device 600 are the same as those of the secondary device 30 “in Figure 4.” EX1005, 38:16-23. Accordingly, the primary unit 700 and the components therein to include the features described in reference to the primary device 10 as shown in FIGs. 1 and 4.

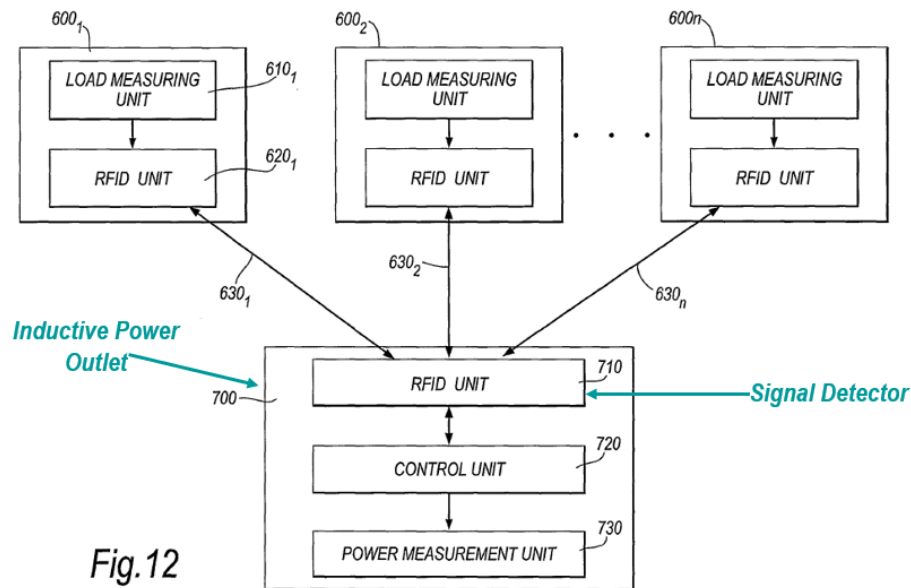
Element [13.1]: at least one input power monitor configured to measure input power received by the primary coil from the power supply;

85. Stevens discloses Element [13.1]. For example, Stevens teaches a power measurement unit 100/730. EX1005, 21:22-23, 38:34-39:6, FIG. 4, FIG. 12. The power measurement unit “provides an output representative of the electrical power drawn by the electrical drive unit 14 to the control unit 16.” EX1005, 18:7-9, *see also* EX1005, *Abstract*, 4:27-5:3. “The power drawn by the electrical drive unit 14 is representative of the power drawn by the primary coil 12.” EX1005, 18:4-11; *see also* EX1005, 22:15-23, 32:32-33:8, 38:9-14.

Element [13.2]: at least one signal detector configured to detect signals carrying data pertaining to output power received by the secondary coil;

86. Stevens discloses Element [13.2]. For example, Stevens discloses the “primary unit 700” as having “an RFID unit 710.” 38:9-14. Stevens teaches using RFID or “any suitable communication link” to permit the secondary device to communicate its power requirement information to the primary unit. *See* EX1005,

38:25-32, 39:24-35, FIGs. 4 (see reference numbers 40 and 38), 12. “The load measure produced by the load measuring unit 610 in each secondary device is supplied to the RFID unit 620 in the device and then transmitted via the relevant RFID link 630 to the RFID unit 710 in the primary unit”:



EX1005, FIG. 12 (annotated), 38:26-32.

Element [13.3]: *at least one processor configured to receive data pertaining to the input power and the output power, the processor further configured to determine an index of power-loss indicative of the efficiency of an inductive coupling between the primary coil and the secondary coil;*

87. Stevens discloses Element [13.3]. For example, as I discussed in my analysis of Element [13.2], Stevens describes using RFID or “any suitable communication link” to communicate power requirement information from the

secondary device to the primary unit. *See* EX1005, 38:25-26, 39:24-35, FIG. 12, FIG. 4. Accordingly, the control unit 16/720 receives the power drawn by the driving circuit and the power requirement information of the secondary device. EX1005, 18:7-9, 38:25-26, 39:24-35, FIG. 12, FIG. 4.

88. Stevens' control unit determines that "if the measured power from the power measurement unit 730 exceeds the sum of the load measures from the secondary devices by more than a shutdown threshold then the control unit 720 concludes that a substantial parasitic load must be present and places the primary unit in the shutdown mode." EX1005, 38:34-39:6. Accordingly, Stevens suggests that the control unit 720 would determine **an index of power-loss** to compare to Steven's shutdown threshold value. EX1005, 38:34-39:6. For example, in the implementation where there is one secondary device (600₁), Stevens determines the difference between the power received by the secondary device 600₁ and the power transmitted by the primary unit 700 (an efficiency differential Δ), which is compared to Stevens's threshold value to identify when the primary unit 700 should be shut down. EX1005, 38:34-39:6.

89. However, even if Stevens does not *explicitly* disclose the control unit being configured to determine the claimed type of "index of power-loss", this feature was commonly implemented in similar prior art systems, such as the systems disclosed in Olson. Olson describes a similar system in which the "microprocessor

212” (e.g., a **processor**) receives data pertaining to the input power and the output power. EX1004, [0071]-[0078], [0112] . FIG. 14. Olson’s microprocessor 212 is configured to determine an efficiency index calculation by receiving (by means of the “current measure block 226”) data pertaining to the “power in” at the primary coil 54 and by receiving (by means of the telemetry antenna 218) data pertaining to the “power out” for the amount of power induced at the secondary charging coil 34. EX1004, [0072], [0074]-[0076]. Indeed, Olson’s FIG. 14 illustrates the “I_RECHRG” output from current measure block 226, which is connected to an analog-digital input (“A/D”) of the microprocessor 212, to provide the microprocessor with data pertaining to the “power in” measure. EX1004, [0072]-[0075] (“the current driving the external antenna”), [0112] (“efficiency is measured coil-to-coil”), FIG. 14. The microprocessor 212 receives “by telemetry” (using the telemetry antenna 218 and the receive block 222) data pertaining to the “power out” measure indicative to the power induced in the implanted medical device. EX1004, [0072]-[0075] (“the charging current”), [0112] (“coil-to-coil”), FIG. 14. Olson also describes that the microprocessor should be configured to determine “a measure of the efficiency of external charging device 48,” which is the claimed type of **index of power-loss** indicative of the efficiency of an inductive coupling between the primary coil and the secondary coil. EX1004, [0075] (“divided by”), [0112] (“by dividing”), *see also* EX1004, [0072] (“controlled by microprocessor 212”), FIG. 14.

Element [13.4]: wherein the index of power-loss comprises at least one of: an efficiency quotient Q , defined as the ratio of the output power to the input power; and an efficiency differential Δ , defined as the difference between the output power and the input power.

90. The Stevens-Olson combination provides Element [13.4] Olson teaches calculating “a ratio of power out divided by power in” as the claimed **efficiency quotient** as the **index of power-loss**. EX1004, [0076], *see also* [0074]-[0075] (“divided by”), [0112] (“efficiency is measured by dividing the power in, i.e., the power received by secondary coil 34, by the power out, i.e., the power transmitted by primary coil 54.”, *see above*, Element [13.3] and ¶49. Olson also teaches that this efficiency quotient advantageously “works not only at high charging or power transfer levels but also at reduced charging levels, as for example, when charging at reduced levels toward the end or beginning of a charging cycle.” EX1004 [0076]-[0077]. Olson teaches the efficiency quotient can be advantageously “scale displayed” to a user, which can be useful for repositioning the relative location of the primary/secondary devices. EX1004, [0076], [0074], *see also* [0112] (“measured coil-to-coil”).

Claim 14

Element [14]: The inductive power outlet of claim 13 additionally comprising at least one circuit-breaker configured to disconnect the primary coil from the power supply.

91. Stevens discloses Element [14]. Stevens teaches restricting or stopping the inductive power transfer from the primary unit. EX1005, 38:34-39:6. Stevens also illustrates in FIG. 9, an electrical drive unit 114 with a first switch 120 connected between a first power supply line of the primary unit (a positive DC voltage) and an output node of the electrical drive unit and a second switch 121 connected between the output node and the return power supply line (i.e., ground) of the primary unit. While primary unit 110 is in normal operation, switches 120 and 121 operate to generate an oscillating voltage to drive the primary inductor 112. However, under software control, switches 120 and 121 act as a **circuit breaker**. EX1005, 33:23-28, *see also* EX1005, 2:18-20, 18:16-19 (describing “a shutdown mode in which the drive to the primary coil 12 is reduced or stopped, preventing heating of the parasitic load.”), 19:11-13, 19:30-32, 37:24-26, FIGs. 2-3, 8, 11.

Claim 15

Element [15.1]: An inductive power receiver comprising at least one secondary coil for inductively coupling to a primary coil and supplying power to an electric load,

92. Stevens discloses Element [15.1]. Stevens teaches a secondary device

comprising “a secondary coil 32” for supplying power to “a storage unit 44” (e.g., an electric load):

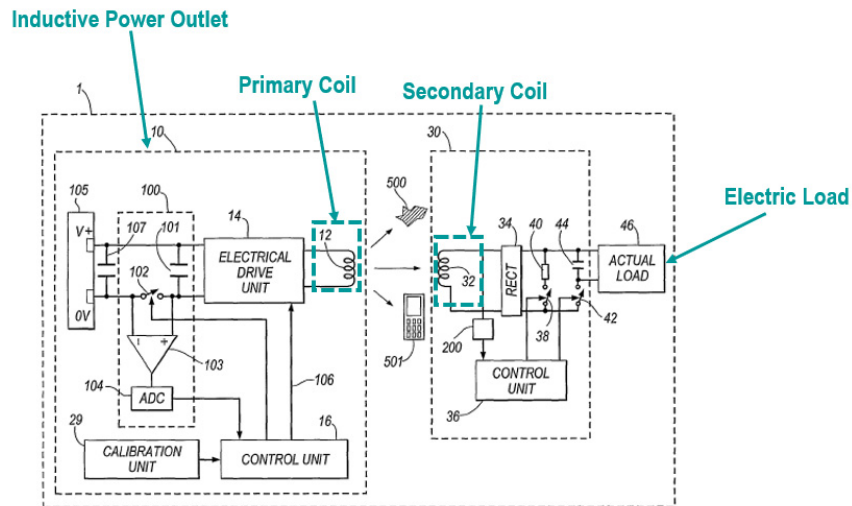
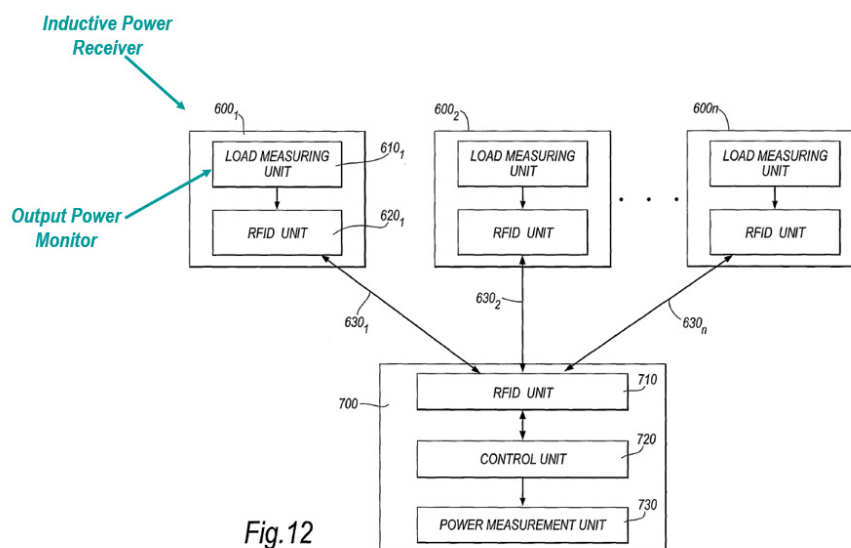


Fig.4

EX1005, FIG. 4, 23:31-33, 17:22-26, 23:31-24:2, FIG. 4.

Element [15.2]: *the inductive power receiver further comprising: at least one output power monitor for measuring output power received inductively by the secondary coil from the primary coil, and*

93. Stevens discloses Element [15.2]. Stevens teaches the secondary device including a “load measuring unit 610”:



EX1005, FIG. 12 (annotated), 38:16-19 (“generally the same as those of the secondary device 30 in Figure 4”).

94. The load measuring unit 610 measures power being supplied to the actual load of the secondary device. EX1005, 38:19-20, FIG. 12. Based on my review of Stevens' teachings, POSITA would have recognized that the power being supplied to the actual load corresponded to the power received by the secondary coil. *See* EX1005, 38:18-20, FIG. 4).

Element [15.3]: at least one signal transmitter configured to transmit signals carrying data pertaining to the output power to the inductive power outlet of claim 13.

95. Stevens discloses Element [15.3]. For example, Stevens teaches the secondary device including an “RFID unit 620”:

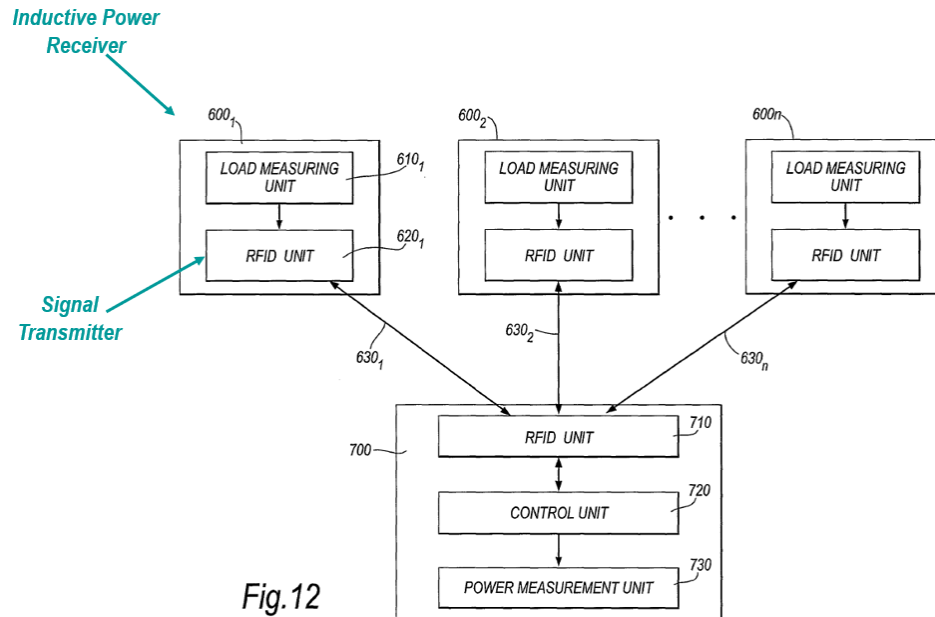


Fig.12

EX1005, 38:18-19, FIG. 12.

96. “The load measure produced by the load measuring unit 610 in each secondary device is supplied to the RFID unit 620 in the device and then transmitted via the relevant RFID link 630 to the RFID unit 710 in the primary unit.” EX1005, 38:26-29. Stevens describes using “any suitable communication link” to permit the secondary device to communicate its power requirement information to the primary unit as an alternative to using an RFID link. *See* EX1005, 38:25-26, 39:24-35. For example, the secondary device “may transmit its power requirement information to the primary unit by varying a load imposed by the secondary device on the primary unit.” EX1005, 5:23-28, 38:25-26, 39:24-35, FIG. 12, FIG. 4.

Claim 16

Element [16]: The inductive power receiver of claim 15 wherein the signal transmitter is selected from a group consisting of: light emitting diodes, radio transmitters, optocouplers, and transmitter circuits.

97. Stevens discloses Element [16]. Stevens teaches “an RFID unit 620” as a **radio transmitter**. EX1005, 38:25-26; 5:25-26, 12:2-4, 38:5-32, FIG. 12. Stevens also teaches other examples of transmitter circuits. EX1005, 5:23-28 (“Alternatively, the ... secondary device may transmit its power requirement information to the primary unit by varying a load imposed by the secondary device on the primary unit.”), 15:1-3 (“Any communication method can be used, and the method is not limited to load variation. For example, infrared or ultrasonic communication can be used. RFID can also be used.”), 39:24-35.

Claim 17

Element [17.1]: The inductive power receiver of claim 15 wherein the transmitter comprises: an ancillary load selectively connectable to the secondary inductive coil, a modulator for modulating a bit-rate signal with an input signal to create a modulated signal, and

98. Stevens discloses Element [17.1]. For example, Stevens describes an inductive power receiver (the secondary device 30) that includes a “secondary coil 32, a dummy load switch 38”, and “a dummy load 40” (e.g., **ancillary load**):

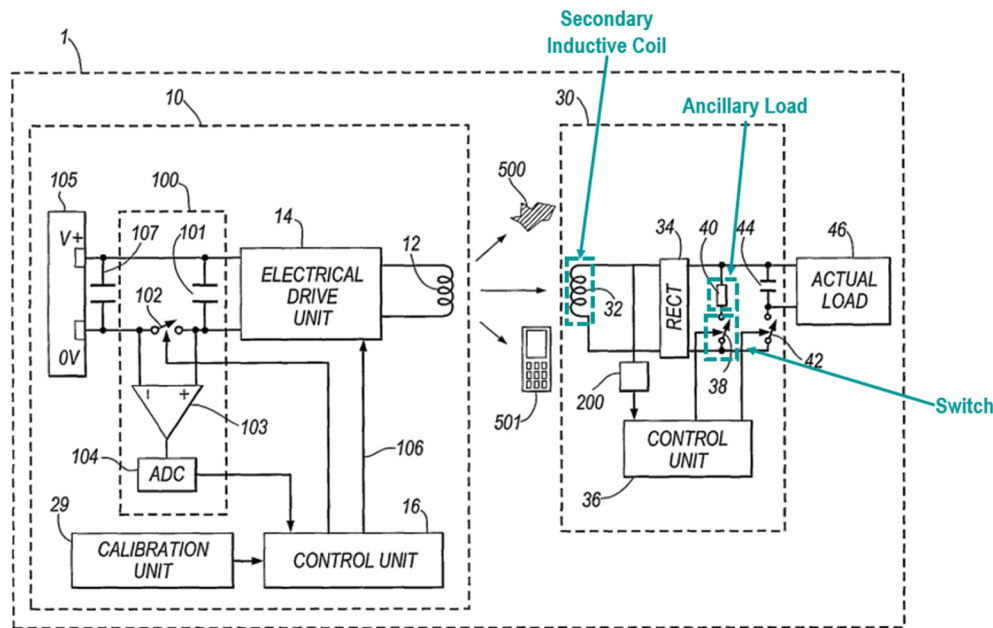


Fig.4

EX1005, FIG. 4 (annotated), 23:31-24:2. The dummy load 40 is selectively connectable to the secondary coil 32 using the dummy load switch 38. *See* EX1005, FIG. 4, 23:31-24:2, 30:13–22.

99. Stevens describes that a “way of dynamically changing the load is to modulate switch [38]” to provide “information about the load requirements and parasitic information of the secondary device 30.” EX1005, 30:13-31:6 (note there is a typo on line 39:20 labeling the switch “40” instead of “38”, *see* FIG. 4); *see also* 39:24-35 (“any suitable communication link”). This information can include “information about the serial number, model number, power requirements or other information stored in the secondary device” by dynamically altering either “synchronously or asynchronously” and “a number of ‘bits’ ... may be used.”

EX1005, 31:1-6. Stevens also states that “each secondary device could vary the load it imposes on the primary unit to communicate the power requirement information.”

EX1005, 39:27-35; *see also* 5:23-28, 6:1-18, 19:13-20, 30:13-22, 30:34-31:6, 32:1-10, 33:10-17. Based on my review, Stevens’ load modulation transmitter would include a modulator for modulating a bit-rate signal with an input signal to create a modulated signal in order to communicate power requirement information to the primary device using “bits.” *See* EX1005, FIG. 4, 5:23-28, 6:1-18, 19:13-20, 23:31-24:2, 30:13-31:6, 32:1-10, 39:27-35.

Element [17.2]: a switch for intermittently connecting the ancillary load to the secondary inductive coil according to the modulated signal.

100. Stevens discloses Element [17.2]. For example, Stevens discloses a dummy load switch 38 provided to selectively connect the dummy load 40 to the secondary coil 32:

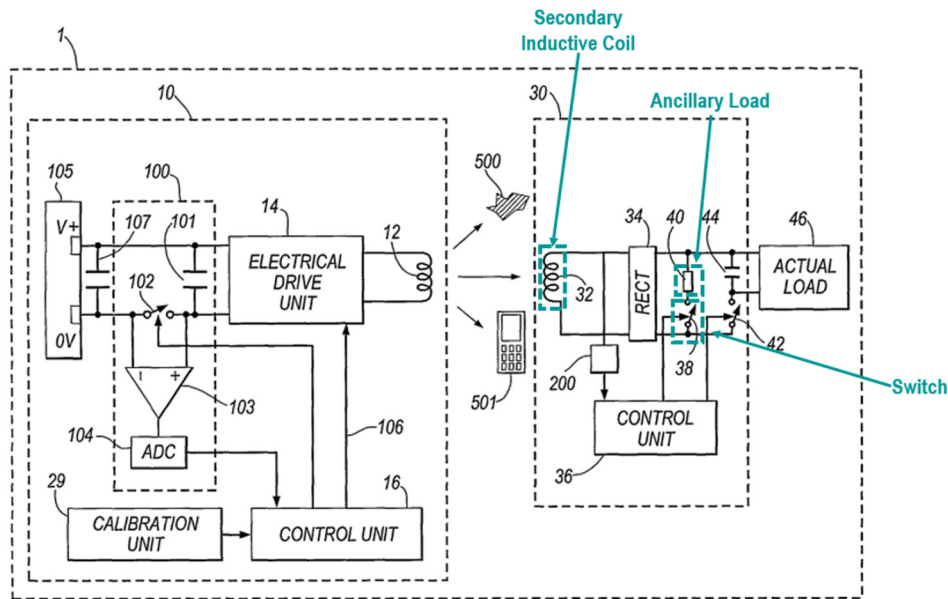


Fig.4

EX1005, FIG. 4, 23:31-24:2, 30:13-22; *See above* Element [17.1].

101. As I discussed in my analysis of element [17.1], Stevens describes that a “way of dynamically changing the load is to modulate switch [38]” to provide “information about the load requirements and parasitic information of the secondary device 30.” EX1005, 30:13-31:6 (note there is a typo on line 39:20 labeling the switch “40” instead of “38”, *see* FIG. 4). Stevens’ dummy load switch 38 is used to intermittently connect the dummy load to the secondary coil according to the modulated signal to transmit information to the primary device using load modulation. *See* EX1005, FIG. 4, 5:23-28, 6:1-18, 19:13-20, 23:31-24:2, 30:13-31:6, 32:1-10, 39:27-35.

Claim 18

***Element [18]: The inductive power receiver of claim 15
wherein the output power monitor is
incorporated into an electric device.***

102. Stevens discloses Element [18]. Stevens states that “the secondary device may be carried in or by a host object which includes the load” where “the host object may be a portable electrical or electronic device having a rechargeable battery or cell.” EX1005, 1:20-26, 21:16-18, *see also* EX1005, 17:32-2 (“The secondary device 30 may be carried in or by an object requiring power such as a portable electrical or electronic device or a rechargeable battery or cell”), 30:34-31:6.

**XI. ANALYSIS – OBVIOUSNESS BASED ON STEVENS AND JIN
(GROUND 3)**

A. Jin (EX1006)

103. Jin describes techniques for transmitting energy between inductively coupled coils. EX1006, [0184], FIG. 22. Jin, like Olson, demonstrates that it was common to measure **an index of power loss** by calculating a transmission efficiency ratio. EX1006, [0093]-[0094]. For example,, Jin describes assessing a coupling condition between coils “using a transmission efficiency as a parameter.” EX1006, [0093]. The transmission efficiency is defined as “Transmission efficiency =(effective current value of secondary side × effective voltage)/(effective current value of primary side x effective voltage).” EX1006, [0094]. A POSITA would have

recognized that this transmission efficiency parameter is exactly the power delivered to the secondary side divided by the power input on the primary side. Jin also explains, improving the transmission efficiency improves the coupling condition between coils and the reliability of signal transmission between the coils. EX1006, [0112].

B. Predictable Combination of Stevens and Jin

104. Based upon my knowledge and experience in the field of the ‘461 patent and my review of Stevens and Jin, it is clear that a POSITA would have been motivated to implement Stevens’ inductive power transfer system according to Jin’s suggestion calculating a transfer efficiency ratio, to achieve known benefits at the time. While Stevens suggests **an index of power-loss** (*above*, IX.A), Jin expressly discloses determining **an index of power-loss** in a manner that achieves helpful benefits. Specifically, Jin describes determining “transmission efficiency” as a quotient calculation—the claimed **efficiency quotient** as the **index of power-loss**. EX1006 [0093]-[0094].

105. There are several rationales that would have prompted a POSITA to implement Jin’s suggestion (e.g., for determining a “transmission efficiency” ratio) in Stevens’ system to achieve known benefits.

106. As a first reason, a POSITA would have been motivated to implement Jin’s suggestion (e.g., for determining a “transmission efficiency” ratio) in Stevens’

system because Jin expressly notes that using this efficiency measure (a ratio of the output power to the input power) advantageously provides a “strong correlation between the transmission efficiency and coupling coefficient.” [0093]-[0094]. Achieving this benefit in Stevens’ system would have increased the likelihood of monitoring for the maximum energy transfer efficiency, which would promote improved charging times and reduced heat generation.

107. As a second reason, a POSITA would have been motivated to implement Jin’s suggestion (for determining a “transmission efficiency” ratio) in Stevens’ system in order to improve the reliability of signal transmission between the coils. EX1006, [0112]. A higher transmission efficiency ratio would enable a higher signal to noise ratio in received load-modulation signals from the secondary coil(s) in the Stevens-Jin combination system.

108. Based upon my knowledge and experience in this field and my review of the straightforward teachings of Stevens and Jin, a POSITA would have possessed the level of skill necessary to implement this combination and would have had a reasonable expectation of success doing so, especially given the similar technologies at issue in each of Stevens and Jin. This is especially apparent considering the similar wireless charging systems described in both Stevens and Jin and their related desires to use conventional indices of power loss to improve power transfer efficiency according to conventional techniques.

C. Application of the Predictable Olson-Jin Combination

Claim 13

Element [13.P]: An inductive power outlet comprising at least one primary coil, for inductively coupling with a secondary coil wired to an electric load, the inductive power outlet further comprising an efficiency monitor comprising:

109. As I discussed above in Section X.B, Element [13.P], Stevens discloses Element [13.P]. EX1005, 1:10-19, 17:9-26, 18:4-11, 19:10-28, 21:13-35, 23:31-33, 38:9-23, 38:34-39:6, FIGs. 1, 4, 12.

Element [13.1]: at least one input power monitor configured to measure input power received by the primary coil from the power supply;

110. As I discussed above in Section X.B, Element [13.1], Stevens discloses Element [13.q]. EX1005, 18:7-10, 21:15-23, 32:32-33:8, 38:9-14, 38:34-39:6, FIG. 4, FIG. 12.

Element [13.2]: at least one signal detector configured to detect signals carrying data pertaining to output power received by the secondary coil;

111. As I discussed above in Section X.B, Element [13.2], Stevens discloses Element [13.2]. EX1005, 38:9-14, 38:25-32, 39:24-35, FIGs. 4 (*see* reference numbers 40 and 38), 12.

Element [13.3]: at least one processor configured to receive data pertaining to the input power and the output power, the processor further configured to determine an index of power-loss indicative of the efficiency of an inductive coupling between the primary coil and the secondary coil;

112. As I discussed above in Section X.B, Element [13.3], Stevens discloses a processor as recited Element [13.3]. EX1005, 18:7-9, 38:25-26, 38:34-39:6, 39:24-35, FIG. 12, FIG. 4 (*see* reference numbers 40 and 38). As I discussed in my analysis above, Stevens teaches that the control unit determines that “if the measured power from the power measurement unit 730 exceeds the sum of the load measures from the secondary devices by more than a shutdown threshold then the control unit 720 concludes that a substantial parasitic load must be present and places the primary unit in the shutdown mode.” EX1005, 38:34-39:6. Accordingly, Stevens teaches that the control unit 720 should determine **an index of power-loss** for purposes of comparing to Stevens’ shutdown threshold value. EX1005, 38:34-39:6. For example, in the implementation in which there is one secondary device (600₁), Stevens would determine the difference between the power received by the secondary device 600₁ and the power transmitted by the primary unit 700 – an efficiency differential Δ – which is then compared to Stevens’ threshold value to identify when the primary unit 700 should be shut down. EX1005, 38:34-39:6.

113. Even if Stevens does not *explicitly* disclose the control unit being

configured to determine the claimed type of “index of power-loss” as recited in Elements [13.3]-[13.4], this feature was commonly implemented in similar prior art systems such as Jin. Jin discloses the conventional practice of assessing an inductive coupling condition between coils “using a transmission efficiency as a parameter.” EX1006, [0093]. Jin teaches that the transmission efficiency should be determined according to a ratio of the output power to the input power: “Transmission efficiency $= (\text{effective current value of secondary side} \times \text{effective voltage}) / (\text{effective current value of primary side} \times \text{effective voltage})$.” EX1006, [0093]-[0094]. This efficiency measure advantageously provides a “strong correlation between the transmission efficiency and coupling coefficient.” [0093]-[0094].

Element [13.4]: wherein the index of power-loss comprises at least one of: an efficiency quotient Q , defined as the ratio of the output power to the input power; and an efficiency differential Δ , defined as the difference between the output power and the input power.

114. The Stevens-Jin combination provides Element [13.4]. As I described above, Jin illustrates that it was a conventional practice to determine **an index of power loss** by calculating a transmission efficiency ratio—one that calculates a ratio of the output power to the input power. EX1006, [0093]-[0094]. In this suggested technique, the transmission efficiency is defined as “Transmission efficiency $= (\text{effective current value of secondary side} \times \text{effective voltage}) / (\text{effective current$

value of primary side x effective voltage),” which provides the claimed **efficiency quotient Q**. EX1006, [0094]. As I described above in Section XI.B, the resulting combination would have predictably achieved a number of known benefits.

Claim 14

Element [14]: The inductive power outlet of claim 13 additionally comprising at least one circuit-breaker configured to disconnect the primary coil from the power supply.

115. As I discussed above in Section X.B, Element [14], Stevens discloses Element [14]. EX1005, 2:18-20, 18:16-19, 19:11-13, 19:30-32, 33:23-28, 37:24-26, 38:16-17, 38:34-39:6, FIGs. 2-3, 8, 11.

Claim 15

Element [15.1]: An inductive power receiver comprising at least one secondary coil for inductively coupling to a primary coil and supplying power to an electric load,

116. As I discussed above in Section X.B, Element [15.1], Stevens discloses Element [15.1]. EX1005, 23:31-33, 17:22-26, 23:31-24:2, 38:16-17, FIG. 4.

Element [15.2]: the inductive power receiver further comprising: at least one output power monitor for measuring output power received inductively by the secondary coil from the primary coil, and

117. As I discussed above in Section X.B, Element [15.2], Stevens discloses Element [15.2]. EX1005, 38:16-20, FIG. 12.

Element [15.3]: at least one signal transmitter configured to transmit signals carrying data pertaining to the output power to the inductive power outlet of claim 13.

118. As I discussed above in Section X.B, Element [15.3], Stevens discloses Element [15.3]. EX1005, 38:18-19, 38:26-29, FIG. 12.

Claim 16

Element [16]: The inductive power receiver of claim 15 wherein the signal transmitter is selected from a group consisting of: light emitting diodes, radio transmitters, optocouplers, and transmitter circuits.

119. As I discussed above in Section X.B, Element [16], Stevens discloses Element [16]. EX1005, 5:25-28, 12:2-4, 15:1-3, 38:5-32, 39:24-35, FIG. 12.

Claim 17

Element [17.1]: The inductive power receiver of claim 15 wherein the transmitter comprises: an ancillary load selectively connectable to the secondary inductive coil, a modulator for modulating a bit-rate signal with an input signal to create a modulated signal, and

120. As I discussed above in Section X.B, Element [17.1], Stevens discloses Element [17.1]. EX1005, 5:23-28, 6:1-18, 19:13-20, 23:31-24:2, 30:13-31:6, 32:1-10, 39:27-35, FIG. 4.

Element [17.2]: a switch for intermittently connecting the ancillary load to the secondary inductive coil according to the modulated signal.

121. As I discussed above in Section X.B, Element [17.2], Stevens discloses

Element [17.2]. EX1005, 5:23-28, 6:1-18, 19:13-20, 23:31-24:2, 30:13-31:6, 32:1-10, 39:27-35, FIG. 4.

***Element [18]: The inductive power receiver of claim 15
wherein the output power monitor is
incorporated into an electric device.***

122. As I discussed above in Section X.B, Element [18], Stevens discloses Element [18]. EX1005, 1:20-26, 17:32-2, 21:16-18, 30:34-31:6.

XII. OVERVIEW OF CONCLUSIONS FORMED

123. This declaration explains the conclusions that I have formed based on my independent analysis. To summarize those conclusions:

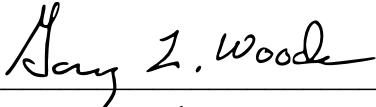
- Based upon my knowledge and experience, and my review of the materials listed above, Claims 13-16, and 18, of the '461 patent are anticipated by Olson (EX1004). *See above*, Ground 1A—Section VIII.
- Based upon my knowledge and experience, and my review of the materials listed above, Claim 17 of the '461 patent is rendered obvious by Olson (EX1004) in view of Stevens (EX1005). *See above*, Ground 1B—Section IX.
- Based upon my knowledge and experience, and my review of the materials listed above, Claims 13-18 of the '461 patent are rendered obvious by Stevens (EX1005) in view of Olson (EX1004). *See above*, Ground 2—Section X.

- Based upon my knowledge and experience, and my review of the materials listed above, 13-18 of the '461 patent are rendered obvious by Stevens (EX1005) in view of Jin (EX1006). *See above*, Ground 3—Section XI.

XIII. CONCLUSION

124. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare 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 Section 1001 of Title 18 of the United States Code).

Executed this 13th day of August, 2024.



Dr. Gary L. Woods

APPENDIX A

Gary L. Woods *Curriculum Vitae*

Updated Jan. 2024

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Education

Stanford University: Ph.D. Applied Physics, 1997 (M.S. 1991)

Advisor: Prof. Martin M. Fejer
National Science Foundation Graduate Fellowship
Dissertation title: *Nonlinear Optical Waveguide Devices Utilizing Intersubband Transitions in III-V Semiconductor Quantum Wells*

Rice University: BSEE & BA Physics, *cum laude*, 1988

Fulfilled requirements for BS in Physics. Phi Beta Kappa, Eta Kappa Nu, Tau Beta Pi, more; George R. Brown Forensics Society, debate team captain; National Merit Scholar; Sid Richardson College Fellow & Athenian Award.

Employment

2008-present: *Professor in the Practice in Computer Technology*, Dept. of Electrical & Computer Engineering, Rice University, Houston, TX. (*Distinguished Professor in the Practice* since 2020).

2006-present: *Consultant*, specializing in debug of integrated circuits and design of optical and electronic systems; Sunnyvale, CA and Houston, TX.

2003-2006: *Senior Scientist*, Credence Systems Corp., Diagnostics and Characterization Group, Sunnyvale, CA (originally Optonics Inc., acquired by Credence in 2003).

2000-2002: *Chief Technical Officer & co-founder*, Spectralane, Inc., Santa Clara, CA

1998-2000: *Senior Researcher*, Intel Corp., Santa Clara, CA

1996-1998: *Postdoctoral Fellow*, University of California, ECE Dept. & Quest Center, Santa Barbara, CA

1988-1989 *Member of Technical Staff*, Texas Instruments Corp. Dallas, TX (summers)

1987 *Undergraduate research asst.*, Rice University ECE dept. Houston, TX (summer)

1985-1986 *Computer programmer*, US Dept. of Energy, Bartlesville, OK (summers)

1984 *Computer operator*, Phillips Petroleum Company, Bartlesville, OK (summer)

Summary of consulting in court cases

- Shenzen Xinxsing E-Commerce Co., Ltd., v. Shenzen Cariku Technology Co., Ltd. PTAB IPR Case # PTAB-IPR2024-00222, US Patent 9,643,506. Wrote declaration supporting petitioners' position.
- Netlist, Inc. vs. Micron Technology, Inc. *et al.*, Federal District Court, Eastern District of Texas. Case # 2:22-cv-203-JRG-RSP, filed June 10, 2022.
 - Patent case, pending.
 - Wrote reports supporting Defendants' position.

- Deposed in Jan 2024.
- Helanea Smith vs. William Q. Williams *et al.*, Case No. 2021-36623, 281st Judicial District, Harris County, Texas.
 - Tort case, pending
 - Performed analyses of wireless communication for plaintiff.
- Ten related PTAB IPR cases involving Scramoge Technology, Ltd, vs. Samsung and Google, among others. 2021-2022. Cases settled. I wrote declarations supporting IPRs. I likely would have been a testifying expert.
 - Google LLC et al v. Scramoge Technology Limited PTAB-IPR2022-00683, US Patent No. 7,825,537
 - Google LLC f/k/a Google Inc. et al v. Scramoge Technology Limited PTAB-IPR2022-00643, US Patent No. 10,193,392
 - Samsung Electronics Co., Ltd. et al v. Scramoge Technology Limited PTAB-IPR2022-00653, US Patent No. 10,199,876,
 - Samsung Electronics Co., Ltd. et al v. Scramoge Technology Limited PTAB-IPR2022-00636, US Patent No. 9,490,652
 - Google LLC v. Scramoge Technology Limited PTAB-IPR2022-00603, US Patent No. 10,804,740
 - Samsung Electronics Co., Ltd. et al v. Scramoge Technology Ltd. PTAB-IPR2022-00478, U.S. Patent No. 10,367,370
 - Samsung Electronics Co., Ltd. et al v. Scramoge Technology Limited PTAB-IPR2022-00385, U.S. Patent No. 9,843,21
 - Samsung Electronics Co., Ltd. et al v. Scramoge Technology Limited PTAB-IPR2022-00284, U.S. Patent No. 9,997,962
 - Samsung Electronics Co., Ltd. et al v. Scramoge Technology Limited PTAB-IPR2022-00241, U.S. Patent No. 9,825,482
 - Samsung Electronics Co., Ltd. et al v. Scramoge Technology Limited PTAB-IPR2022-00185, U.S. Patent No. 10,424,941
- Hamamatsu vs. Semicaps, Federal District Court, Northern District of California, case #17-cv-03440-DMR, Filed June 14, 2017.
 - Patent case, settled.
 - Worked for plaintiff Semicaps. Wrote reports on infringement and invalidity.
 - If case had gone to trial, I likely would have been a testifying expert.
- Hamamatsu vs. Semicaps; PTAB IPR2017-02110 & IPR2017-02112; both filed 09/15/2017
 - PTAB IPR cases; both decided in favor of Semicaps.
 - I worked for the respondents in 2018-2019 and wrote declarations concerning prior art and opposing the petitioners' expert's opinions to support patent validity. I did not testify.
- Nokia vs. Apple; International Trade Commission. Case # 337-TA-1039; Filed 01/27/2017(?). The case ended up settling.
 - Patent case
 - I worked for the defendants in 2017. If the case had continued to a hearing at the ITC I likely would have been a testifying expert.
- NFC Technology, LLC. Vs. Samsung Electronics Co.; Ltd. et al., Federal District Court, Eastern District of Texas; Case # 2:15-cv-283; Filed 2/26/2015. Case ended up settling.
 - Patent case
 - I worked for the defendants in 2015 & 2016. I provided advice on prior art, claim construction, infringement analysis, etc. I likely would have been a non-testifying expert had the case made it to trial.
- X6D Limited vs. Volfoni, Inc. Federal District Court, Central District of California; Case # CV10-09583 MMM, Filed 9/23/2011. I do not know the outcome of this case.
 - Patent case.
 - I worked for the plaintiffs in 2011 and 2012 and prepared an expert report. I would have been the testifying expert if the case had made it to trial.

- X6D Limited; X6D USA Inc.; and XpanD, Inc. vs. Li-Tek Corporation Company et al., Defendants; Federal District Court, Central District of California; Case #10-cv-02327-GHK-PJW. Filed 3/30/2010. I do not know the outcome of this case.
 - Trade secret and patent case.
 - I worked for the plaintiffs in 2011-2012 and prepared expert reports. I would have been the testifying expert if the case had made it to trial

Educational programs & university courses taught

1. “Senior Design Lab” (Elec 494), ECE Dept., Rice University. AY2009-present. Yearlong 2-3 credit “capstone” course for all graduating seniors. Mentored approx. 10 senior teams each year. Co-created interdisciplinary “collaborative capstone” course across ECE, BioEngineering and Mechanical Engineering. Many senior teams won state, national, and international awards in areas ranging from electrical engineering to global health. Every project in my course, every year, has had a working prototype by spring. My teams have won numerous national and international awards.
2. “Introduction to Physical Electronics” (Elec 305), ECE Dept., Rice University. F’08, F’09, F’10; S’11-S’19. A 3-credit junior-level lecture course on semiconductor devices (FETs, ICs, BJTs, etc.), transmission lines, and antennas. The course was consistently ranked among the best ECE courses by Rice ECE undergrads.
3. “Fundamentals of Electrical Engineering II Lab” (Elec 244), ECE Dept., Rice University, S’15, S’20. New laboratory course for sophomores covering basics of circuits (RLC, discrete transistors, opamps, PWM, class D amplifiers, control with digital hardware in the loop.). After lockdown, distributed parts kits & scope dongles to enable circuit construction by students at home.
4. “Electronic Measurement Systems” (Elec 243), ECE Dept., Rice University, S’20, S’22, S’23. Co-taught. A circuits course for non-majors, a core course for sophomores in the Dept. of BioEngineering at Rice. Developed and administrated new lab assignments.
5. “Photonics Measurements” (Elec 364), ECE Dept., Rice University, S’22, S’23. Developed and taught a laboratory-based course covering lasers, optics, spectroscopy, electro-optics, and microscopy. Course based on graduate level text *Building Electro-Optical Systems* by Hobbs.
6. “Basic Electronics” (F’19), a 3-hour workshop on introductory electronics taught to about 100 engineering freshmen. Developed from scratch and funded with an internal grant. Equipment purchased includes ADALM2k USB dongle which now supports general activities in the Oshman Engineering Design Kitchen (OEDK).
7. “Fundamentals of Electrical Engineering I Laboratory” (Elec 240), ECE Dept., Rice University, F’18, F’20-F’23. A one credit course companion to the core Elec 241 Fundamentals of EE course. Adapted from the MOOC which I helped to develop (see below.)
8. “Survey of Engineering Disciplines” (Engi 150), ECE Dept., Rice University, F’16. A one-credit seminar for freshmen to expose them to types of careers open to engineers.
9. “Introduction to Embedded Programming” (Elec 497), ECE Dept., Rice University, S’13, S’14, F’14, F’15, F’16. F’17. Zero/one-credit course on microcontroller programming in C and PCB design for senior design teams without an ECE student. Developed “Escape Platform” embedded programming PCB and software base for teaching purposes.
10. “Fundamentals of Electrical Engineering Laboratory”, Massive Open Online Course (MOOC) offered through Coursera, Spring ’14. Assisted with development of laboratory assignments and parts kit. This was one of the first MOOCs ever to offer a laboratory component through a parts kit purchased separately by enrollees.
11. “Fundamentals of Electrical Engineering II Lab” (Elec 242), ECE Dept., Rice University, S’14. Developed a stand-alone set of laboratory exercises for the 4-credit course. Spun out as a separate course (Elec 244) in Spring ’15.

12. “Analog Circuits Lab” (Elec 342), ECE Dept., Rice University, S’09, S’10, F’11. Developed a new 4-credit lab course on intermediate analog circuits (amplifiers, FETS & BJTs, small signal models, feedback, audio power amplifiers, PCB design.) Course culminated in design and construction of audio power and amplifier on a PCB.
13. “Project Management and Professional Issues” (Elec 394), ECE Dept., Rice University, S’10, S’11, S’12. 2-credit course on project management, career choices, professional interactions, and intellectual property.
14. “Semiconductor device physics in 4 hours,” an original half-day lecture course covering device physics from p-n junctions through FETs. Presented at Credence Systems Corp., Feb. 2007.
15. “Design Debug,” an original 3-day lecture + laboratory course on techniques for debug of IC designs, offered through Semitracks, Inc. Presented at U.S. Dept. of Defense, June 2007. See <http://www.semitracks.com/courses/design/design-debug.php>

Honors

- *George R. Brown Award for Superior Teaching*, April 2016 & April 2019. Awarded annually to the top 10 instructors out of about 600 at Rice University, based on input from recent students.
- *George R. Brown Award for Superior Teaching*, April 2018 & April 2021. Finalist (one of top 25 but not one of top 10).
- *Hudspeth Award*, April 2019. Awarded by Rice Office of Student Activities to the top advisors of student clubs.

Rice academic service and responsibilities

- *Member of ECE undergraduate committee* 2008-present, Chair AY20-21. Inputs on curricular changes and ABET readiness. Developed new senior design (capstone) course structure. Developed new curricular structure to support Vertically Integrated Projects (VIP).
- *Member, Faculty Committee Engineering Design Minor*, 2016 – present. Oversight of policies supporting the new Engineering Design Minor.
- *Faculty Sponsor, Rice Electric Vehicle Club*, 2016-present. Starting in AY ’18-’19 I made the REV part of my Vertically Integrated Projects (VIP) team. They successfully completed the Shell Eco Marathon course for the first time in about 5 years.
- *Academic advisor, Engineering Design Minor*, 2016-present. Advised students pursuing or considering the Engineering Design Minor.
- *School of Engineering Curriculum Review Committee*, F’18-present. (Chair AY 2018, ’19, ’20-23). Reviewed proposed courses within SoE for credit-worthiness. As Chair, tried to convince 7 tenured/tenure-track faculty members to perform a 30-minute task using only constant hectoring and guilt as motivators.
- *Coordinator of Vertically Integrated Projects in ECE Dept.*, 2014-present. Developed course content for VIP projects. VIP projects involved about 10-12 undergrads along with grad students, postdocs and PIs. Program is currently being expanded to 5 departments in two schools.
- *ECE Undergraduate academic advising*, 2008-present. Responsibility for curricular and career advice for about 1/3 of Rice ECE majors.
- *Oversight of ECE undergraduate teaching lab*, 2014-present. Developed and drove implementation of plan to update and modernize equipment in the lab where core circuits courses are taught for all ECE majors and non-majors.
- *Chair of ECE undergraduate awards committee*, 2013-2014 -- responsibility for nominating students for Rice awards.

- *Divisional Advisor* for Sid Richardson (residential) College, 2010-2019; for Duncan (residential) College, 2019-2020, McMurtry (residential) College, 2021-present. Responsibility for advising Freshmen and Sophomores majoring in any Engineering discipline.
- *First-Year Mentor and Faculty Associate*, Sid Richardson (residential) College, 2009-2019; for Duncan (residential) College, F'19-present. Social interactions with students, informal advising of individuals, occasional meetings with freshman groups, frequent lunches, etc.
- *Mentoring of Freshman design teams*, AY 2010-11 -present. Mentored 1-2 freshman design teams in Engi 120 (Intro to Engineering Design) course in all but one semester.
- *OEDK "office hours"* – 2014-'2019 For 2-3 weeks before the Engineering Design Showcase in April each year, I made myself available from 10PM- 12AM nearly every evening to provide assistance with electronic design & troubleshooting for any team. Since COVID much of this advising has been remote.

Grants and awards

1. G. Woods, F. Li, D. Subramanian, L. Duenas-Osorio, "Scalable and Robust Prototype of Sensor Network for Real-Time Street-Level Flood Measurement", Houston Solutions Lab grant, \$73K, AY 2018-19.
2. G. Woods, R. Ramos, L.Yu, , "Creating a Curricular Scaffolding Structure to Evaluate and Enhance Performance of Vertically Integrated Projects," Rice University Quality Enhancement Program on the Scaffolding Experiential Inquiry and Research in the Curriculum, \$30K, AY 2018-19.
3. G. Woods, R. Simar, "Enhancing Experiential Learning in Design of Electronics", Rice University Quality Enhancement Program on the Scaffolding Experiential Inquiry and Research in the Curriculum, \$30K, AY 2017-18.
4. G. Woods, "Freshman Seminar -- Survey of Engineering Disciplines," Rice University Excellence in Engineering Education grant, \$7K, AY 2016-17.
5. G. Woods, "Integrated Electronics Ecosystem for the OEDK", Rice University Brown Foundation Teaching Grant, \$5K, 2016.
6. B. Aazhang, J. Cavallaro, G.L. Woods, on sub-award via Georgia Tech from Helmsley Foundation for establishing Vertically Integrated Projects among members of the international VIP Consortium. Jan 2014-present. Amount due to Rice is about \$130,000 over 3 years.
7. J. Cavallaro, G.L. Woods, National Space Grant Foundation Award # Xhab 2014-03, "SpaceRing: A Versatile, Scalable Power-Generation and Cooling System For Deep-Space Habitats", (co-PI). \$20,000.
8. J. Kono, G. Woods, R. Vaitai, (co-PI) "RAMSES: Repetitive advanced magnet for student experiments and science international senior design project," Rice Faculty Initiatives Fund, 2013, \$20,000.
9. G.L. Woods, M.K. O'Malley, Z.M. Oden, (PI) "Course Module on Embedded Electronics Systems for Multidisciplinary Senior Design Projects", Rice University Brown Foundation Teaching Grant, 2012, \$5000
10. G.L. Woods, K. Kelly, "Vivid Demonstrations of Concepts in Physical Electronics," Rice University Brown Foundation Teaching Grant, 2011, \$4000.
11. F. Koushanfar, S. Reda, G.L. Woods, "Algorithmic Techniques for Post-Silicon Characterization Using Infrared Emissions" (co-PI). NSF #1116858, \$260,000, 2011-2014

Other activities

Member of Technical Advisory Board and co-founder, 2009-present: InView Technology Corp., Austin TX. Advisor to startup company seeking to commercialize compressive-sensing technology developed at Rice for the application of non-visible camera systems. Developed an analog optoelectronic front end with 100x performance improvement over commercial systems.

Consultant, 2006-present.

- Advising semiconductor companies on optical probing related to debugging integrated circuits. Several successful “debug wins,” helping to accelerate product-launch dates.
- Expert legal consultant in several federal patent cases (district court, PTAB, and ITC) in fields such as RF, circuits, PCB design, and optoelectronics

Publications & Patents

Journal Articles

1. G. Timothy Noe, G. Timothy Noe, Ikufumi Katayama, Fumiya Katsutani, James J. Allred, Jeffrey A. Horowitz, David M. Sullivan, Qi Zhang, Fumiya Sekiguchi, Gary L. Woods, Matthias C. Hoffmann, Hiroyuki Nojiri, Jun Takeda, and Junichiro Kono, “Single-shot terahertz time-domain spectroscopy in pulsed high magnetic fields,” *Optics Express*, vol. 24 (26), p. 30328 (2016).
2. G. Timothy Noe, Qi Zhang, Joseph Lee, Eiji Kato, Gary L. Woods, Hiroyuki Nojiri, and Junichiro Kono, “Rapid scanning terahertz time-domain magnetospectroscopy with a table-top repetitive pulsed magnet,” *Applied Optics* vol. 53 (26), p. 5850 (2014).
3. G.T. Noe II, H. Nojiri, J. Lee, G.L. Woods, J. Léotin, J. Kono, “A table-top, repetitive pulsed magnet for nonlinear and ultrafast spectroscopy in high magnetic fields up to 30T”, *Review of Scientific Instruments* vol. 84 (12) p. 123906, 2013.
4. D.T. Morris, C.L. Pint, R. S. Arvidson, A. Lüttge, R.H. Hauge, A.A. Belyanin, G.L. Woods, J. Kono, “Midinfrared third-harmonic generation from macroscopically aligned ultralong single-wall carbon nanotubes,” *Phys. Rev. B* vol. 87 (16), p.161405, 2013.
5. Z. M. Oden, M. K. O'Malley, G. Woods, T. Kraft, B. Burke, “Outcomes of Recent Efforts at Rice University to Incorporate Entrepreneurship Concepts into Interdisciplinary Capstone Design,” *International Journal of Engineering Education*, vol. 28, no 2., pp.1-5, 2012.
6. U. Kindereit, G. Woods, J. Tian, U. Kerst, R. Leihkauf, and C. Boit, "Quantitative Investigation of Laser Beam Modulation in Electrically Active Devices as Used in Laser Voltage Probing," *IEEE Transactions on Device and Materials Reliability*, vol. 7, pp. 19-30, 2007.
7. J. Y. Liao, G. L. Woods, and H. L. Marks, "Rapid diagnostics of ASIC circuit marginalities using dynamic laser stimulation," *IEEE Transactions on Device and Materials Reliability*, vol. 6, pp. 9-16, 2006.
8. G. L. Woods, P. Papaparaskeva, M. Shtaif, I. Brener, and D. A. Pitt, "Reduction of Cross-Phase Modulation-Induced Impairments in Long-Haul WDM Telecommunication Systems Via Spectral Inversion," *IEEE Photonics Technology Letters*, vol. 16, pp. 677-9, 2004.
9. A. Imamoglu, H. Schmidt, G. Woods, and M. Deutsch, "Strongly interacting photons in a nonlinear cavity," *Physical Review Letters*, vol. 79, pp. 1467-70, 1997.
10. H. C. Chui, G. L. Woods, M. M. Fejer, E. L. Martinet, and J. S. Harris, Jr. "Tunable mid-infrared generation by difference frequency mixing of diode laser wavelengths in Intersubband InGaAs/AlAs quantum wells," *Applied Physics Letters*, vol. 66, pp. 265-7, 1995.
11. E. L. Martinet, H. C. Chui, G. L. Woods, M. M. Fejer, J. S. Harris, Jr., C. A. Rella, B. A. Richman, and H. A. Schwettman, "Short wavelength (5.36-1.85 μ m) nonlinear spectroscopy of coupled InGaAs/AlAs Intersubband quantum wells," *Applied Physics Letters*, vol. 65, pp. 2630-2, 1994.
12. H. C. Chui, E. L. Martinet, G. L. Woods, M. M. Fejer, J. S. Harris, Jr., C. A. Rella, B. I. Richman, and H. A. Schwettman, "Doubly resonant second harmonic generation of 2.0 μ m light in coupled InGaAs/AlAs quantum wells," *Applied Physics Letters*, vol. 64, pp. 3365-7, 1994.
13. H. C. Chui, E. L. Martinet, G. L. Woods, M. M. Fejer, J. S. Harris, Jr., C. A. Rella, B. I. Richman, and H. A. Schwettman, "Doubly resonant second harmonic generation of 2.0 μ m light in coupled InGaAs/ AlGaAs quantum wells," *Applied Physics Letters*, vol. 64, 1994.

14. L. Gordon, G. L. Woods, R. C. Eckardt, R. R. Route, R. S. Feigelson, M. M. Fejer, and R. Byer, "Diffusion-bonded stacked GaAs for quasiphasematched second-harmonic generation of a carbon dioxide laser," *Electronics Letters*, vol. 29, pp. 1942-4, 1993.

Conference papers and presentations

1. Z.M. Oden, E. Richardson, G. Woods, A. Dick, M. O'Malley, "A model for a successful collaborative capstone design course," paper P-Th-670, *Biomedical Engineering Society Annual Meeting*, 2014.
2. G.T. Noe II, Q. Zhang, J. Lee, E. Kato, H. Nojiri, G. Woods, J. Kono, "Terahertz Time-Domain Magnetospectroscopy using a Table-Top Repetitive Pulsed Magnet", *CLEO:QELS_Fundamental Science*, 2014.
3. A.M. Andalcio, P. Breen, L.A. Hendricks, T.J. Sarkar, G.T. Noe, G.L. Woods, J. Kono, and J. Leotin, "Compact single-shot terahertz time-domain spectroscopy system for magneto-optics with a mini-coil pulsed magnet," *International Conference on Infrared, Millimeter and Terahertz Waves (IRMMW-THz) Conference*, 2013.
4. K. Dev, G. Woods, S. Reda, "High-throughput TSV testing and characterization for 3D integration using thermal mapping," in *Design Automation Conference*, 2013.
5. G.T. Noe II, H. Nojiri, J. Leotin, G. Woods, A. Belyanin, and J. Kono, "Superfluorescence from a Dense Electron-Hole Plasma in Pulsed High Magnetic Fields" in *CLEO:QELS_Fundamental Science*, 2013.
6. S. Su, J. Kerwin, S. Crowe, J. Cavallaro, G.L. Woods, "Teaching embedded programming to electrical engineers, BioEngineers, and mechanical engineers via the escape platform," in *Interdisciplinary Engineering Design Education Conference (IEDEC)*, 2013.
7. D.T. Morris, G.L. Woods, J. Kono, C.L. Pint, R.H. Hauge, "Second Harmonic Generation in Highly Aligned Carbon Nanotubes on GaAs," American Physical Society Meeting Abstracts, p.28015, 2011.
8. T. Sun, G. Woods, K.F. Kelly, "Compressive imaging applied to infrared-based semiconductor failure analysis," *International Conference on Infrared, Millimeter and Terahertz Waves (IRMMW-THz) Conference*, 2011.
9. Z.M. Oden, M.K. O'Malley, G.L. Woods, T.M. Volz, "Work in progress- Implementing and evaluating efforts to engage interdisciplinary teams to solve real-world design challenges," in *Frontiers in Education (FIE)*, 2011.
10. A. N. Nowroz, G. Woods, and S. Reda, "Improved Post-Silicon Power Modeling Using AC Lock-In Techniques," in *Design Automation Conference 2011*.
11. T. Sun, G. L. Woods, M.F. Duarte, K. Kelly, C. Li, and Y. Zhang, "OBIC Measurements without Lasers or Raster Scanning based on Compressive Sensing," in *Proceedings of International Symposium on Testing and Failure Analysis (ISTFA)*, 2009. Outstanding Paper Award ISTFA 2009.
12. U. Kindereit, G. Woods, J. Tian, U. Kerst, and C. Boit, "Investigation of Laser Voltage Probing Signals in CMOS Transistors," in *International Reliability Physics Symposium (IRPS)*, 2007, pp. 526-33.
13. G. L. Woods, "High Bandwidth Probing of Internal Nodes in Operating ICs," in *Pacific Northwest Conference on Test (BAST)*, Bodega Bay, CA, 2006.
14. Q. Wang, Z. Mai, K. Tan Pik, J. Lam, G. Woods, B. Cain, D. Brown, and L. Ross, "Backside Fault Isolation Technique in 0.13- μ m and 90nm Product Prototyping," in *Physical and Failure Analysis of Integrated Circuits (IPFA)*, Singapore, 2006, pp. 125-8.
15. R. Wampler, P.-K. Ong, R. Billings, D. Meehl, and G. L. Woods, "Dramatic Reduction in Optical Probing Time Via Test-Loop Compaction (TLC) of ATPG-Generated Test Loops," in *IEEE Semiconductor Debug and Diagnosis Workshop (SDD)*, Santa Clara, CA, 2006.

16. S. Kasapi and G. L. Woods, "Voltage Noise and Jitter Measurement using Time-Resolved Emission," in *International Symposium on Testing and Failure Analysis (ISTFA)*, Santa Clara, CA, 2006.
17. G. L. Woods, B. Cain, R. Herlein, A. Syed, and T. Namura, "Analog Circuit Failure Analysis Using Time-Resolved Emission," in *International Symposium on Testing and Failure Analysis (ISTFA)*, Austin, TX, 2005.
18. G. L. Woods, "Solving Design Marginality with GlobalScan," in *Credence Technical Forum*, Santa Clara, CA, 2005.
19. G. L. Woods, "Combining ATPG with in-chip probing to dramatically shorten debug time," in *Cadence Designer Network CDNLive*, Santa Clara, CA, 2005.
20. K. Sanchez, R. Desplats, F. Beaudoin, P. Perdu, J. P. Roux, G. Woods, and D. Lewis, "Dynamic Laser Delay Variation Mapping (DVM) Implementations and Applications," in *European Symposium on Reliability and Failure Analysis (ESREF)*, Bordeaux, France, 2005.
21. K. Sanchez, R. Desplats, F. Beaudoin, P. Perdu, S. Dudit, G. Woods, and D. Lewis, "Dynamic Laser Delay Variation Mapping (DVM) Implementations and Applications," in *International Symposium for Testing and Failure Analysis (ISTFA)*, Santa Clara, CA, 2005.
22. K. Sanchez, R. Desplats, F. Beaudoin, P. Perdu, D. Lewis, P. Vedagarbha, and G. Woods, "Delay variation mapping induced by dynamic laser stimulation," in *International Reliability Physics Symposium (IRPS)*, 2005, pp. 305-11.
23. J. Y. Liao, C. Xiaoding, H. L. Marks, C. Nishizaki, G. L. Woods, P. Vedagarbha, and N. Nataraj, "Rapid diagnostics of an ASIC IP block using dynamic laser scanning," in *Physical and Failure Analysis of Integrated Circuits (IPFA)*, 2005, pp. 27-31.
24. J. Liao, X. Chen, H. Marks, and G. L. Woods, "Localization of marginal circuits for yield diagnostics utilizing a dynamic laser stimulation probing system," in *European Symposium on Reliability and Failure Analysis (ESREF)*, Bordeaux, France, 2005.
25. G. Woods, H. Koike, P. Vedagarbha, K. Wilsher, K. Sanchez, and R. Desplats, "Laser-Induced Timing Alteration in Integrated Circuits," in *LSI Test Symposium*, Osaka, Japan, 2004.
26. G. L. Woods, P. Papaparaskeva, I. Brener, D. A. Pitt, and M. Shtaf, "Reduction of self- and cross-phase modulation-induced impairments in long-haul WDM telecommunication systems via spectral inversion," in *Optical Fiber Communication Conference*, 2004.
27. G. L. Woods and S. Kasapi, "Spectrally- and temporally-resolved dynamic emission from CMOS ICs," in *Lasers and Electro-Optics Society, (LEOS)*, 2003, pp. 598-9 vol.2.
28. G. Woods and S. Kasapi, "Spectrally- and Temporally-Resolved Dynamic Emission from CMOS ICs," in *IEEE Lasers and Electro-Optics Society Annual Meeting*, 2003, pp. 598-9.
29. J. S. Vickers, R. Ispasoiu, D. Cotton, J. Frank, B. Lee, G. Woods, and S. Kasapi, "Time-Resolved Photon Counting System Based on a Geiger-Mode APD and Solid Immersion Lens," in *LSI Test Symposium*, Osaka, Japan, 2003.
30. S. Rusu, S. Seidel, G. Woods, D. Grannes, H. Muljono, J. Rowlette, and K. Petrosky, "Backside infrared probing for static voltage drop and dynamic timing measurements," in *International Solid-State Circuits Conference*, 2001, pp. 276-7, 454.
31. G. L. Woods, T. M. Eiles, and V. Rao, "Time-resolved emission measurements for speedpath debug," in *Intel Research & Development Conference*, Sacramento, CA, 2000.
32. G. L. Woods, "Silicon Backside emission measurements," (*invited talk*), in *Infrared Emission Users' Group Conference*, Half Moon Bay, Ca, 2000.
33. T. Eiles, G. Woods, and V. Rao, "Optical probing of flip-chip-packaged microprocessors," in *International Solid State Circuits Conference*, San Francisco, CA, 2000, pp. 220-1.

34. T. M. Eiles, G. L. Woods, and V. Rao, "Optical Probing of VLSI IC's from the silicon backside," in *25th International Symposium for Testing and Failure Analysis*, Santa Clara, CA, 1999.
35. G. L. Woods, "Nonlinear optical devices based on intersubband transitions in III-V quantum wells" (*invited talk*) in *American Physical Society Annual Meeting*, San Jose, CA, 1996.
36. E. L. Martinet, G. L. Woods, H. C. Chui, J. S. Harris, Jr., M. M. Fejer, C. A. Rella, and B. A. Richman, "Phase-resolved nonlinear spectroscopy of InGaAs/AlGaAs asymmetric quantum wells in the mid-infrared (3-11 μm)," in *International Quantum Electronics Conference*, Anaheim, CA, 1994.
37. E. L. Martinet, G. L. Woods, H. C. Chui, J. S. Harris, Jr., C. A. Rella, B. A. Richman, and M. M. Fejer, "Free-electron laser nonlinear spectroscopy of doubly resonant (5.5-3.0 μm and 4.1-2.1 μm) InGaAs/ AlGaAs asymmetric quantum wells," in *Quantum well and superlattice physics V*, Los Angeles, CA USA, 1994, pp. 331-41.
38. E. L. Martinet, G. L. Woods, H. C. Chui, M. M. Fejer, and J. S. Harris, Jr., "Phase-resolved second harmonic generation in InGaAs/AlGaAs quantum wells," in *7th International Conference on Superlattices, Microstructures, and Microdevices*, Banff, Alberta, Canada, 1994.
39. H. C. Chui, G. L. Woods, M. M. Fejer, E. L. Martinet, and J. S. Harris, Jr., "Tunable mid-infrared generation by mixing of near-infrared wavelengths in intersubband quantum wells," in *Lasers and Electro-Optics Society Annual Meeting, 1994. LEOS '94 Conference Proceedings. IEEE*, 1994, pp. 175-6 vol.1.

Magazine article

1. P. Vedagarbha, G. Woods, H. Koike, and K. Sanchez, "Laser-Induced Debug and Failure Analysis," *cover story of Semiconductor International*, Dec. 2004.

U.S. Patents Issued

1. Kelly, Kevin F.; Baraniuk, Richard G.; Woods, Gary; Sun, Ting; Turner, Matthew, "Apparatus and method for compressive imaging and sensing through multiplexed modulation via spinning disks," USA Patent #9521306B2, Issued 2016.
2. G.L. Woods, J.M. Tidman, "Adaptively filtering compressive imaging measurements to attenuate noise," USA Patent #8,717,463, Issued 2014
3. K.F. Kelly, G.L. Woods, L. McMackin, R.F. Bridge, J.M. Tidman, D.E. Hewitt, "Dynamic range optimization in a compressive imaging system," USA Patent #8,634,009, Issued 2014.
4. M.L. Villafana, M. DiBattista, G. Woods, "Techniques employing light-emitting circuits," USA Patent #8,451,009, Issued 2013.
5. S. Kasapi, K. Wilsher, G. Woods, W. Lo, R. Ispasoiu, N. Nataraj, Boiadjeva, N. , "Apparatus and method for probing integrated circuits using laser illumination", USA Patent # 7,616,312; Issued 2009.
6. G. Woods, S. Kasapi, K. Wilsher, "Method and apparatus for measuring high-bandwidth electrical signals using modulation in an optical probing system", USA Patent #7,450,245; Issued 2008.
7. H. Suri and G. Woods, "System and method for determining probing locations on IC", USA Patent # 7,243,039; Issued 2007.
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9. G. L. Woods and S. Kasapi, "Apparatus and method for determining voltage using optical observation", USA Patent # 7,012,537; Issued 2006.
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Graduate-student supervision

1. Technical advice and service on MS thesis committee of Adam Samaniego, a student in the group of Prof. Ashok Veeraraghavan at Rice University, 2013-14.
2. Darius Morris, a student in the group of Prof. Jun Kono in ECE Dept. at Rice University. 2011-2012.
3. Hands-on supervision of experimental research of Ulrike Kindereit, a doctoral student in the group of Professor Christian Boit at TU-Berlin, 2005-2006. (See publication list).

Summary of capstone teams

- Primary faculty advisor or technical mentor for >100 capstone teams (~75% with grading + technical responsibility, ~25% with significant technical mentorship) in the yearlong collaborative capstone (senior design) course. Of all the teams, ~40% were interdisciplinary (not counting double majors).
- Sponsors/ Customers (approx.) more than: Research 26, Students 13, Industry 23, External collaborators 27, Other 23
- Results: ~8 teams with conference/ journal publications or patents; ~8 with clinical trials or deployments; ~6 commercializations; ~10 Vertically Integrated Projects; numerous awards at university, national, and international levels.
- More than 20 projects involving rechargeable batteries, recharging circuits, or wireless power transmission.