UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD. AND SAMSUNG ELECTRONICS AMERICA, INC.,

Petitioners,

v.

AQ CORPORATION,

Patent Owner.

DECLARATION OF DAVID K. CHOI, Ph.D

REGARDING

U.S. Patent No. 11,728,564

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I. INTRODUCTION

1. My name is David K. Choi, Ph.D. I have been retained by Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. (collectively "Samsung" or "Petitioners") as an independent expert in this proceeding.

2. I understand Samsung is challenging the validity of claims 1-22 of U.S. Patent No. 11,728,564 (the "'564 Patent") in this petition for *inter partes* review ("IPR"). I refer to these as the "Challenged Claims."

3. I have been asked to consider whether certain references invalidate the Challenged Claims.

4. I am being compensated for my time in connection with this matter at the consulting rate of $750 per hour. My compensation is not affected by the content of my opinions, testimony, or the outcome of this matter.

5. The prior art references on which my opinions are based are:

- PCT Publication No. 2017/175886 ("Seong," attached as exhibit 1006)
- U.S. Patent Application Publication No. 2019/0109373 ("Ahn," attached as exhibit 1007)
- U.S. Patent No. 10,269,005 ("005Lee," attached as exhibit 1008)
- Korean Patent Publication No. 10-2017-0093670 ("Cho," attached as exhibit 1010)
- U.S. Patent Application Publication No. 2017/0228721 ("721Lee," attached as exhibit 1011)

- U.S. Patent Application Publication No. 2018/0198209 ("Kang," attached as exhibit 1012)

6. In my opinion, the Challenged Claims are invalid based on the following:

- The combination of Seong, Kang, and Cho renders the Challenged Claims obvious;
- The combination of Ahn and 721Lee renders the Challenged Claims obvious; and
- The combination of 005Lee, Seong, and Ahn renders the Challenged Claims obvious.

II. BACKGROUND AND QUALIFICATIONS

7. I received my B.S. degree in physics from the University of California, Berkeley in 1993, my M.S. degree in Electrical and Computer Engineering from California State University, Fullerton in 1996, and my Ph.D. degree in Electrical and Computer Engineering from the University of California, Santa Barbara in 2001. By November 2019, I had earned a Ph.D. in Electrical and Computer Engineering and had over 25 years of professional and academic experience in research and product development in digital integrated circuit (IC) design, analog circuit design (including power electronics/power management systems), RF/Microwave circuit design,

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wireless communications, and semiconductor electronics.[1]

8. From September 1993 to July 1994, I worked as a research assistant in the Department of Physics at the University of California, Irvine. In this role, I was responsible for the analysis and design of a cryogenic camera system for mid-Infrared imaging of deep space phenomenon using (at the time) the largest available (1 Megapixel, 1024x1024) Charge Coupled Device (CCD) and custom Fabry-Perot Interferometer.

9. From January 1995 to August 1996, I worked as a Digital Design Engineer at Western Digital Corporation in the ASIC design group (acquired by Adaptec Inc.). In this role, I used a number of industry standard VLSI design tools from Cadence, Synopsis, Meta, etc. to perform static critical delay analysis, characterize and generate libraries for custom digital logic cells, and to analyze and design clock trees and custom ASIC pad driver cells. I received an award for outstanding achievement for developing a "no re-spin" solution to correct a design error preventing a new ASIC from being powered on and was recognized for my analysis of circuit and

[1] In practically all of my digital, analog, power electronics, and RF/Microwave circuit design experience, I have designed, directed, and approved design of multi-layer printed circuit boards of various types.

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system level meta-stable logic.

10. I worked at the Nokia Research Center as a Senior Research Engineer from April 2001 to March 2006. In that role, I designed, built, and tested RF circuits, RF systems, and power management systems. My work included designing a novel LDMOS-based Chireix Outphasing (base station) transmitter for UMTS systems, development of an OFDM RF system simulator (with physical impairments and forward error correction (FEC)), development of baseband PAPR reduction techniques for OFDM radio systems, development of a high power, high precision, 16-bit digitally-controlled (Half-bridge) switched-mode power supply, and development of compact planar antennas on printed circuit substrates for use in mobile phones.

11. From July 2006 to February 2007, I worked as a group leader and staff engineer in the Infrastructure Products Group at RF Micro Devices. In that role, I worked on advanced product development, including the development of a GaN HEMT dual carrier UMTS Doherty base station transmitter and a scalable GaN HEMT non-linear simulator model.

12. From March 2007 to July 2008, I worked as a Section Manager of the Technology Strategy Team in Technology Intelligence & Collaboration at Samsung Electronics. In that role, I worked on technical feasibility and

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business opportunity analysis of nanotechnology, and market and technical analysis of biomedical electronics and THz imaging.

13. From July 2008 to February 2011, I worked as a Technical Manager and Principal Engineer in the Advanced Development Group at Aethercomm, Inc. In that role, I worked on product development of pulsed/CW wideband, high power RF transmitters implemented in silicon LDMOS, GaAs FET and HBT, and GaN HEMT device technologies. I also worked on the design of other RF/microwave components such as transformers, baluns, power detectors, switches, filters, magnetics (including inductors with and without ferrites), phase shifters, frequency control, signal processing elements and rectangular waveguides, microwave cavities, as well as, DC power management systems (including full and half-bridge converters), control logic, temperature compensation, fault protection, etc.

14. From May 2011 to December 2012, I worked as a Senior R&D RF Hardware Engineer in R&D Hardware Engineering at LGS Bell Labs Innovations. In that role, I developed high power, highly-linear, and efficient RF transmitter solutions for various wireless standards (including GSM/EDGE, CDMA, WCDMA, and LTE) using peak to average power reduction (PAPR) techniques, analog and digital (pre-distortion) linearization, and various high-Q (SAW, BAW, FBAR, ceramic, and

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cavity) filters.

15. From August 2013 to March 2014, I worked as a Technical Director in the RF/microwave Power Amplifier Business Unit at Mercury Systems, Inc. In that role, I directed and led all aspects of Mercury Systems' RF/microwave Power Amplifier Business Unit.

16. Since February 2012, I have been the Principal and Owner of RF Design Concepts, Ltd. In this role, I provide consulting services, including product design and development related to RF/microwave circuits, power amplifiers, power management systems (including wireless charging applications), and semiconductor fabrication, advanced IC packaging, as well as for nascent scientific research/technologies.

17. In addition to my work experience in industry, I have also taught electrical engineering (Microelectronics[2] i.e., semiconductor circuits, diodes, transistors, and transistor circuits) at the university level. From March 2013 to March 2014 and from August 2015 to August 2016, I was an

[2] The cumulative nature of this subject matter necessarily included reviewing, and often re-teaching, the fundamentals of electronic circuit theory, including concepts such as Ohm's Law, series and parallel circuits (and their equivalencies), Kirchoff's Laws, etc.

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Adjunct Professor in the Department of Electrical, Computer, and Energy Engineering at the University of Colorado, Boulder where I gave graduate level electrical engineering seminars and supported graduate research in wireless communications (including transmitter, combiner, and advanced architectures), wireless charging (including antennas and antenna arrays), and other related topics. Also, from August 2004 to August 2008, I was a Visiting Scholar in the Department of Electrical & Computer Engineering at the University of California, San Diego. I have several published articles in the field of electrical engineering and power amplifier design, including adaptive impedance matching. A list of these publications can be found in my curriculum vitae, which is attached as Ex. 1003.

III. DOCUMENTS AND MATERIALS CONSIDERED

18. In forming the opinions expressed in this Declaration, I relied upon my education, training, knowledge, and experience in the relevant field of the art, as well as information pertaining to the documents described below.

19. In preparing this Declaration, I have considered the materials referenced herein, including the ’564 Patent and its file history, the Seong, Cho, Kang, Ahn, 721Lee, and 005Lee prior art references on which my opinions are based, and other documents listed in the Exhibit List of the Petition. These references and documents reflect the state of the relevant art at the time of

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the alleged invention and the background knowledge of a POSA.

20. I have also reviewed the Patent Owner ("PO")'s Complaint filed in the related litigation, *AQ Corporation v. Samsung Electronics Co., Ltd. et al.*, Case No. 2:25-cv-01012-JRG.

21. I have also reviewed PO's Infringement Contentions filed in the above-captioned related litigation.

IV. LEGAL PRINCIPLES

22. Samsung's counsel has informed me of certain legal standards. I have applied these understandings in my analysis as detailed below. I am not an attorney and offer no legal opinions.

23. I have been informed and understand that a patent claim is invalid if it is obvious, and that obviousness requires that the claim be obvious from the perspective of a person of ordinary skill in the relevant art at the time of the alleged invention. I have been informed and understand that a claim may be obvious in view of a single prior art reference, or may be obvious in view of a combination of two or more prior art references.

24. I have been informed and understand that the level of ordinary skill in the art may be determined by considering such factors as the education level of those working in the field, the sophistication of the technology, the types of problems encountered in the art, the prior art solutions to those

problems, and the speed at which innovations are made. I have been informed and understand that not all of these factors need be considered and that one or more of these factors may control.

25. I have been informed and understand that an obviousness analysis is based on several factors, including the scope and content of the prior art, what differences, if any, existed between the alleged invention and the prior art, and the level of ordinary skill in the pertinent art at the time of the alleged invention.

26. I have been informed and understand that to determine whether a claim is obvious, it is appropriate to consider, among other factors:

(1) whether the teachings of the prior art references disclose known concepts combined in familiar ways, and when combined, would yield predictable results; (2) whether a person of ordinary skill in the art could implement a predictable variation, and would see the benefit of doing so; (3) whether the claimed elements represent one of a limited number of known design choices, and would have a reasonable expectation of success by those skilled in the art; (4) whether a person of ordinary skill would have recognized a reason to combine known elements in the manner described in the claim; (5) whether there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed

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in the patent; and (6) whether the innovation applies a known technique that had been used to improve a similar device or method in a similar way.

27. I further have been informed and understand that while it may be helpful to identify a reason for this combination, common sense should guide and no rigid requirement of finding a teaching, suggestion, or motivation to combine is required.

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

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29. I have been informed and understand that a prior art reference may expressly or inherently describe a limitation of a claim. I have been informed and understand that if the prior art necessarily includes or functions in accordance with a claim's limitation, then the prior art inherently discloses that limitation. I have been informed and understand that to establish inherency, the evidence must make clear that the missing descriptive matter is necessarily present in the item of prior art and that it would be so recognized by persons of ordinary skill in the art.

V. PERSON OF ORDINARY SKILL IN THE ART

30. In my opinion, a Person of Ordinary Skill in the Art ("POSA") in the subject matter of the '564 Patent would have had a bachelor's degree in electrical engineering or a similar field and 2-3 years of experience in antenna design, wireless charging, and/or contactless wireless communication. Additional education could offset less experience and vice versa, and a POSA could have also obtained similar knowledge and experience through other means.

31. I have been a POSA since at least 2012. The opinions I am offering are from the perspective of a POSA at the time of the alleged invention. For the purposes of my opinions below, I have been asked to assume that the relevant time frame is the relevant priority date for the Challenged Claims.

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VI. TECHNOLOGY BACKGROUND

32. The Challenged Claims are directed to smartphone antenna modules comprising well-known components (including a "substrate" with opposing surfaces, "coil[s]," "extension lines," and "vias") arranged in well-known "antenna pattern[s]" (including "inner" and "outer" "ring[s]") formed on each side of the substrate to perform well-known wireless communication functionality (Near Field RF Communication (NFC) and wireless battery charging). Ex1001, Claims.

33. In my opinion, these features and configurations were well-known, as were the '564 Patent's claims' remaining elements. Ex1001, Claims.

34. As will be analyzed in detail below, the '564 Patent claims certain configurations of very well-known elements, such as antenna modules, antenna patterns (coils and c-shaped coils (with gaps) for NFC and wireless charging), extension lines (also known as antenna feeds/feed lines), the use of both sides of a substrate (including antenna patterns form on each side), vias to electrically connect antenna patterns on opposite sides of a substrate, coils connected in parallel,[3] and battery operated smartphones

[3] The fact that two basic circuit elements, such as resistors, capacitors, and inductors, can be connected either in series or in parallel, Ex1016, 10-11 is rudimentary well

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(which can be charged wirelessly). In addition to these well-known elements, the combinations of these were also well-known and disclosed in the prior art. It is fair to say that, at least the independent claim of the '564 Patent, merely claims a certain printed circuit board layout.

35. PCB design is constrained by scientific fundamentals, manufacturing design rules, industry standards such as MIL-PRF-55110F (and/or its commercial counterparts such as IPC-2221) but in commercial products such as smartphones perhaps most stringently by size and cost. In my own experience, I have created, requested creation of, and approved custom printed circuit board artwork to be stored and reused in such CAD database libraries, as is standard industry practice in printed circuit board layout design, but reusing standard and custom library elements is practically an imperative for IC layout design. Given this, a POSA looking to design an antenna module on a substrate would have been motivated to look to

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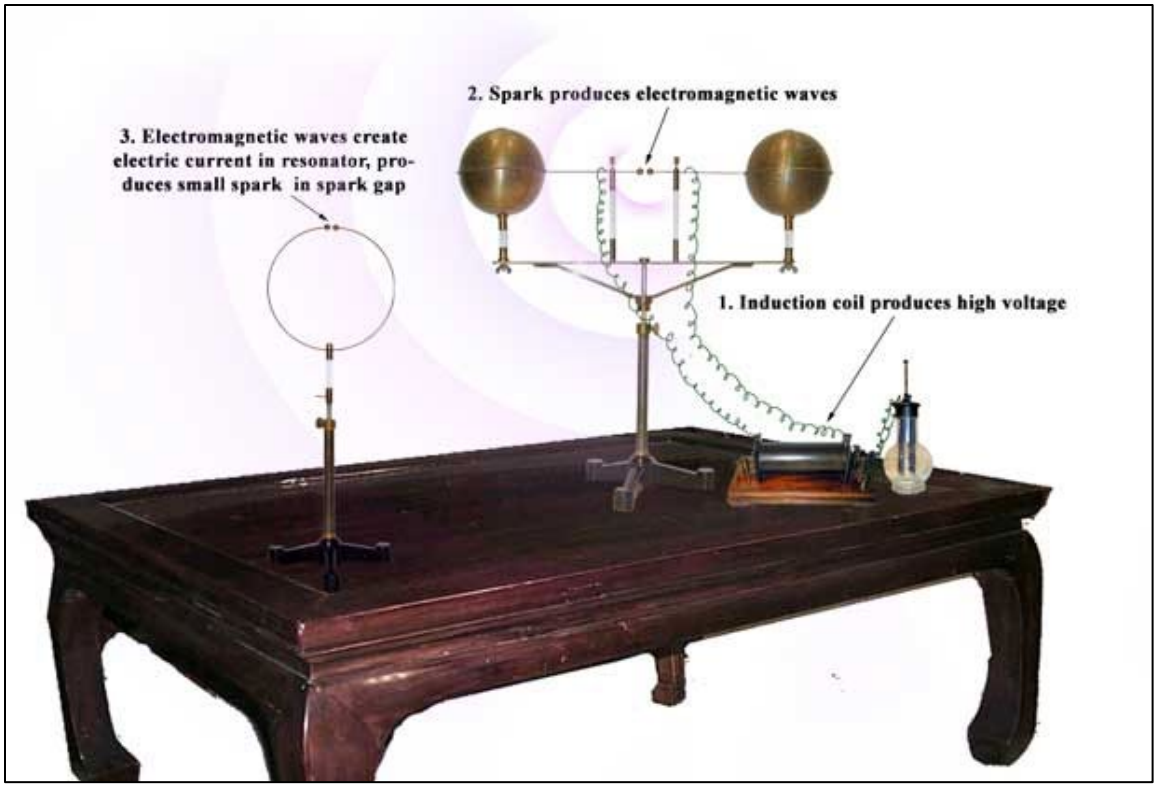
within the knowledge of a POSA, especially given that it is an elementary topic covered in basic circuit analysis, typically covered in the first or second year of a typical undergraduate electrical engineering program.

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known, existing elements, as well as configurations of elements, rather than to try to "reinvent the wheel." A POSA would have also known and been motivated to use elements from database libraries to create hierarchical designs, which allow for trying different configurations of elements (as well as later modifying the layout design) without having to redraw each and every element, which is both very time consuming and prone to errors. Just as an artist would look to use existing palettes, templates, etc. (and borrow new ones), printed circuit board designers are constantly on the lookout for new designs, techniques, and tried and true "tricks of the trade" to facilitate and expedite the layout design process.

36. The same type of antennas described in the '564 Patent have been known since the earliest days of wireless communication. In fact, Heinrich Hertz, one of the forefathers of radio communications, used a coil antenna in his famous "1886 spark-gap dipole transmitter and loop receiver experiment," (Ex1020, 1), a rendition of which is shown below.

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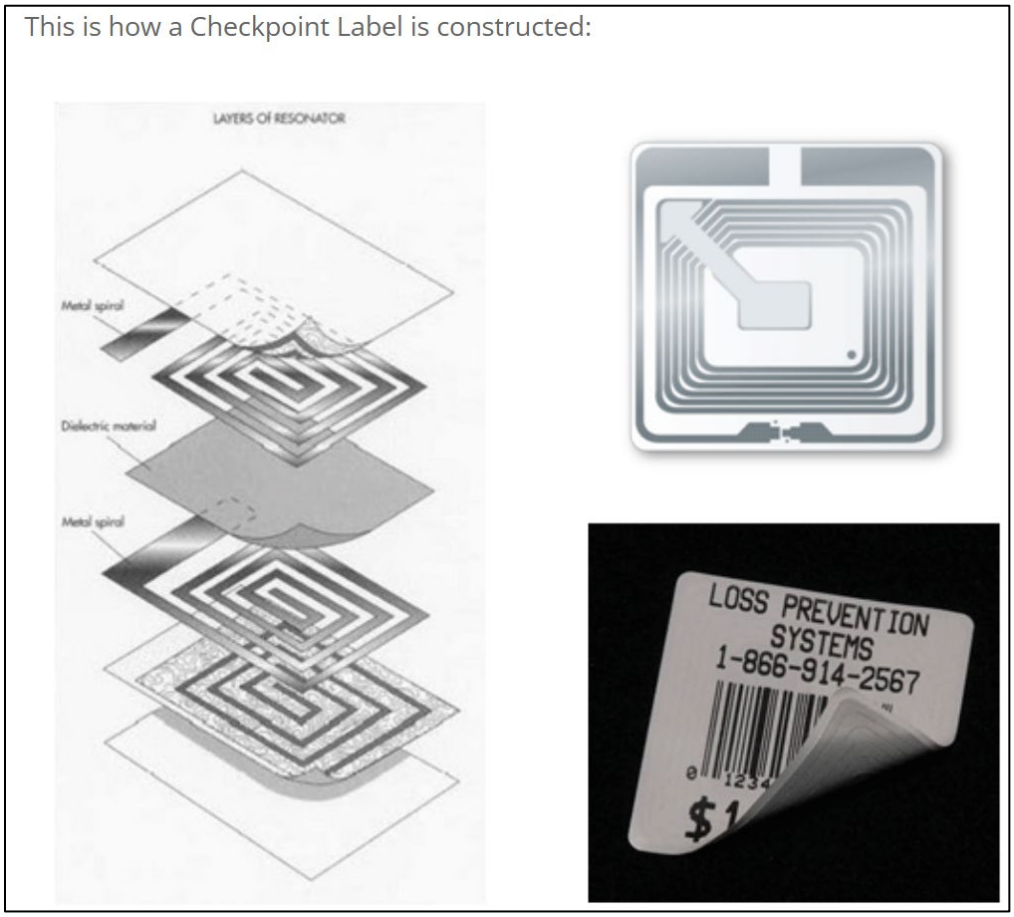
Ex1024, 1.

37. In the hundred-plus years that have passed since Hertz's seminal works, antennas of myriad types, sizes, and shapes have become common place, especially in the past couple of decades. Whether they be large and conspicuous (and accordingly contemptuous) such as cellphone tower antennas, or others that are small enough to be unobtrusive, antennas are ubiquitous in daily modern life. Although I do not recall precisely when they were first put into use[4], I remember finding small, thin, printed RFID

[4] My best guess would be sometime in the early to mid 1990's.

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security tags in books, CD jewel cases, and other items; below is an example of one of such RFID tags with a printed spiral antenna[5].



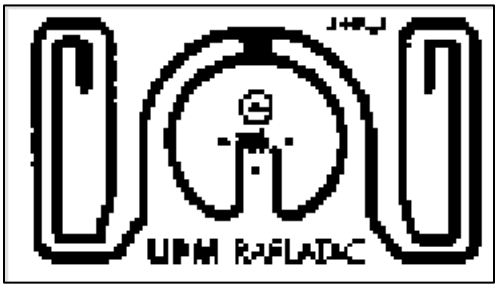
Ex1025, 1.

38. Similar small printed antenna patterns, including the ring type or circular shaped patterns on thin flexible substrate, which are the subject of the '564

[5] It's worth noting that in the rendition showing how the Checkpoint security label is constructed, metal spiral antennas are shown overlayed on opposing surfaces of a thin dielectric substrate material.

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Patent, have been commercially available at least since the late 2000's. For instance, I understand that the SMARTRAC "Satellite M3" RFID tag was available as early as March 31, 2009, as was the SMARTRAC "M3 Button" RFID tag was available as early as October 5, 2009:



Ex1019, 6 (SMARTRAC "Satellite M3").



Ex1019, 6 (SMARTRAC "M3 Button").

39. The only wireless-communication functionalities claimed by the '564 Patent are NFC and wireless battery charging. Ex1001, Claims. These functionalities were well-known in the art by November 27, 2019 (the '564 Patent's earliest claimed priority date). The origins of NFC can be traced back to "Thomas Edison in a radio frequency experiment conducted in the late 1800's." Ex1018, 2. But more recently, it has been understood that "Near-field communication (NFC) is [well known as] a type of radio

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frequency identification (RFID), which is a contactless communication technology that operates in a frequency range centered on 13.56 MHz." *Id.* NFC "technology allows users to send identification information wirelessly to the receiver for tracking and security purposes. NFC technology is only usable within a limited distance; therefore, it is relatively secure and is used in various areas, such as industry [1–3], medicine [4–13], and banking and finance [14–16]. Most electronics, such as modern smartphones and credit cards, are equipped with basic NFC technology, and are naturally used in everyday life [17,18]." *Id.*

40. Wireless power transfer (WPT), also referred to as wireless charging, was originally conceived as early as 1891, when Nikola Tesla "began his work on wireless power transmission at his laboratory in Colorado, USA. He managed to power a small incandescent lamp by current induced in a three-wound coil and the circuit was grounded at one end and the other end was free [2]. The transmitter used a resonant circuit and was connected to ground. Tesla's successful experiment was the first demonstration of wireless power transfer." Ex1017, 1. "He demonstrated the concept of wireless power transmission" and designed the famous Wardenclyffe tower [(shown below)] "for trans-Atlantic wireless telephony," "but the tower was not completed due to lack of fund[ing]." *Id.* Additionally, Tesla

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disclosed invention of wireless power transmission as early as 1897 and was issued patents on his inventions in the year 1900. Ex1029; Ex1030.



Fig. 1 Wardenclyffe Tower [3]

Ex1017, 1.

41. As in the '564 Patent, Tesla's patent disclosed coils for wireless transmission, "the apparatus at one point is used as a transmitter, the coil A in this case constituting a high-tension, secondary, and the coil C the primary, of a transformer." Ex1029, 1:40-44. Since Tesla disclosed his invention, transformers (illustrated below) have been used extensively to "step-down" high voltage (usually 110VAC or 220VAC) alternating current electrical power from household wall outlets to lower voltages more suitable to power various consumer electrical and electronic devices.

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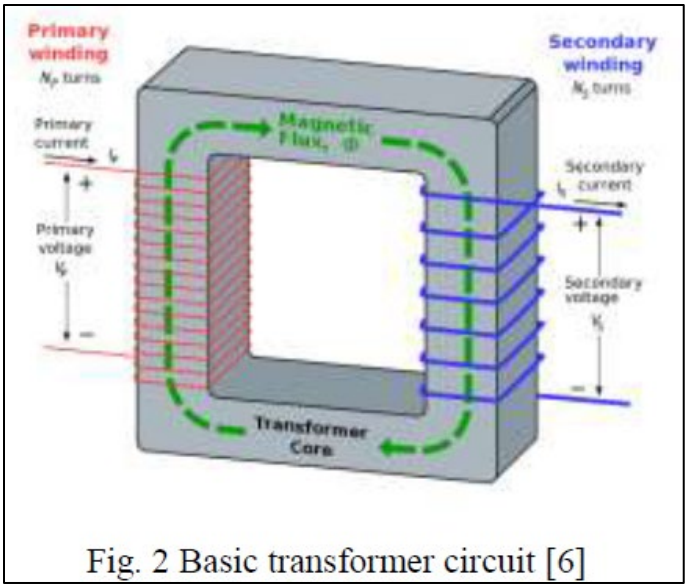


Fig. 2 Basic transformer circuit [6]

Ex1017, 1.

42. The Qi (pronounced "chee") standard, used in most smartphones, was introduced in 2010, (Ex1026), by "the Wireless Power Consortium" (formed in 2008), with "more than 220 international companies [that] are now members of it [27]." Ex1017, 6.

43. Combining multiple antennas on a single antenna module was also well known before the '564 Patent. For example in 1989, Shoemaker disclosed the invention of a "microwave circuit module[]," "more particularly, [] an antenna array that is relatively efficient, is relatively inexpensive to manufacture" while also offering "simplicity in construction," and "is light in weight." Ex1031, 1:7-8. Compared with using disparate antennas, combining multiple antennas in a single module, is obviously relatively inexpensive and simple to manufacture, offers light weight, and space

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efficient construction, especially when implemented on printed circuit substrates, as the '585 patent discloses. *Id.*, 3:1-7.

44. Using coil modules was also a well-known approach to use space more efficiently, particularly as smartphones became thinner and thinner over time and included more and more technology.

45. As an example, in 2017, Seong identified this problem and addressed it by teaching a space-efficient antenna module having multiple antennas formed on "the top surface or the bottom surface" of a single "substrate" to "reduce the overall size of the antenna structure" and "to efficiently use the internal space" of a smartphone. Seong, Abstract, ¶¶9-12.

46. As another example, in 2017, Cho also recognized this problem of limited space in smartphones by teaching a space-efficient antenna module that is "capable of increasing the spatial efficiency of various types of coils" by locating "multiple [coil] windings on one side of the center portion" of the substrate and "multiple windings on the other side of the center portion" so "the wireless charging coil," "the second wireless communication coil," and other coils "may utilize both sides of the substrate." Cho ¶¶4, 5, 9, 75, 79.

47. As another example, in 2018, Kang addresses the problem that "spaces for installing an NFC antenna or MST antenna are limited" by providing

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"improved layout[s]" and "shape[s]" for three or more coil antenna patterns that may be in a shape that is "different from that of the periphery of the PCB," including, for example, "a circular-spiral shape." Kang, ¶¶33, 179, 248, 249. Kang further teaches that the three-or-more coils can be concentric ("one off the three or more coils surrounds another coil that surrounds one or more coils") and "[e]ach coil can be used as one of an MST antenna, an NFC antenna and other antenna that uses a coil antenna, such as wireless charging antenna." *Id.*, ¶¶216, 238. Furthering its space-savings goal, Kang teaches forming coil antennas on both "a first major surface and a second major surface facing away from the first major surface" of "a flexible PCB," and further teaches connecting coils using "vias." *Id.* ¶¶5-15, 76, 174-75, 231, 247-49, 261, 263, Figs. 46, 48-49, Cl. 6.

48. Running coil extension lines through coil gaps created by C-shaped lines was also well-known before the '564 Patent. For example, in 2010, U.S. Patent Application Publication No. 2010/0090824 to Rowell et al. ("Rowell") taught the benefits of "[a] near field apparatus compris[ing] a Radio Frequency (RF) coil including at least one of a shorting bridge from a first point to a second point along an electrical path of the RF coil and/or a discontinuity in the electrical path of the RF coil." Ex1014, Abstract.

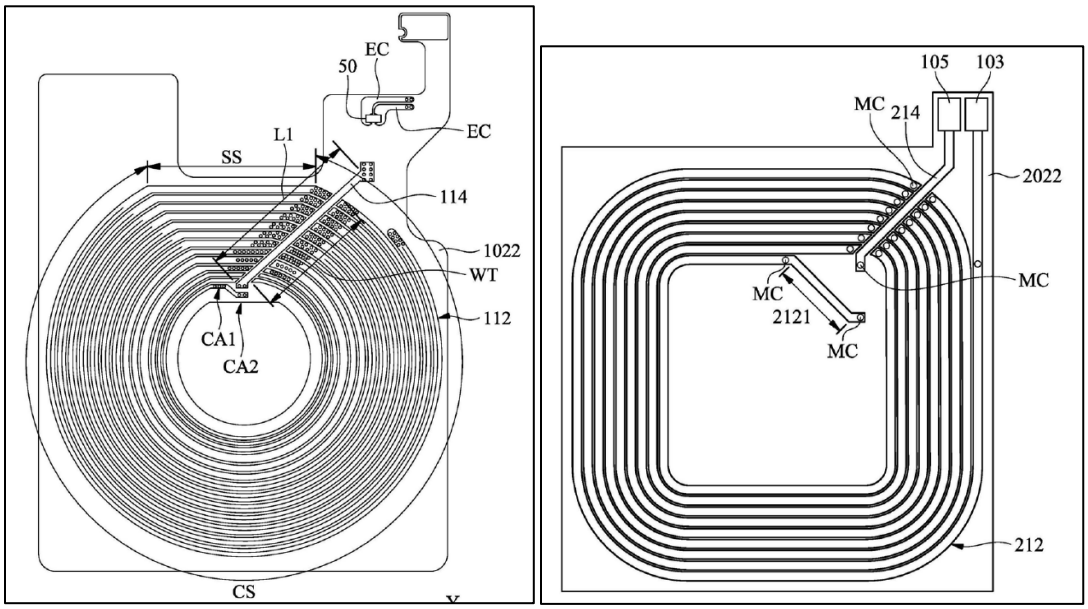
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Rowell discloses a "double-layer spiral type coil shown in FIG. 1," including "embodiments include[ing] two or more shorting bridges and/or gaps." *Id.*, ¶27. "FIG. 3 is an illustration of exemplary RF coil 300, adapted according to one embodiment of the invention. RF coil 300 is topologically similar to RF coil 100 (FIG. 1) in that it is a double-layer spiral coil. RF coil 300 is disposed upon Printed Circuit Board (PCB) 304 with one layer on a top surface of PCB 304 (as shown in view 310) and another layer on a bottom surface of PCB 304 (as shown in view 320). Via 305 connects the two layers by providing a conductive path through PCB304." *Id.*, ¶29. Rowell explains some major benefits of using cross-over bridges and gaps in the coil windings, "As shown in FIG. 4, the embodiment of FIG. 3 provides performance in a lower frequency band than a coil without a gap or a short, but with no increase in coil size. It is estimated that the coil of FIG.3 occupies ***seventy percent less surface area*** than a coil of the same shape as that of the coil of FIG. 3, lacking a gap or a shorting bridge, and configured to operate in the 13.56 MHz frequency band. Thus, one advantage of some embodiments is that coils can be miniaturized. Furthermore, the frequency split can provide for multi-band performance in some embodiments." *Id.*, ¶31.

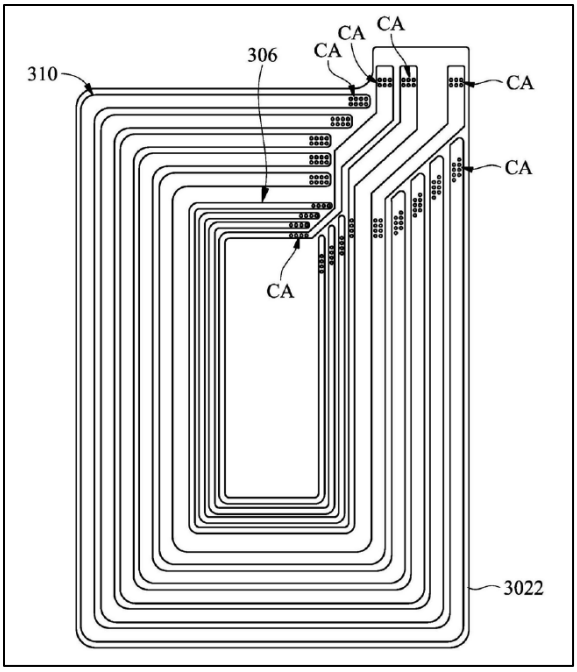
49. As another example, in August 2019, Chinese Patent CN209266128 taught

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using (at least under PO's apparent interpretation of these claim limitations, as shown in PO's Complaint and as discussed in more detail in this Declaration) C-shaped lines to create gaps in inner and outer coils that are connected and aligned in a radial direction and further taught running generally parallel extension lines through them:

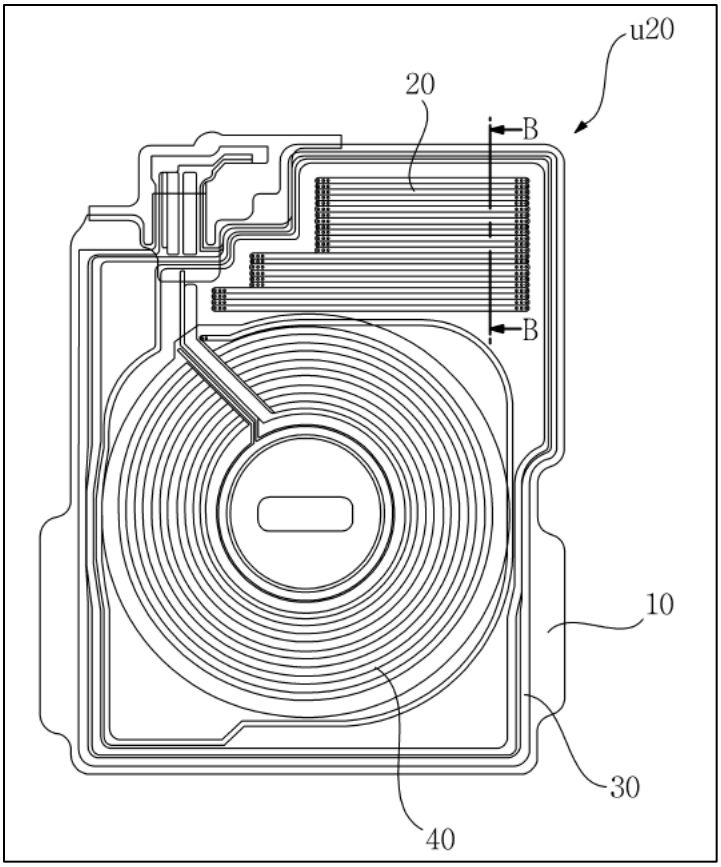


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Ex1032, Figs. 4, 10, 25.

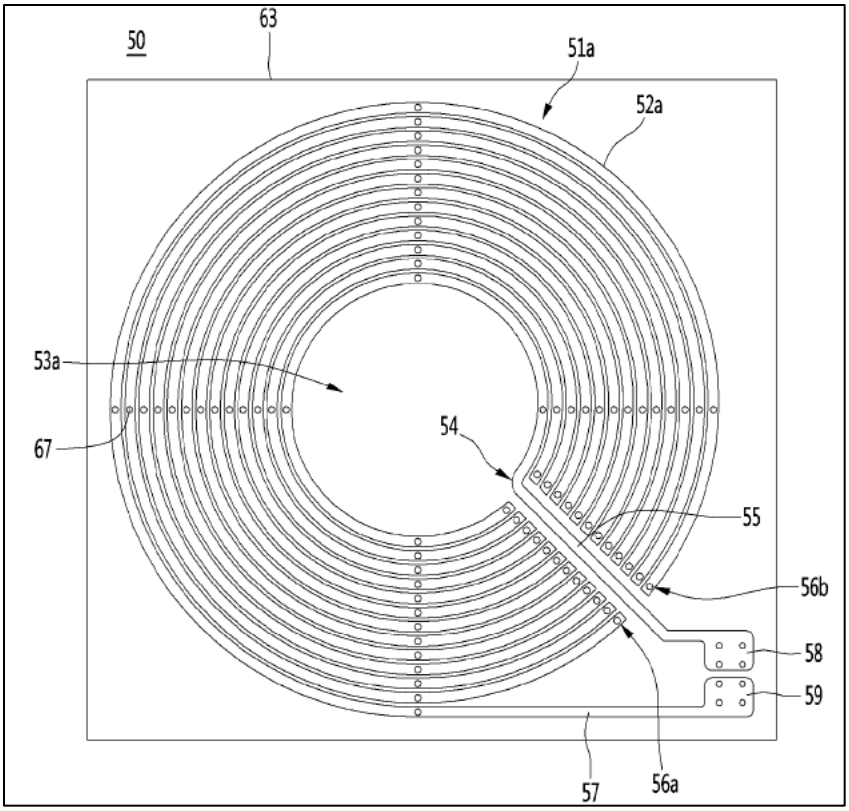
50. As another example, in 2018, Korean Patent No. KR20180113064 taught using (at least under PO's apparent interpretation of these claim limitations, as shown in PO's Complaint and as discussed in more detail in this Declaration) C-shaped lines to create gaps in inner and outer coils that are connected and aligned in a radial direction and further taught running generally parallel extension lines through them:



Ex1033, Fig. 4.

51. As another example, in April 2019, PCT WO 2019/070090 taught using (at least under PO's apparent interpretation of these claim limitations, as shown in PO's Complaint and as discussed in more detail in this Declaration) C-shaped lines to create radially-extending gaps in coils and further taught running generally parallel extension lines through them:

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Ex1034, at Fig. 7.

52. In short, as explained in more detail in this Declaration, in my opinion, each of elements claimed by the ’564 Patent were well-known in the art, and it was well known to combine them.

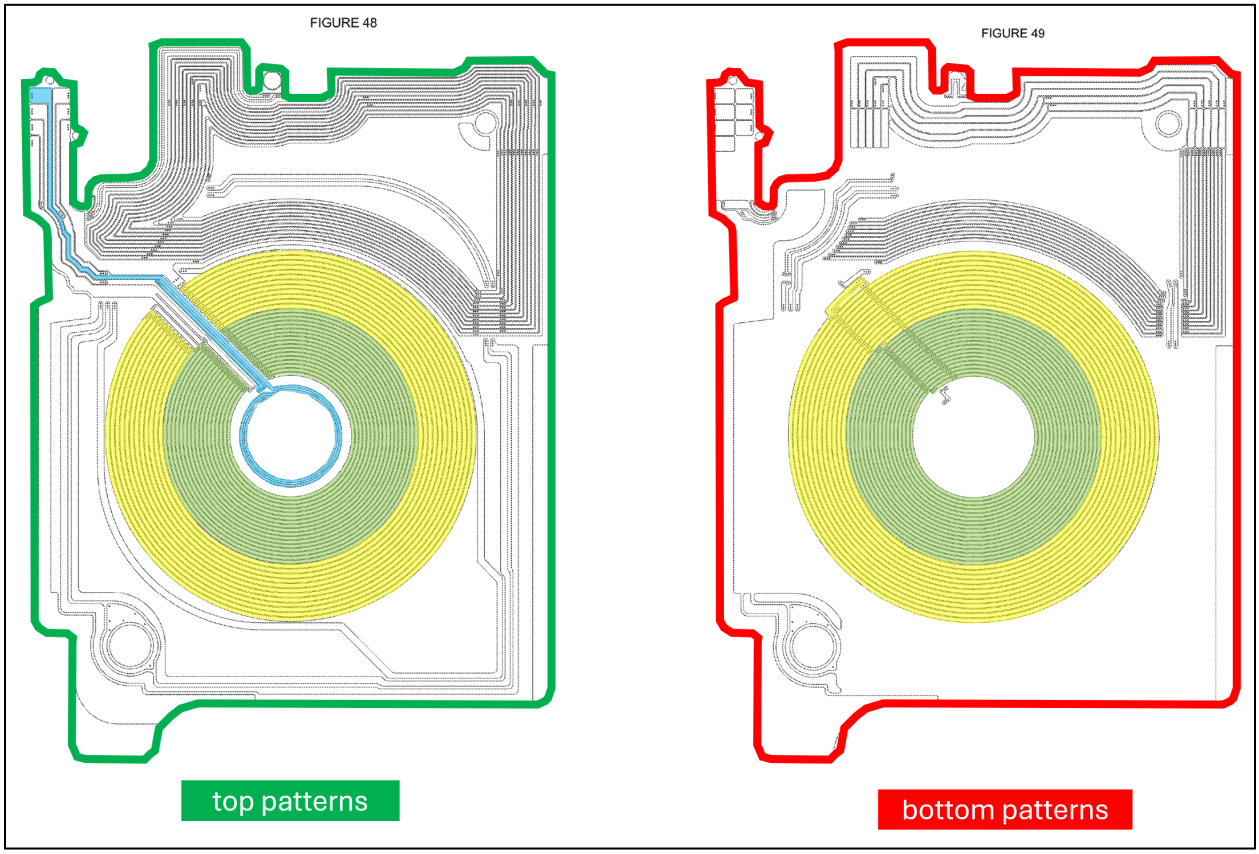
VII. BACKGROUND OF THE ’564 PATENT

53. The ’564 Patent is titled “Smartphone Antenna In Flexible PCB.” Ex1001, Title. The ’564 Patent states that it issued on August 15, 2023, from U.S. Patent Application No. 17/955,126, filed on September 28, 2022. *Id*., Cover. The ’564 Patent also states that it claims priority to provisional application No. 62/941,636, filed on November 27, 2019. *Id*.

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A. Summary of the '564 Patent's Specification

54. The '564 Patent identifies "spaces for installing an NFC antenna or MST antenna are limited" in smartphones as a problem that the '564 Patent contends requires "additional efforts for designing antennas' structures and layout of components in smartphones," and the '564 Patent purports to solve this alleged problem by shaping and arranging "coil antenna patterns" (shown below in **yellow**, **green**, and **blue**) on overlapping portions of both a "**top**" and a "**bottom**" surface of a PCB and "electrically connect[ing]" them "through a plurality of vias":



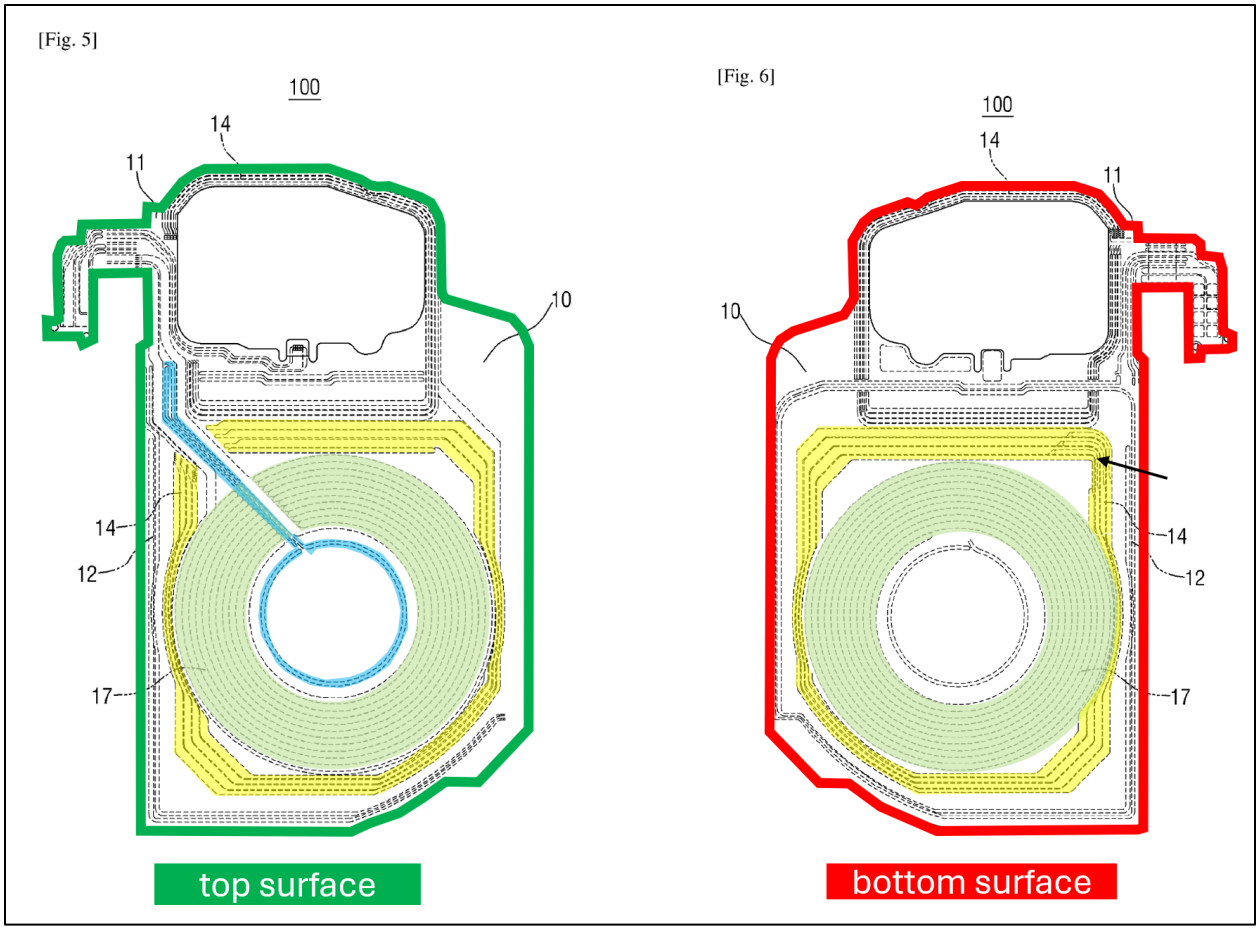
’564 Patent, 41:50-42:4, Figs. 48-49[6].

55. In my opinion, each of the antenna components, shapes, and layouts claimed by the ’564 Patent were well-known in the art. For example, it was well known by November 27, 2019 (the earliest claimed priority date of the ’564 Patent) to form wireless-communication antennas (including NFC (Near Field Communication), MST (Magnetic Secure Transmission), and WPC (Wireless Power Charging)) on both sides of an antenna module substrate. In my opinion, this art renders obvious each and every Challenged Claim.

56. As one example, Seong taught an essentially identical layout used to address the same space-efficiency problem as the ’564 Patent purports to solve:

[6] All annotations added.

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Seong, Figs. 5-6 (depicting "**WPC pattern 17**", "**MST pattern 14**", "**NFC pattern 12**").

57. Ahn does too:

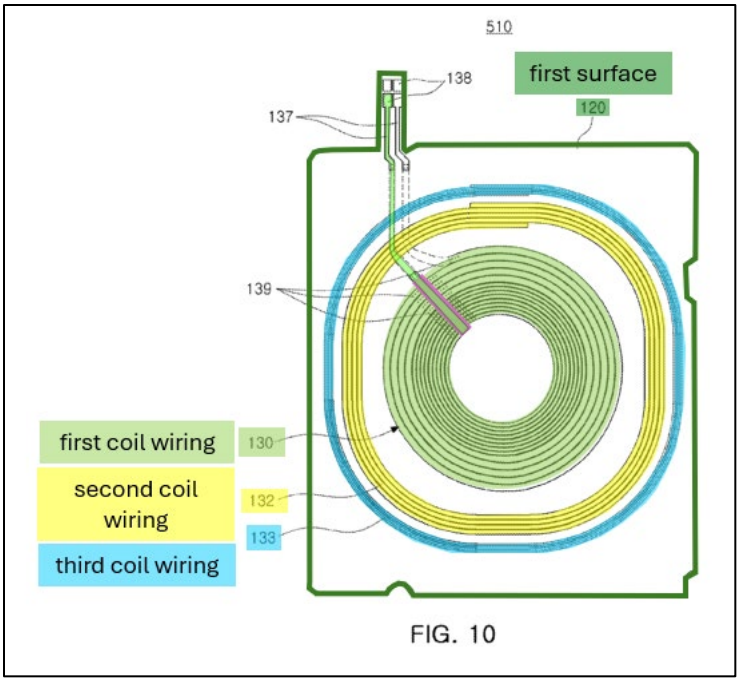


FIG. 10

Ahn, Fig. 10.

58. So, too, does 005Lee:

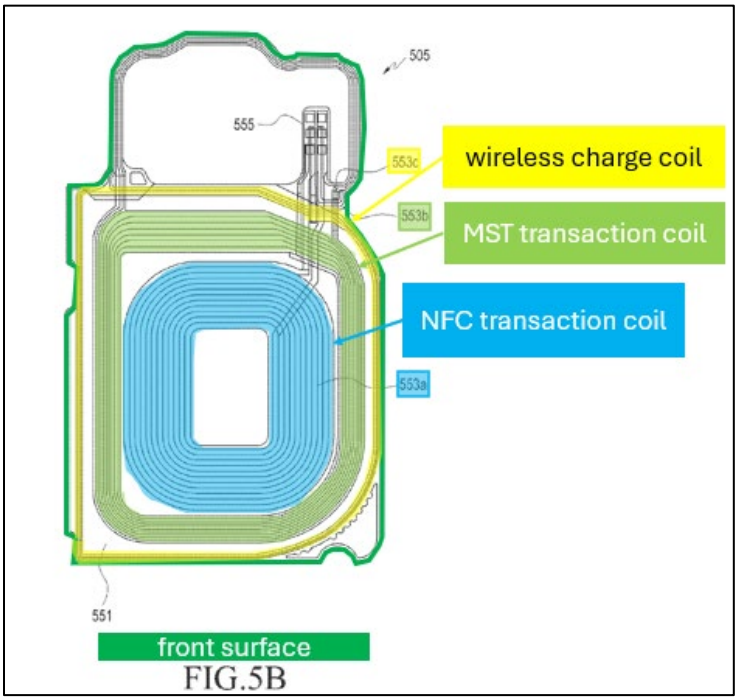


FIG.5B

005Lee, Fig. 5B.

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B. Prosecution History of the ’564 Patent

59. I have reviewed the prosecution history of the ’564 Patent. The following is my understanding:

60. During prosecution, the Examiner allowed the ’564 Patent’s claims without any prior-art-based rejections. Ex1004. The Examiner’s Reasons for Allowance stated that the following was “not found in the prior art of record”:

> the outer antenna pattern comprising a plurality of concentric circular lines and defining a radially-extending outer gap into which the plurality of concentric circular lines of the outer antenna pattern does not extend, wherein at least part of the concentric circular lines of the outer antenna pattern overlaps the outer coil formed on the first major surface and is connected to the outer coil through vias, wherein at least part of the concentric circular lines of the outer antenna pattern generally surround at least part of the concentric circular lines of the inner antenna pattern, whereinthe radially-extending outer gap and the radially-extending inner gap are connected and aligned in a direction

Ex1004, 222-223.

61. As I explain in this Declaration, in my opinion these limitations were well-known in the art and were taught by the references identified herein.

C. Priority Date of the Challenged Claims

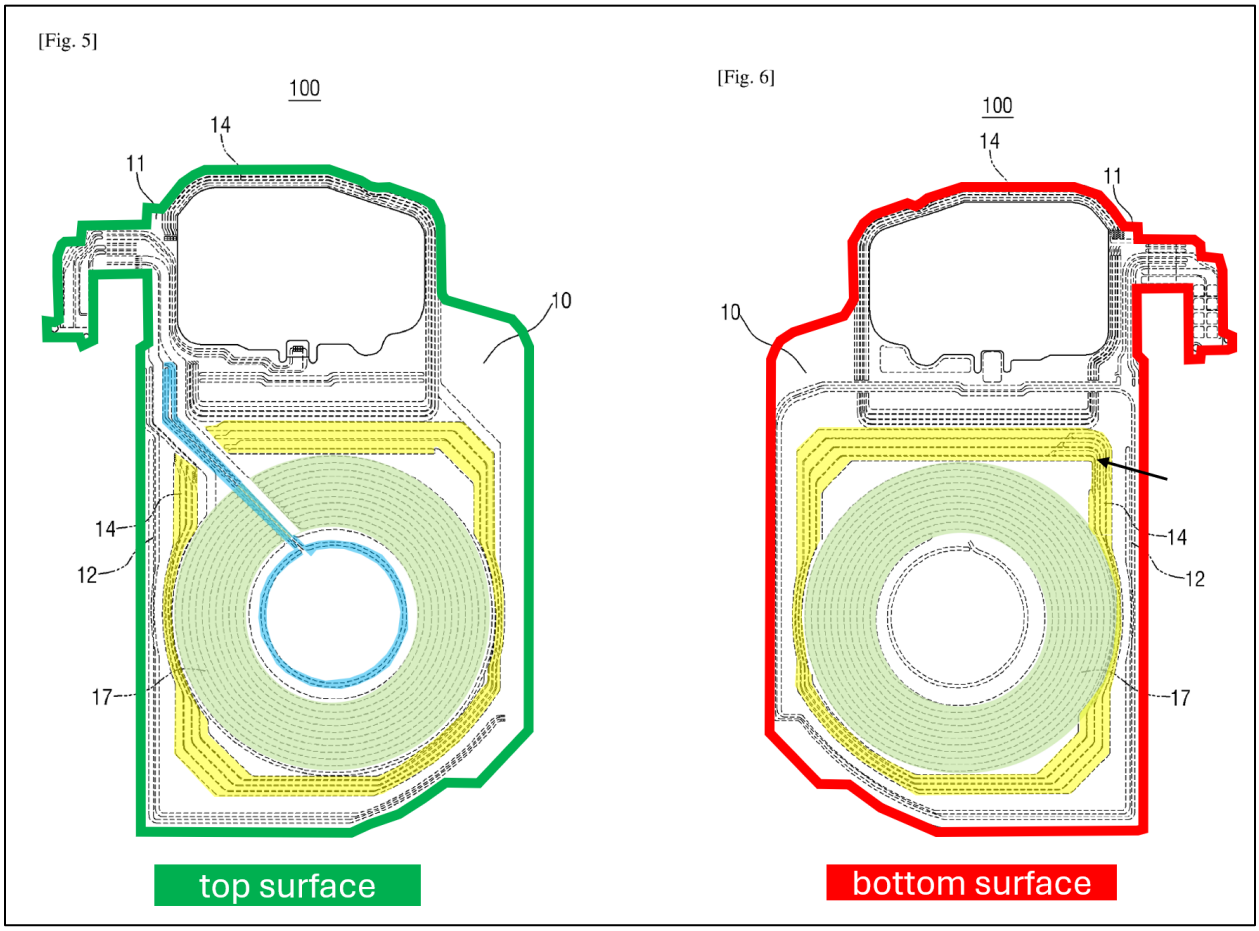
62. For the purposes of my analysis, I have been instructed to apply, and have applied a priority date of November 27, 2019 for the Challenged Claims.

VIII. BACKGROUND OF THE PRIOR ART

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A. Seong

63. Seong is a PCT application from 2017 that teaches an "antenna structure" for "smartphones":



Seong, Abstract, Fig. 5.

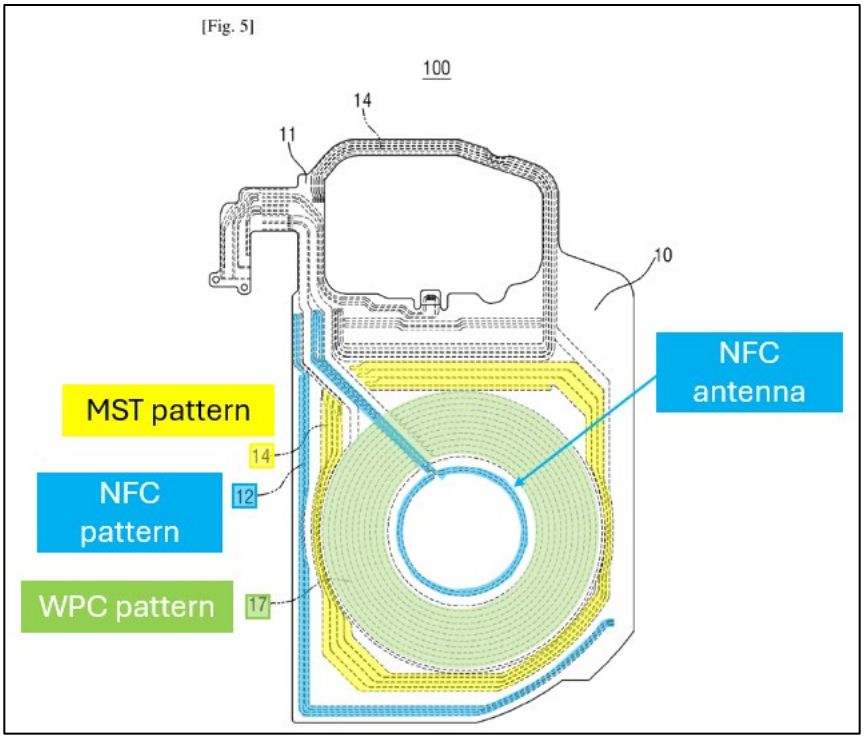
64. The Seong reference addresses the identified problem of limited space in smartphones for antenna modules by teaching an antenna module containing multiple antennas that are formed on the top surface and on the bottom surface of a single "substrate" in order to "reduce the overall size of the antenna structure" and "to efficiently use the internal space" of a

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smartphone. Seong, Abstract, ¶¶9-12, 16-17, 34-42, 63-69, 74, 80, Figs. 5-15, 17, Cls. 1, 6-7.

65. Seong teaches the use of multiple types of antenna patterns. These include NFC (Near Field Communication), MST (Magnetic Secure Transmission), and "WPC (Wireless Power Charge)." Seong, Abstract, ¶2. Seong's figures depict a circular "**WPC pattern 17**" and further depict that the innermost portion of an "**NFC pattern 12**" is circular too, as shown below. Seong, Fig. 5. Seong also depicts an "**MST pattern 14**" that includes rounded portions and generally follows the shape of the substrate. *Id.* However, Seong explains that, "to produce optimal performance, … the shape and layout arrangement of the antenna patterns may be varied as needed," which, in my opinion, a POSA would have known was common:

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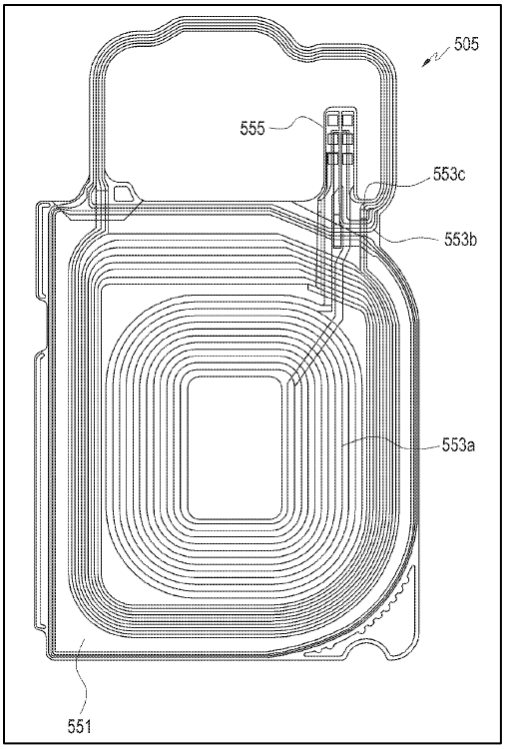


Seong, Fig. 5, ¶63.

B. 005Lee

66. 005Lee is an April 2019 U.S. patent. 005Lee teaches a smartphone antenna module that has multiple coil antenna patterns that are formed on a "front" and a "back" surface of a substrate:

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005Lee, 17:4-19, Fig. 5B.

67. 005Lee addresses the identified problem of limited space in smartphones by teaching multiple antennas formed on the "front" and the "back" surface of a "flexible printed circuit board":

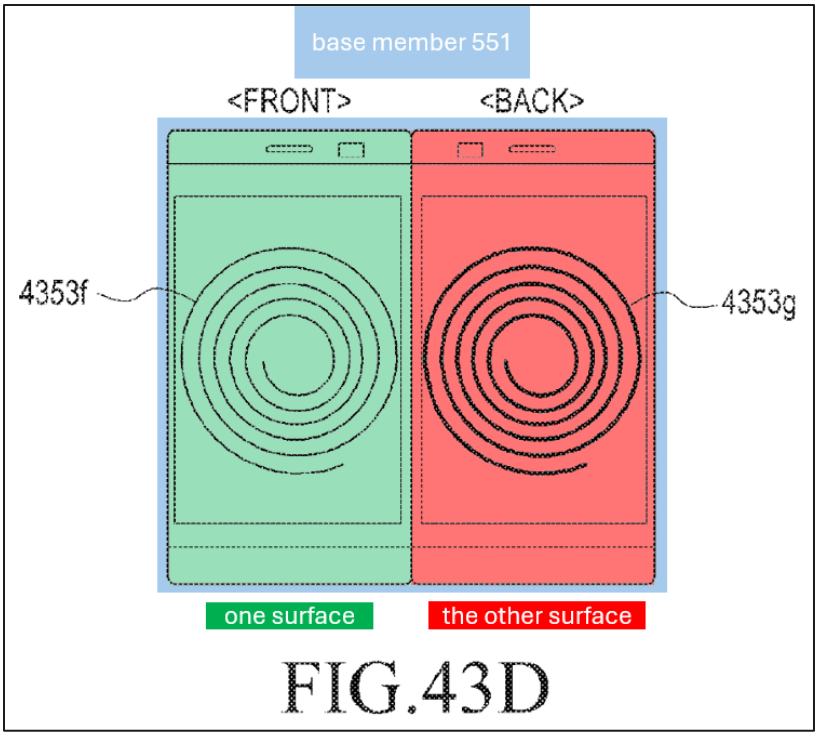


FIG.43D

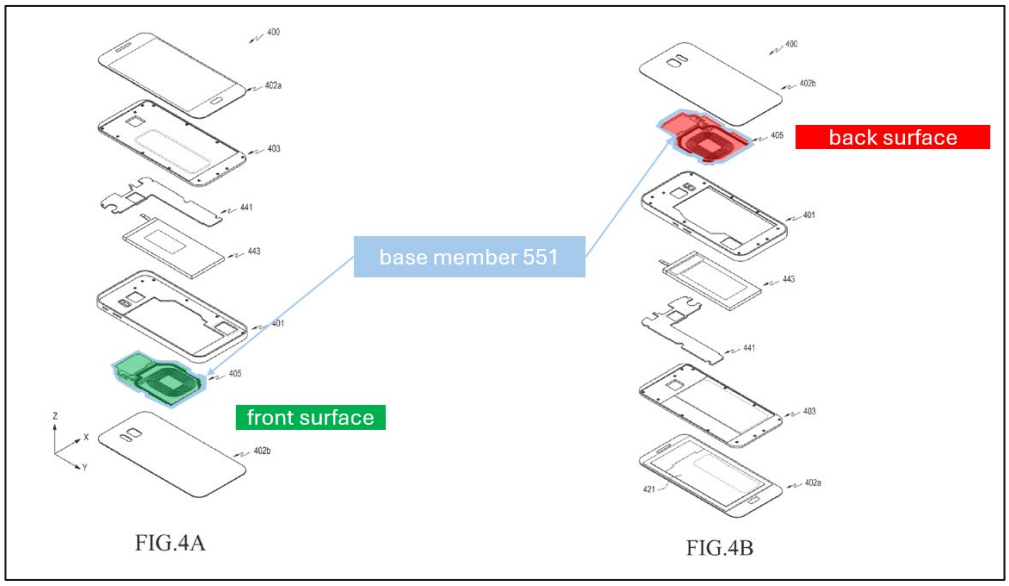


FIG.4A FIG.4B

005Lee, 17:24-28, 49:55-62, Figs. 4A-4B, 43D.

68. 005Lee teaches that that its coil antenna patterns may function as a NFC, MST, and as a "**wireless charge coil**," and 005Lee further teaches that those coil antenna patterns "can be configured in the form of a circle, and

all the centers of the circles of respective coils coincide with each other":

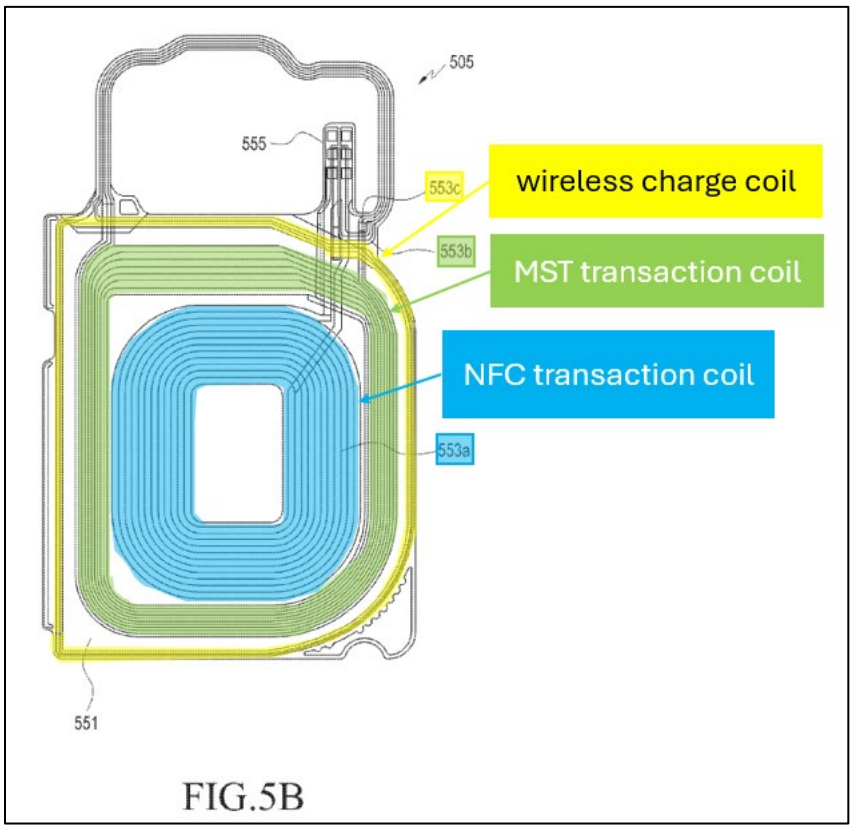


FIG.5B

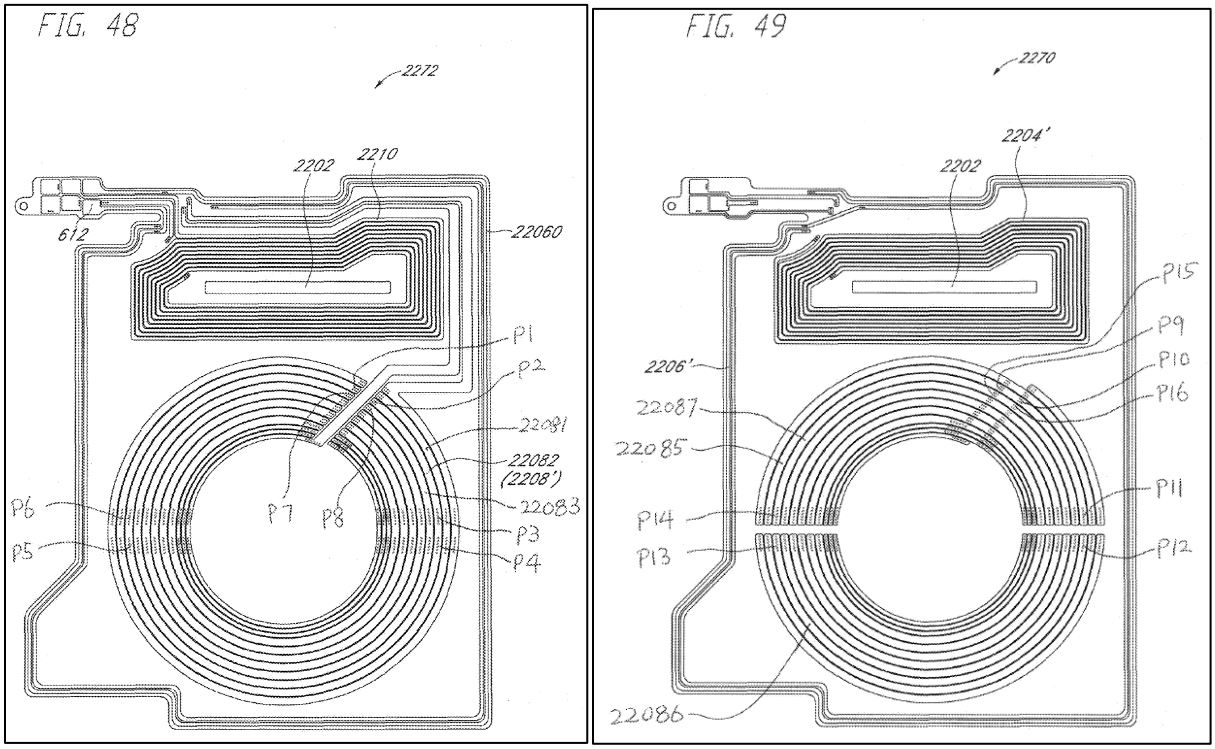
005Lee, 17:67-18:4, 19:28-35.

C. Kang

69. Kang is a 2018 published U.S. patent application that shares a nearly identical specification as the '564 Patent. Kang, Cover; Ex1013. The only differences are approximately one column of disclosure added at the very end of the '564 Patent's specification (the '564 Patent adds the second half of column 41 and the first half of column 42) and a few figures (the '564 Patent adds '564 Patent Figs. 45-55 while removing Kang Figs. 15-20). *Id.* Kang teaches an "antenna module … for use in a smartphone" as shown

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below:



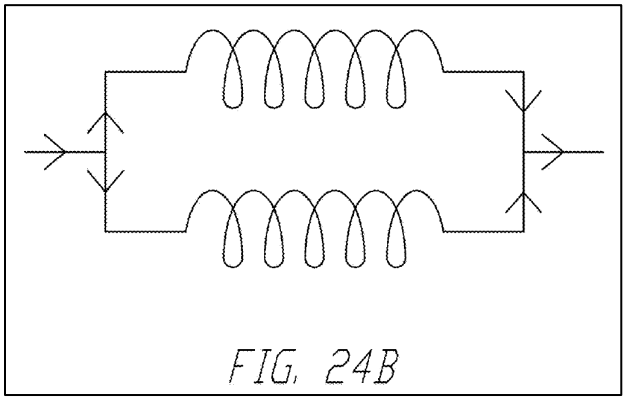
Kang, Abstract, Figs. 48-49.

70. Kang addresses the identified problem of limited space by providing "improved layout[s]" and "shape[s]" for three or more coil antenna patterns that may be in a shape that is "different from that of the periphery of the PCB," including, for example, "a circular-spiral shape." Kang, ¶¶33, 179, 248, 249. Kang additionally teaches that the three-or-more coils can be concentric, and Kang also teaches that each coil can be "one of an MST antenna, an NFC antenna and … wireless charging antenna." *Id.*, ¶¶216, 238, 259, Fig. 49. Additionally, Kang teaches forming coil antennas on both "a first major surface and a second major surface facing away from

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the first major surface" of "a flexible PCB," and Kang also teaches connecting coils using "vias." *Id.* ¶¶5-15, 76, 174-75, 231, 247-49, 261, 263, Figs. 46, 48-49, Cl. 6.

71. Also, Kang teaches that "[t]o form a connected-in-parallel coil antenna as shown in FIG. 24B the two coils may be connected in parallel," as Kang shows below in Figure 24B:

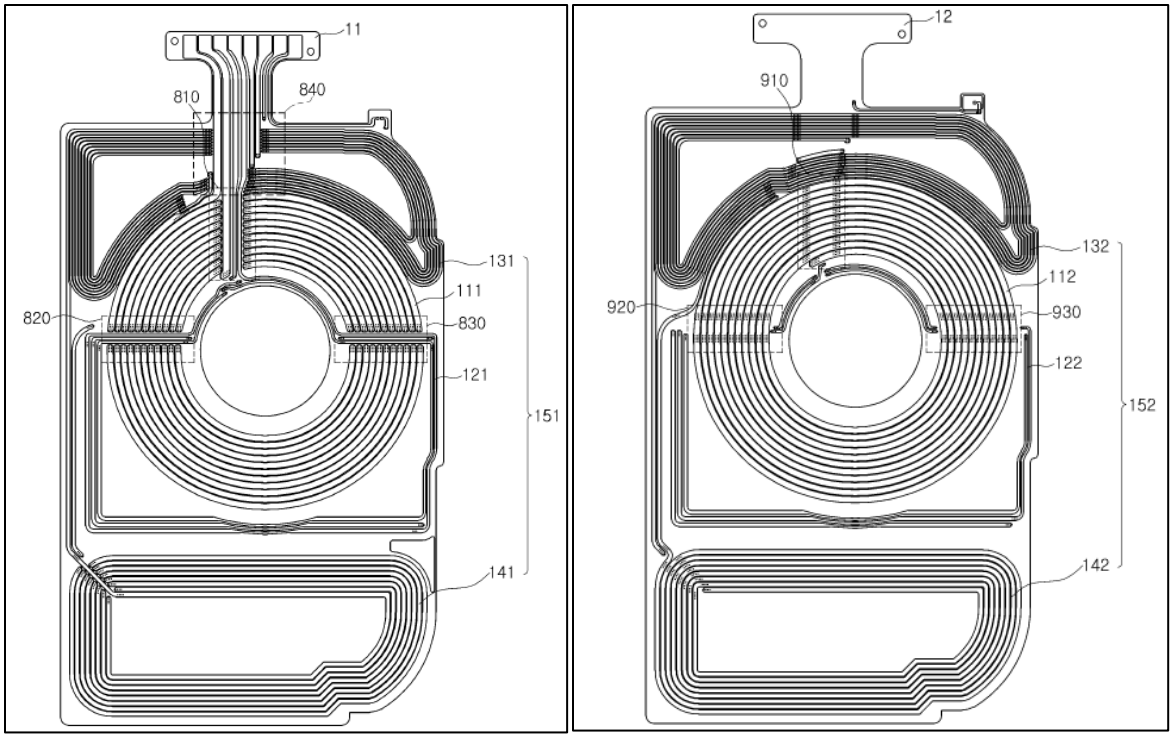


Kang ¶¶214, 217, Fig. 24B.

D. Cho

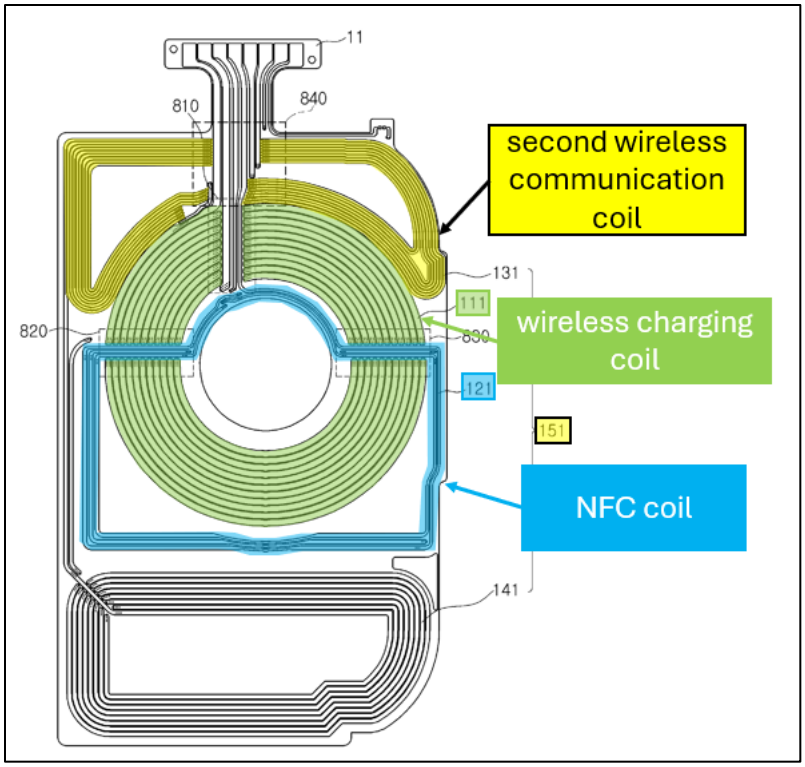
72. Cho is a 2017 Korean published patent application that teaches a smartphone "coil module":

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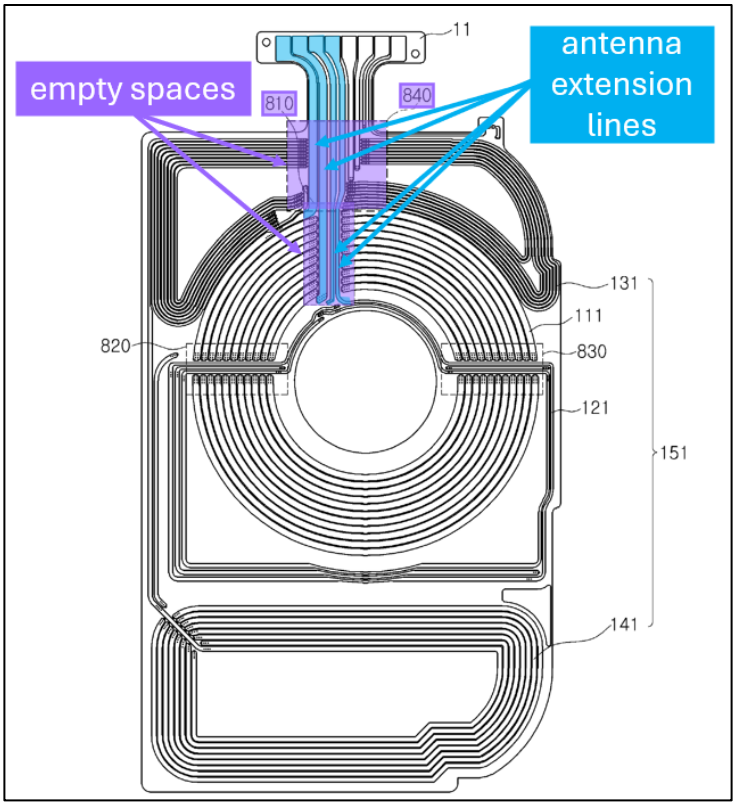
Cho, Figs. 8-9.

73. Cho addresses the identified problem of limited space in smartphones by teaching a smartphone antenna module that has various "types of coils for wireless communication"—including "**NFC**," the "**wireless charging coil**," and the "**second wireless communication coil**"—and Cho further teaches that these coils can be formed on "both sides of the substrate":



Cho ¶¶3, 4, 5, 9, 75, 79, Fig. 8.

74. Cho additionally teaches that those coil patterns can be connected using "a plurality of vias." *Id.*, Cls. 2, 10. To further improve coil space efficiency, Cho additionally teaches the use of connected and aligned "**hollow spaces**," "**empty spaces**," or "**spaced apart spaces**" (i.e., gaps) in the coils through which **antenna extension lines** run, as I show in the annotated figure below:



Cho, Fig. 8, ¶¶64, 68, 72.

E. Ahn

75. Ahn is an April 2019 U.S. patent application publication that teaches a smartphone "antenna" "coil assembly," as shown below:

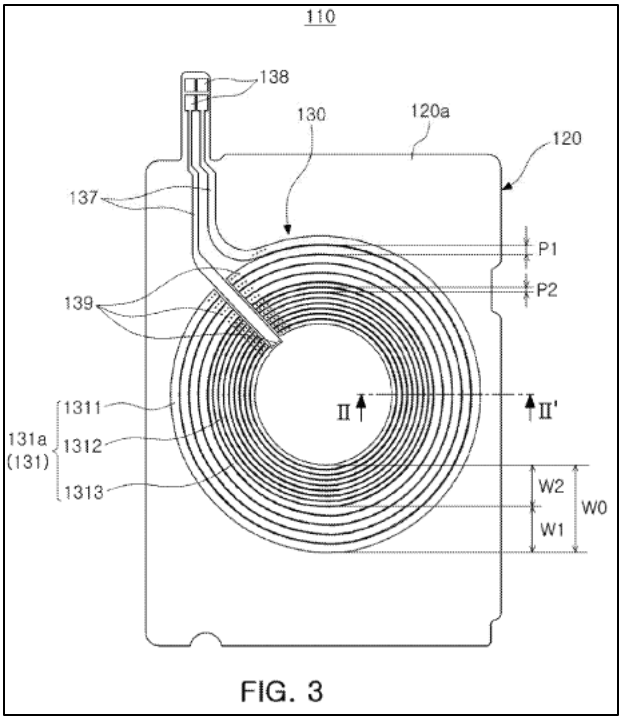


FIG. 3

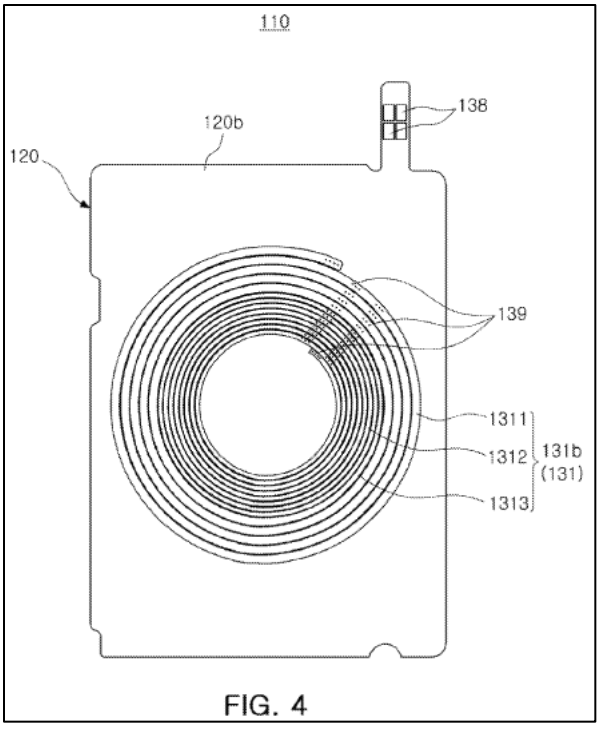


FIG. 4

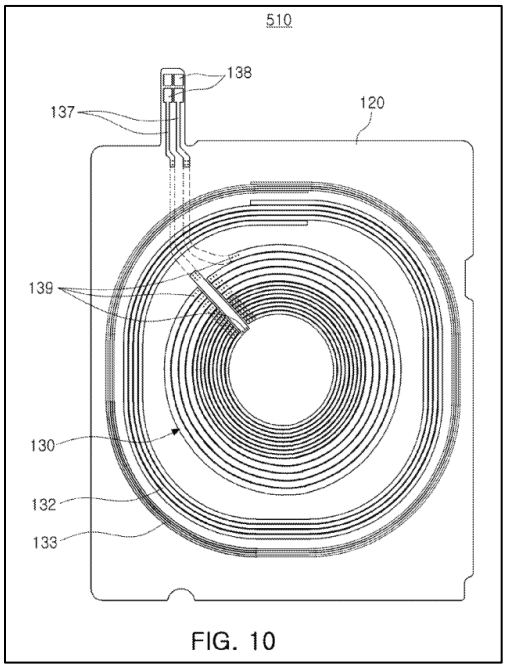


FIG. 10

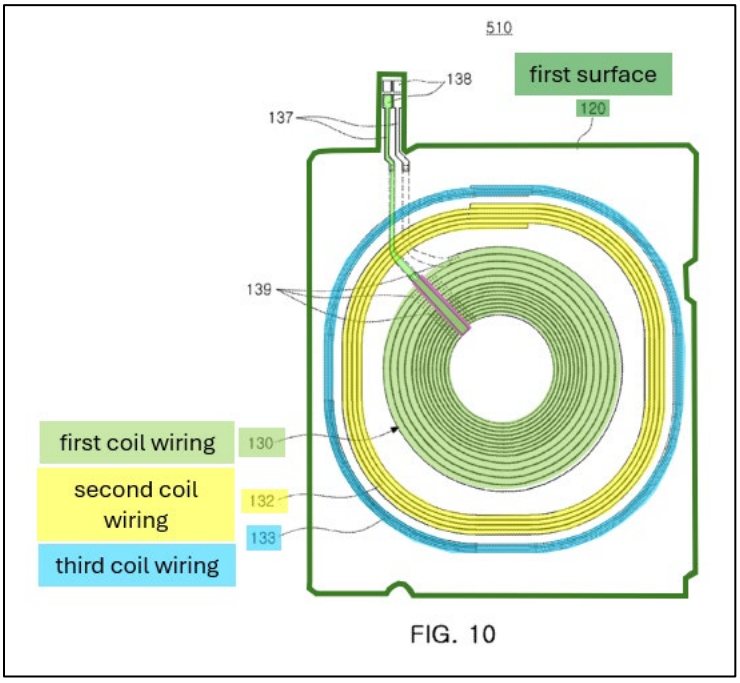
Ahn, Abstract, ¶¶23, 47-48, 125, Cl. 18, Figs. 3-4, 10.

76. Ahn addresses the identified problem of limited space in smartphones by teaching multiple antennas that are formed on a "first surface 120a" and

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on a "second surface 120b" of a "substrate 120." Ahn, ¶¶4, 27-28, 65, 68, 71, 99-100, 127, Figs. 3-4, 10.

77. Ahn explains that its antenna module may have different types of coils for wireless communication. These include NFC, MST, "**wireless charging**" and "radio frequency identification (RFID)," as shown in the annotated figure below:

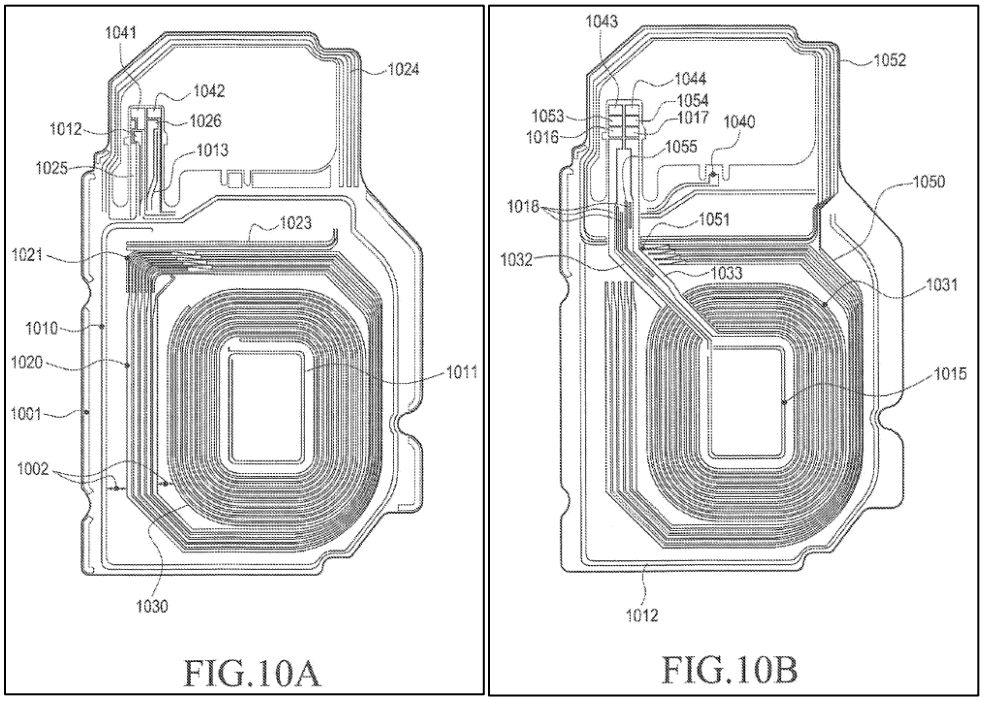


Ahn ¶¶18, 23, 125, Fig. 10.

78. Ahn teaches that that "both ends" of each of these coil wirings "need to be connected to the connection pads 138," and Ahn further teaches that this connection can be accomplished by running "lead wirings 137" through a "disconnection region" of the coils in a "diameter (radial) direction." Ahn ¶¶72-73, 124-25, Fig. 10.

F. 721Lee

79. 721Lee is a 2017 U.S. patent application publication that teaches an antenna module for a smartphone, as shown below:



721Lee, Figs. 10A-10B.

80. 721Lee addresses the identified problem of limited space in smartphones by teaching "a plurality of coils that are disposed on a first layer … [and] a plurality of coils that are disposed on a second layer," and that the "coils disposed on the first layer and the second layer [] overlap[] each other." 721Lee, ¶¶12, 122, Figs. 6A-6B.

81. 721Lee teaches forming a "plurality of coils" on multiple parallel layers, including "**MST coil 1021/1050**," "**wireless charging coil 1030/1031**," and "**NFC coil 1011/1015**," as shown in the annotated figures below:

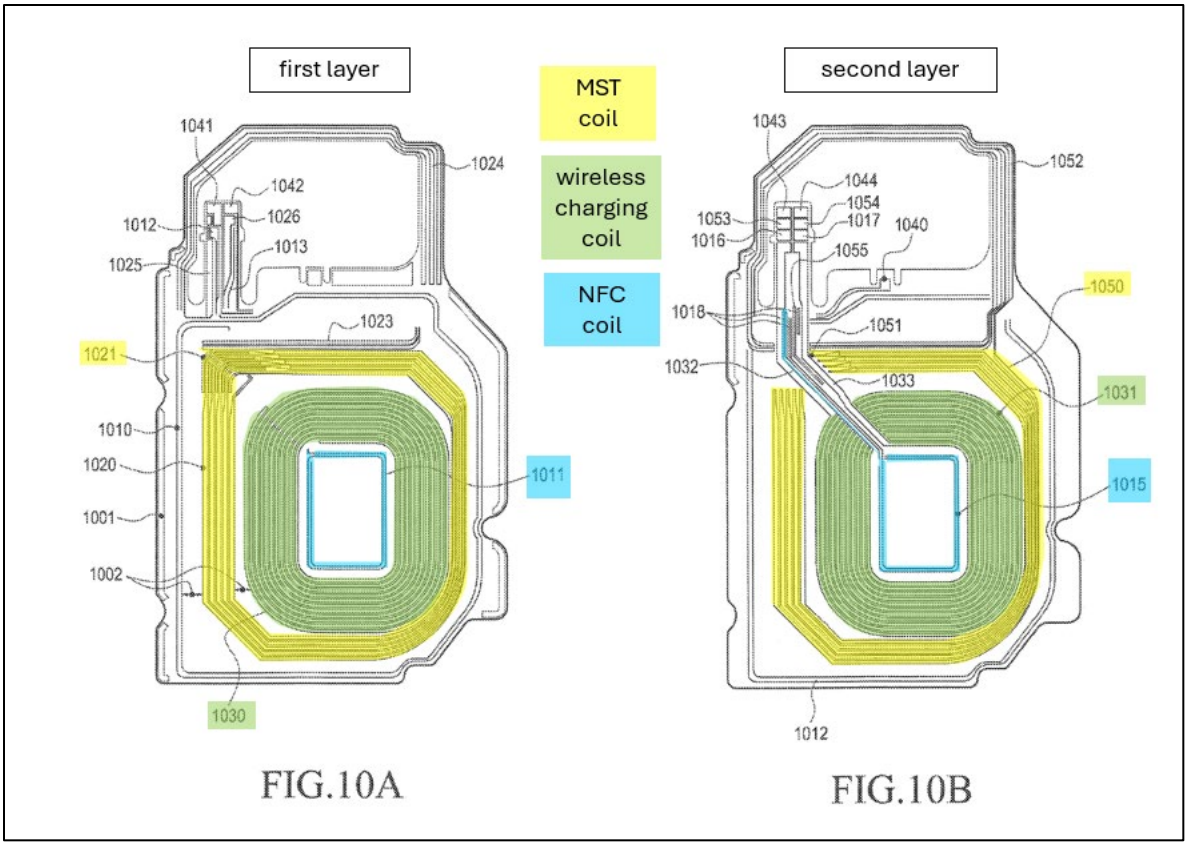


FIG.10A FIG.10B

721Lee, Abstract, ¶¶28-29, Figs. 10A-10B.

82. 721Lee teaches that its coils "may have the **opened loop** form," such that the coils have connected and aligned radially-extending gaps through which the coils "may be connected to the input/output terminals" using extension lines, as shown in the annotated figure below:

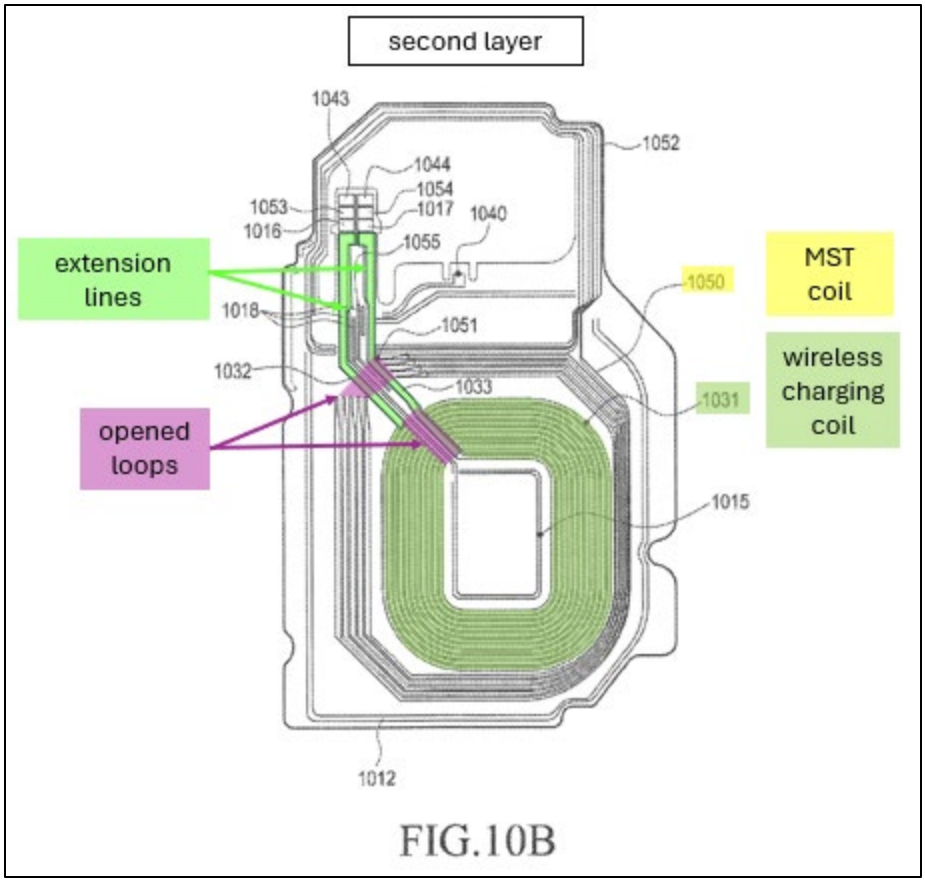


FIG.10B

721Lee, ¶140, Fig. 10B.

IX. CLAIM CONSTRUCTION

83. I am unaware of any claim construction determinations related to the '564 Patent.

84. For purposes of this proceeding, I have been asked to consider, and have considered, whether the Challenged Claims are invalid as obvious under their plain and ordinary meaning.

X. INVALIDITY OPINIONS: '564 PATENT

85. In my opinion, the Challenged Claims of the '564 Patent are invalid based on the following references and combinations: the combination of Seong,

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Kang, and Cho render obvious the Challenged Claims; the combination of Ahn and 721Lee render obvious the Challenged Claims; the combination of 005Lee, Seong, and Ahn render obvious the Challenged Claims; and it would have been obvious to a POSA to combine the teachings of these references.

86. As part of my obviousness analysis, I have considered the scope and content of the prior art, and whether any differences between the alleged invention and the prior art are such that the subject matter, as a whole, would have been obvious to a person having ordinary skill in the art at the time of the alleged invention, which I have been asked to assume was November 27, 2019, for the Challenged Claims of the '564 Patent, as discussed above. I have also considered the level of ordinary skill in the pertinent art.

87. I describe in detail below the scope and content of the prior art, as well as any differences between the alleged invention and the prior art, on an element-by-element basis for each Challenged Claim of the '564 Patent.

A. Ground 1: Seong Renders Claims 1-22 Obvious In View Of Kang And Cho

1. A POSA Would Have Been Motivated To Combine The Teachings Of Seong, Kang, And Cho

88. These references overcome limited space in smartphones with space-

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efficient WPC, NFC, and MST antennas, optimizing shape and layout, placing coils on both sides of a substrate. Section VIII. In my opinion, a POSA reading Seong would have been motivated to incorporate Kang's and Cho's teachings. All three references teach antenna patterns on both sides of a substrate in a smartphone, including WPC, NFC, and MST antennas. Ex1006, Abstract, Figs. 5-6, ¶¶63-64; Ex1012 ¶¶262-263, Figs. 46, 48-49, Cl. 6; Ex1010 ¶¶63-69, Figs. 8-9. If Seong is found to not expressly teach a claimed limitation, as discussed below, in my opinion, it would have been obvious to a POSA to adopt well-known, predictable, and finite approaches taught by Kang and Cho to Seong's substrate to achieve wireless communication functions in a space efficient module.

89. ***First***, Seong's antenna patterns on its substrate's top and bottom surfaces are connected through vias. Ex1006 ¶¶4, 33-34, 77, Figs. 5-6. Further, in my opinion, a POSA would have found connections by vias obvious in view of Kang and Cho. Ex1012 ¶263, Cl. 6; Ex1010 Cl. 2, 10; ¶¶66-67, 73. Via-connected coils can have increased surface area and improved communication performance in a space-efficient manner.

90. In my opinion, a POSA would have reasonably expected success. Vias were common and would have been obvious to try as there were a finite number of predicable solutions for connecting antenna patterns on

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different surfaces.

91. ***Second***, in my opinion, a POSA would have been motivated to use concentric, circular-shaped coils for Seong's WPC and MST patterns, as Kang teaches, and to connect and align their radially extending gaps, as Kang and Cho teach. In my opinion, a POSA reading Seong's teaching that coil "shape and layout" "may be varied," Ex1006 ¶63, and reviewing Seong's depiction of WPC pattern 17 as circular, *id.*, Figs. 5-6, would have understood MST patterns with concentric circles were common and space-efficient. Further, in my opinion, a POSA would have been motivated to look for references teaching layouts furthering Seong's space-efficiency goal, including Kang and Cho. Ex1012 ¶¶3, 179, Figs. 46, 48-49; Ex1010 ¶¶5, 9. Kang furthers that goal with concentric coils shaped "different from that of the periphery of the PCB," including "circular-spiral shape[s]." Ex1012 ¶¶248-49, Figs. 43, 46, 48-49. Kang and Cho also further Seong's space-efficiency goal with connected and aligned inner and outer gaps, which, similar to Seong's disclosure, let extension lines through. Ex1012 Figs. 48-49; Ex1010 Fig. 8, ¶¶64, 68, 72.

92. In my opinion, a POSA would have reasonably expected success. There were a finite number of predictable coil shapes and arrangements, and concentric circles were common and yielded predictable results. Seong

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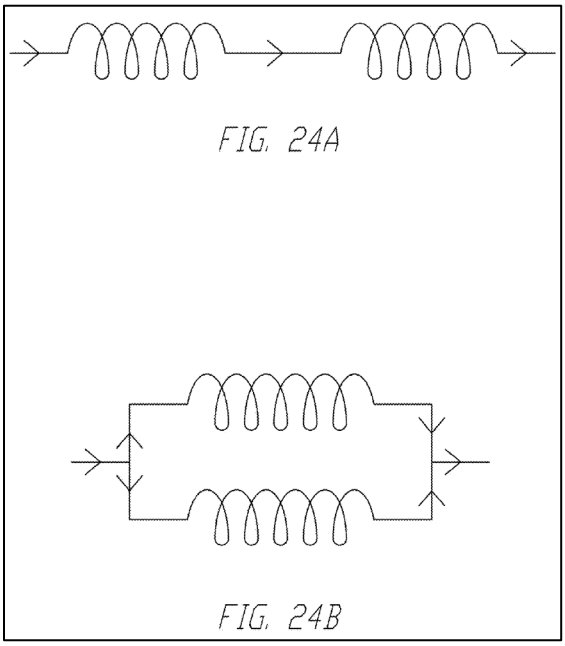
teaches circular coils, including WPC antenna 17, and teaches other shapes could be used. Ex1006 ¶63, Figs. 5-6. Kang teaches using "different" coil shapes, including concentric circles. Ex1012 ¶¶33, 179, 248-49, Fig. 43, 46, 48-49. It was well-known that coils "can be wound in a variety of shapes," including "circular." Ex1010 ¶¶37, 57, Cls. 6, 14.

93. ***Third***, in my opinion, a POSA would have been motivated to electrically connect Seong's WPC and MST patterns in parallel. In my opinion, a POSA would have understood parallel connections may be more secure, and thus preferable for high-security, close-distance transactions, such as NFC payment transactions. Seong does not explicitly disclose how its WPC and MST patterns are electrically connected. In my opinion, a POSA would have been motivated to look to references teaching how to electrically connect inner and outer coils. Kang teaches such coils can be electrically connected for improved performance[7] and flexibility and in

[7] Operating the two coils in parallel offers improved flexibility and performance, for example, by providing a larger active area over which to perform wireless charging and/or to improve coil efficiency by reducing parasitic series resistance in a parallel combined coil.

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one of two ways[8]—"in series or in parallel"—as shown in the annotated figure below:



Ex1012 ¶¶150, 214, 217, 237, Figs. 24A, 24B.

94. Electrically connecting Seong's WPC and MST patterns in parallel was a simple design choice and would have been obvious to try.

95. In my opinion, a POSA would have reasonably expected success. Parallel

[8] Kang's coils are used in two terminal configuration, that is, with both terminals, as opposed to only one (which is known as a single-ended configuration), being driven. As such, there are only two was to reasonably connect Kang's coils (while preserving its two terminal configuration), either in series, or in parallel, as shown in Figs. 24a and 24b. Kang, Figs. 24A-24B.

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electrical connection was well-known, straightforward, and achieved predictable results.

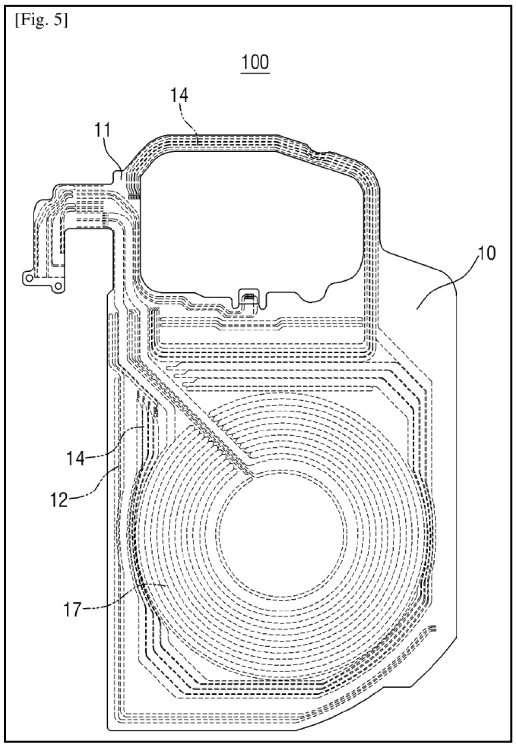
2. [1]

a. [1pre]

Reference Number	Claim Limitation
[1pre]	A smartphone antenna module comprising:

96. In my opinion, to the extent the preamble is limiting, Seong teaches it.

97. Seong teaches a "smartphone[]" "antenna structure [(100)]" as shown in the figure below:



Ex1006 ¶¶2-3, 51-53, Fig. 5.

98. In my opinion, a POSA would have understood that this is a smartphone

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antenna module. For example, it comprises multiple antennas.

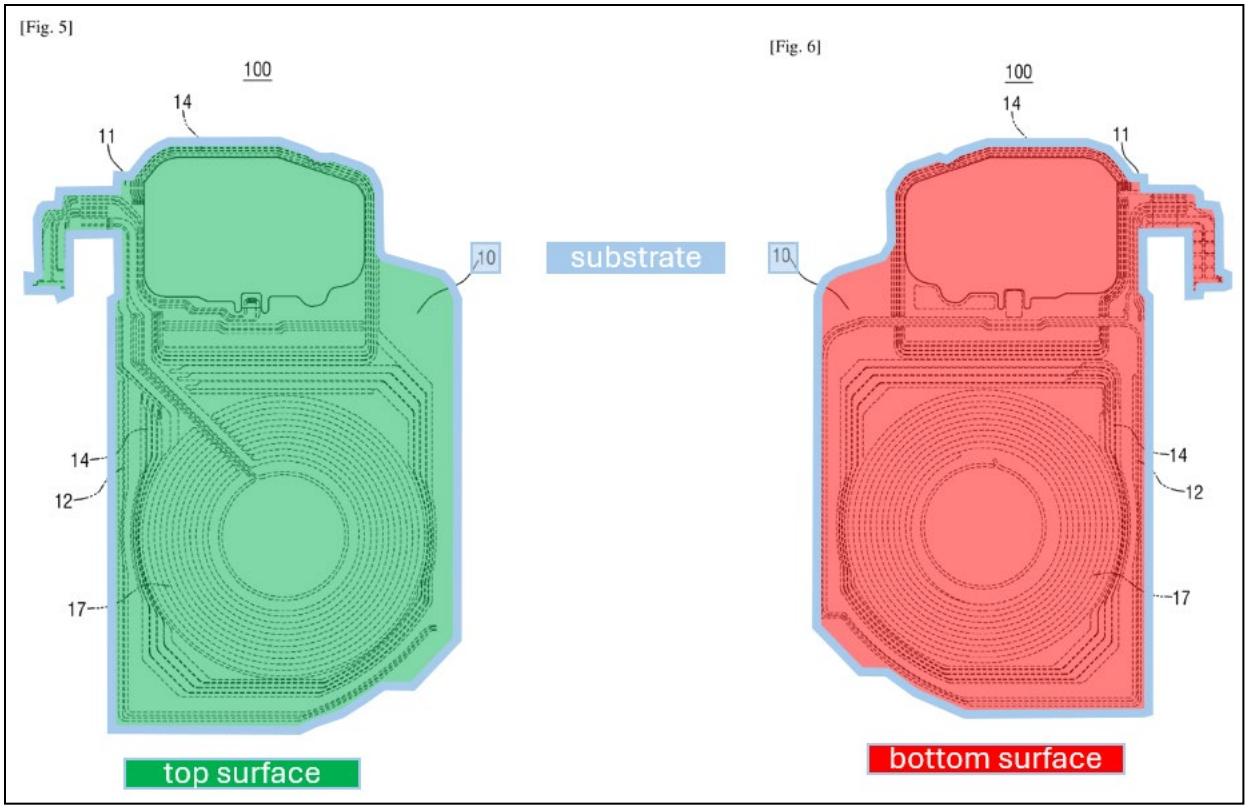
b. [1a]

Reference Number	Claim Limitation
[1a]	a substrate having a first major surface and a second major surface facing away from the first major surface;

99. In my opinion, Seong teaches this limitation.

100. Seong teaches "antenna structure [(100)]" "includes a **substrate [(10)]** having" a "**bottom surface**" (first major surface) and a "**top surface**" (second major surface) on which "NFC pattern, MST pattern, [and/or] WPC pattern may be formed." Ex1006 Abstract, ¶16. The "**top surface**" faces away from the "**bottom surface**" as shown in the annotated figures below:

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Ex1006, Figs. 5 ("antenna patterns formed on the top surface of the substrate"), 6 ("antenna patterns formed on the bottom surface of the substrate"), ¶¶33-34; *id.*, Figs. 7-13.

c. [1b]

Reference Number	Claim Limitation
[1b]	a first antenna pattern formed on the first major surface and comprising an inner coil and an outer coil surrounding the inner coil;

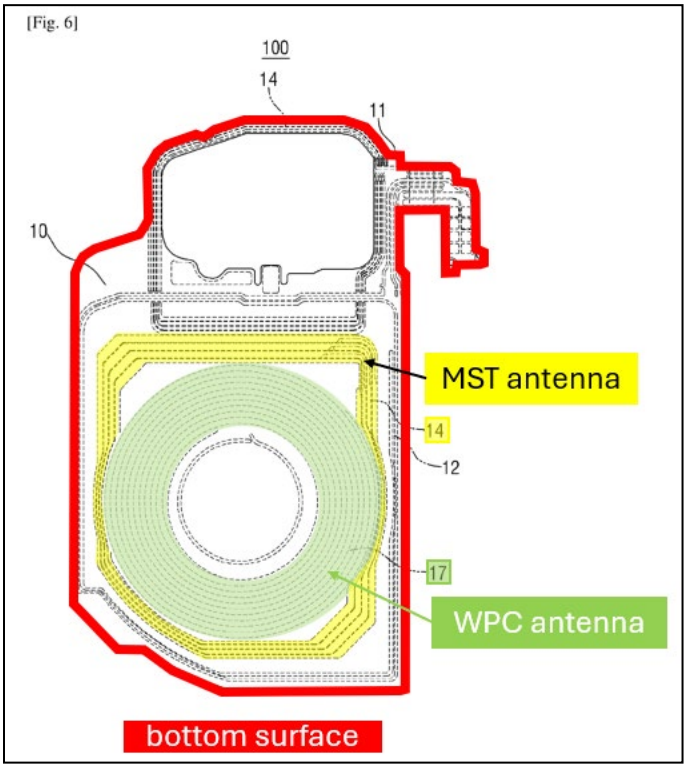
101. In my opinion, Seong teaches this limitation.

102. Seong teaches "a composite antenna structure in which an NFC pattern, an MST pattern, and a WPC pattern are simultaneously formed on a single

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substrate" (first antenna pattern). Ex1006 ¶¶1, 5, 9-10, 12, 34, Abstract, Fig. 6.

103. Seong's first antenna pattern is on the "**bottom surface**" (first major surface) and comprises "**WPC antenna**" (inner coil) and "**MST antenna**" (outer coil) surrounding "**WPC antenna**" as shown in the annotated figure below:



Ex1006, Fig. 6.

104. In my opinion, a POSA would have understood that Seong's MST, NFC, and WPC "antennas" comprise coils, including because Seong depicts coils in Figs. 5-6, 11-13, and 15. Ex1006, Abstract. The '564 Patent similarly describes "MST antenna" and "NFC antenna" as "coil antennas."

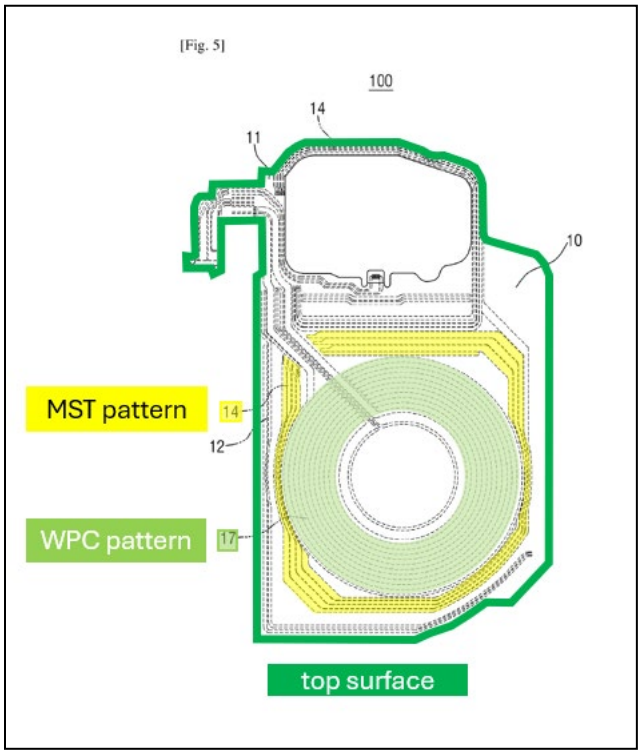
Ex1001, 16:24-27, 30:42-45.

d. [1c]

Reference Number	Claim Limitation
[1c]	a second antenna pattern formed on the second major surface and comprising an inner antenna pattern, and an outer antenna pattern;

105. In my opinion, Seong teaches this limitation.

106. Seong teaches a second antenna pattern on the "**top surface**" (second major surface) comprising "**WPC pattern**" (inner antenna pattern) and "**MST pattern**" (outer antenna pattern) as shown in the annotated figure below:



Ex1006, Figs. 5.

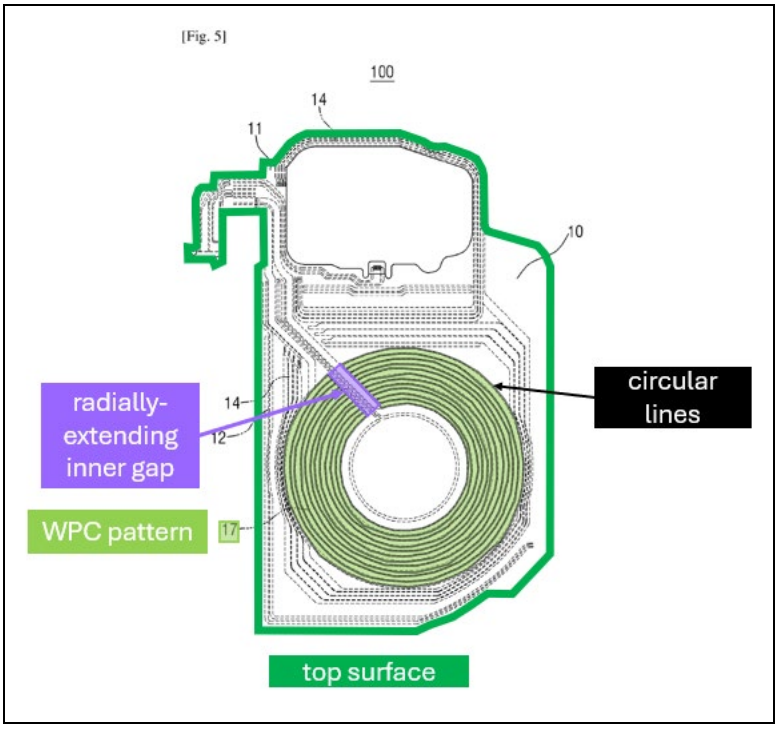
e. [1d]

Reference Number	Claim Limitation
[1d]	the inner antenna pattern comprising a plurality of concentric circular lines and defining a radially-extending inner gap into which the plurality of concentric circular lines of the inner antenna pattern does not extend, wherein at least part of the concentric circular lines of the inner antenna pattern overlaps the inner coil formed on the first major surface and is connected to the inner coil through vias; and

107. In my opinion, Seong teaches this limitation, or alternatively, the Seong-Kang-Cho combination renders it obvious.

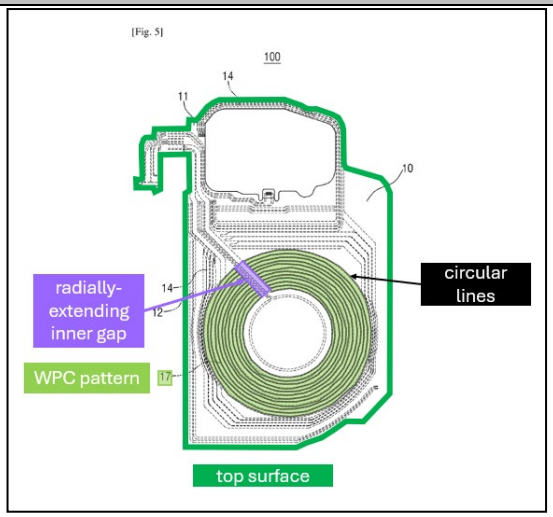
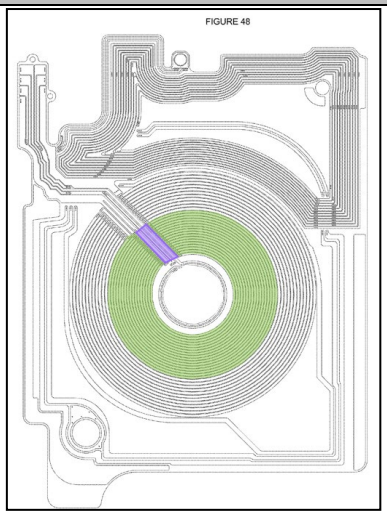
108. Seong's "**WPC pattern**" comprises a plurality of concentric **circular lines** defining a **radially-extending inner gap** into which the plurality of concentric **circular lines** of "**WPC pattern**" does not extend as shown in the annotated figure below:

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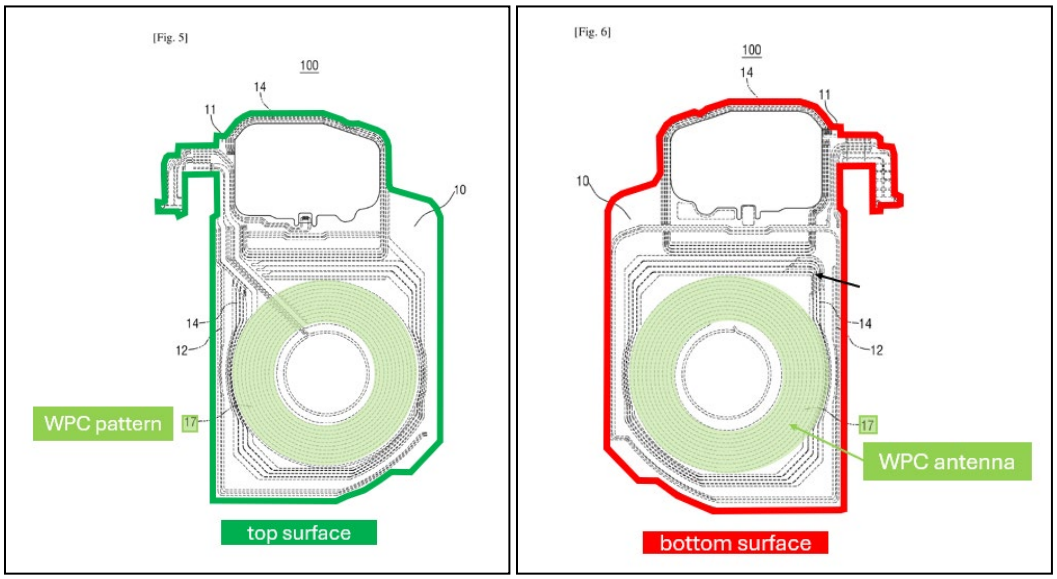


Ex1006, Fig. 5.

109. This is at least as much disclosure as the ’564 Patent as shown in the annotated figures below:

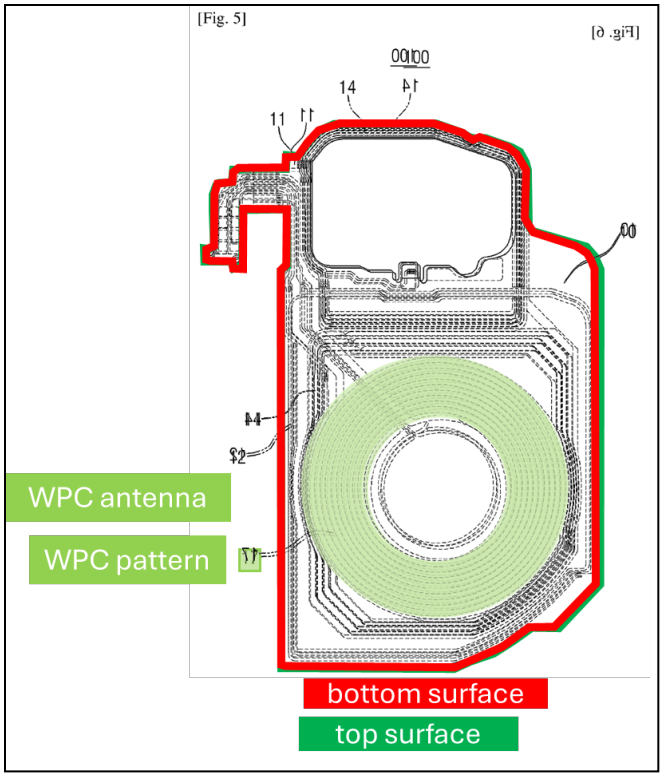
Ex1006, Fig. 5	Ex1001, Fig. 48
	

110. Further, at least part of the concentric **circular lines** of Seong's "**WPC pattern**" on the "**top surface**" (inner antenna pattern) overlaps "**WPC antenna**" on the "**bottom surface**" (inner coil) as shown in the annotated figures below:



Ex1006, Figs. 5, 6.

111. This can be seen by overlaying Seong Figures 5-6 as shown in the annotated figure below:



Ex1006, Figs. 5-6 (inverted and combined).

112. Further, Seong teaches, and the Seong-Kang-Cho combination renders obvious, "**WPC pattern**" on the "**top surface**" is connected to "**WPC antenna**" on the "**bottom surface**" through vias. Seong's coils formed on opposing surfaces of the substrate "are connected to respective terminals" to "be electrically connected to internal [smartphone] components." Ex1006 ¶¶4, 33-34, 77, Figs. 5-6. Seong depicts coils from the same antenna pattern (NFC, WPC, MST) formed on the top and bottom surfaces of the substrate. Ex1006, Figs. 5-8, ¶¶ 63, 65, 68. In my opinion, a POSA would have understood these coils are interconnected through the PCB using vias. Moreover, common sense would dictate that the "**WPC**

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pattern" on the "top surface" (inner antenna pattern) would be connected to the "WPC antenna" formed on the "bottom surface" (inner coil), which it overlaps, with vias, otherwise the "radially-extending inner gap" formed in the inner antenna pattern would mean the "WPC pattern" on the "top surface" (inner antenna pattern) would be inoperable since it would then comprise nothing more than a number of open circuited line segments.

113. In addition, in my opinion, this limitation would have been obvious in view of Kang and Cho. Section X.A.1. Kang teaches electrically antenna patterns on different surfaces to each other through a plurality of "vias." Ex1012 ¶¶76, 231, 247-49, 261, 263, Cl. 6.

114. Cho also teaches electrically connecting antenna patterns on different surfaces to each other through a "plurality of vias." Ex1010 Cls. 2, 10, ¶¶66-67, 73.

f. [1e]

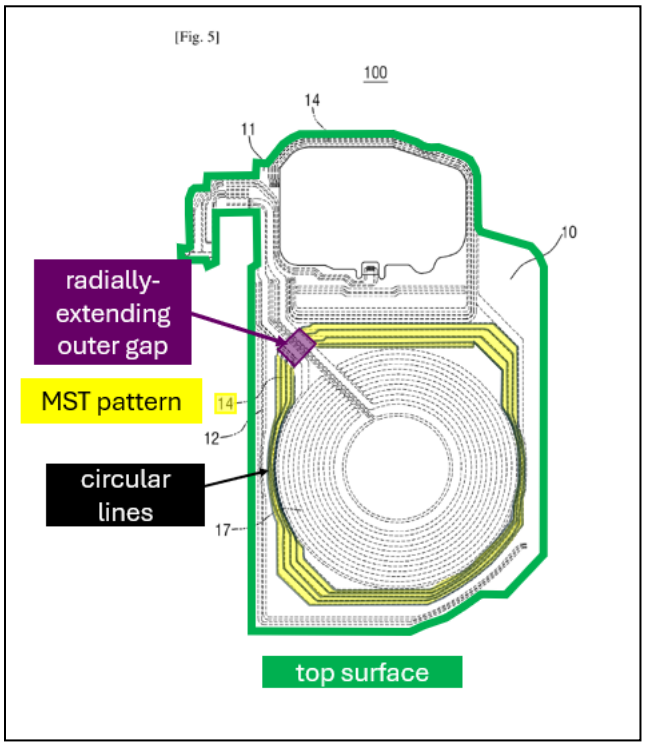
Reference Number	Claim Limitation
[1e]	the outer antenna pattern comprising a plurality of concentric circular lines and defining a radially-extending outer gap into which the plurality of concentric circular lines of the outer antenna pattern does not extend, wherein at least part of the concentric circular lines of the outer antenna pattern overlaps the outer coil formed on the first major surface and is connected to the outer coil through vias,

115. In my opinion, Seong teaches this limitation, and the Seong-Kang-Cho

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combination renders it obvious.

116. Seong's "**MST pattern**" (outer antenna pattern) comprises a plurality of **concentric circular lines** defining a **radially-extending outer gap** into which the plurality of concentric **circular lines** of "**MST pattern**" does not extend as shown in the annotated figure below:

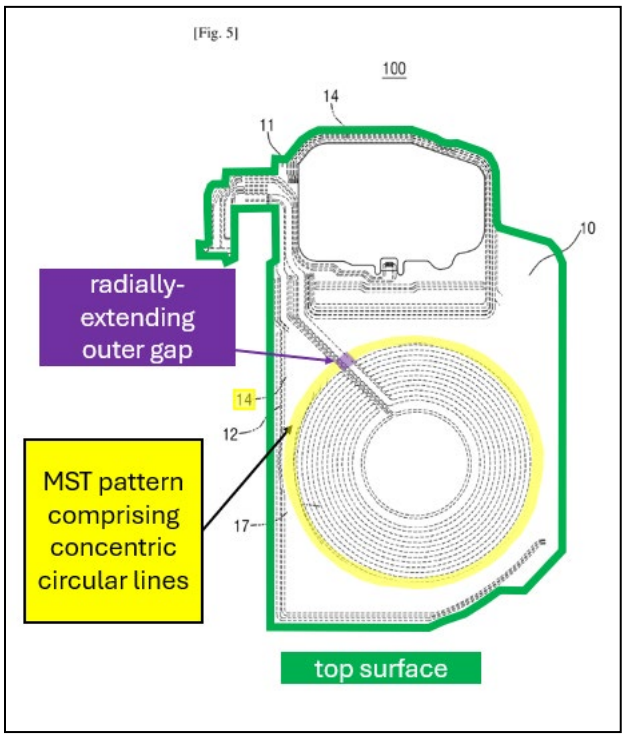


Ex1006, Fig. 5.

117. In addition, in my opinion, a POSA would have found this limitation obvious in view of Seong. Seong's "**WPC pattern**" and "NFC pattern" are "circular" and Figures 5-6's antenna patterns' shapes, including "**MST pattern**," "may be varied as needed." Ex1006 ¶¶63, 66, 75. In my opinion, a POSA would have found it obvious to use a circular shape for Seong's

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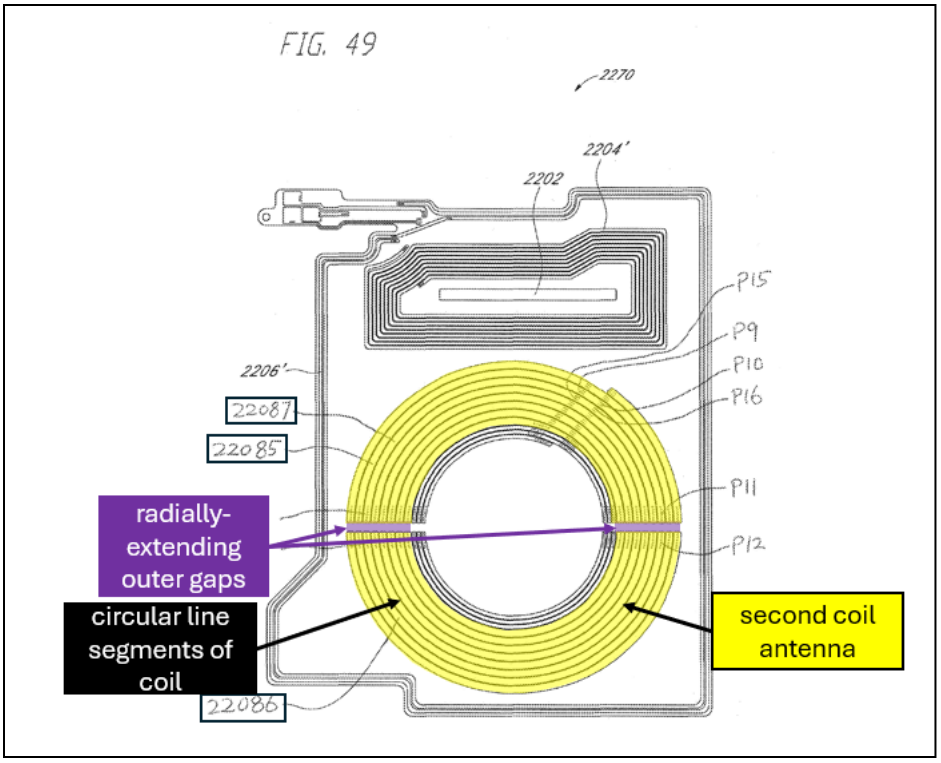
"**MST pattern**," as shown in modified Figure 5 below. Section X.A.1.



Ex1006, Fig. 5 (modified based on Ex1006 ¶63 and Ex1012 ¶¶33, 179, 216, 238, 248-49, Figs. 43, 46, 48-49).

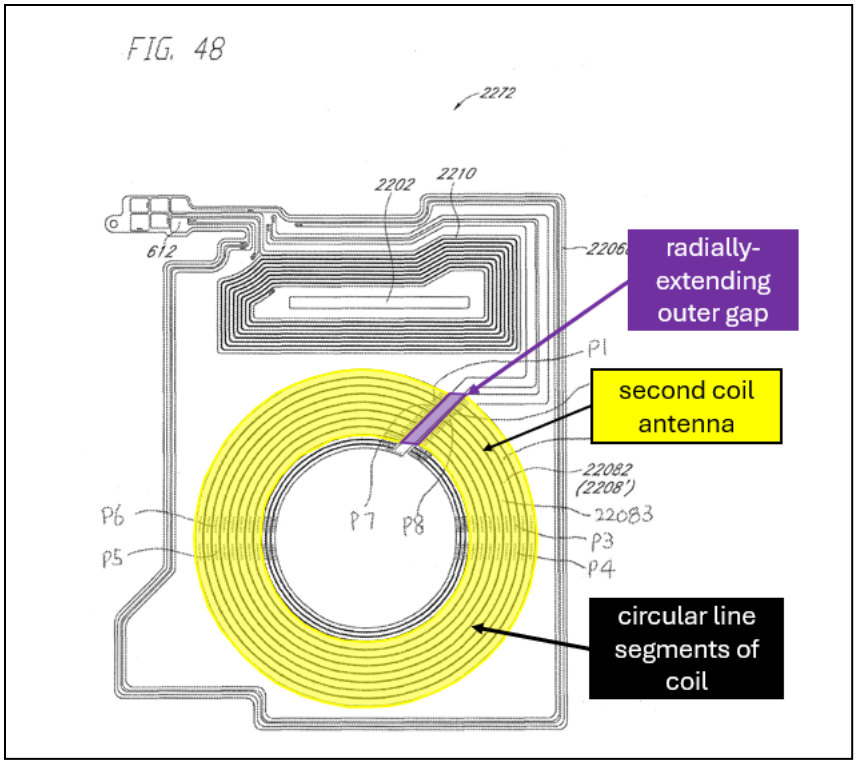
118. In addition, this limitation would have been obvious in view of Kang and Cho. Section X.A.1.

119. Kang teaches multiple ways of comprising an outer antenna pattern out of a plurality of concentric circular lines defining a radially-extending outer gap. Kang Figure 49 teaches "**second coil antenna**" comprising a plurality of concentric circular "**line segments of coil**" defining a **radially-extending outer gap** on the "**second coil antenna**" as shown in the annotated figure below:



Ex1012 ¶¶26, 262, Fig. 49.

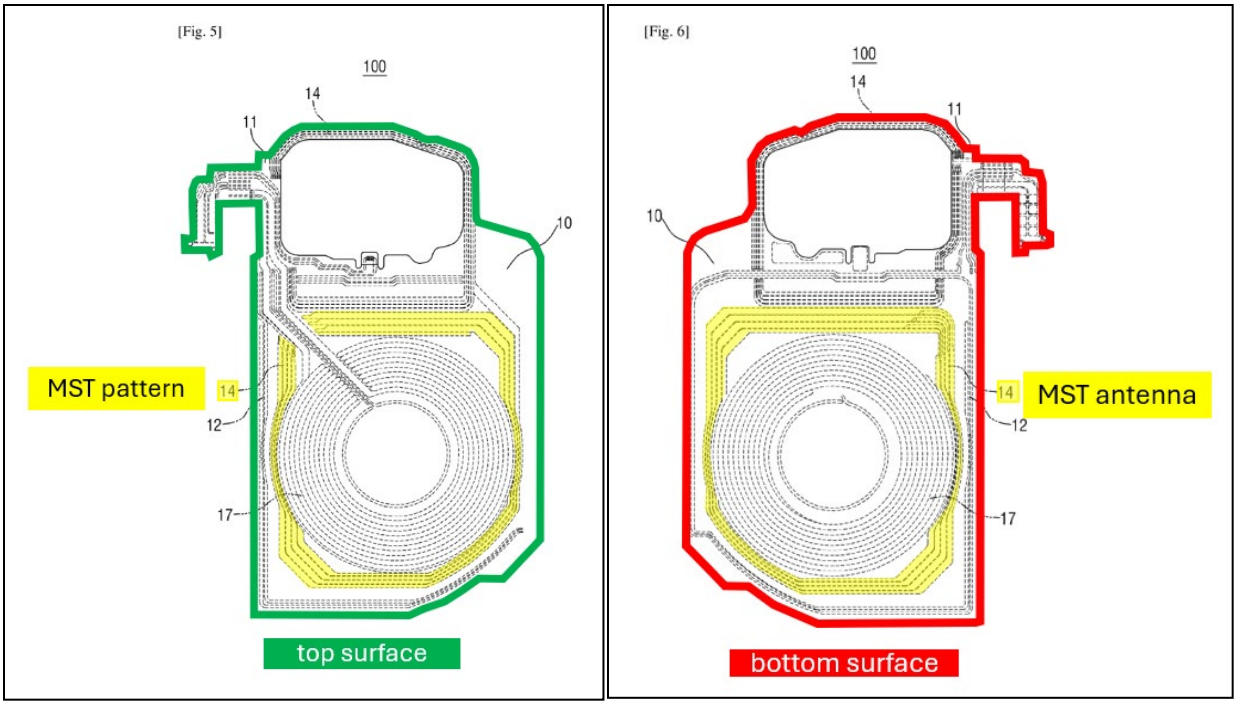
120. Kang Figure 48 teaches this too as shown in the annotated figure below:



Ex1012 ¶262, Fig. 48.

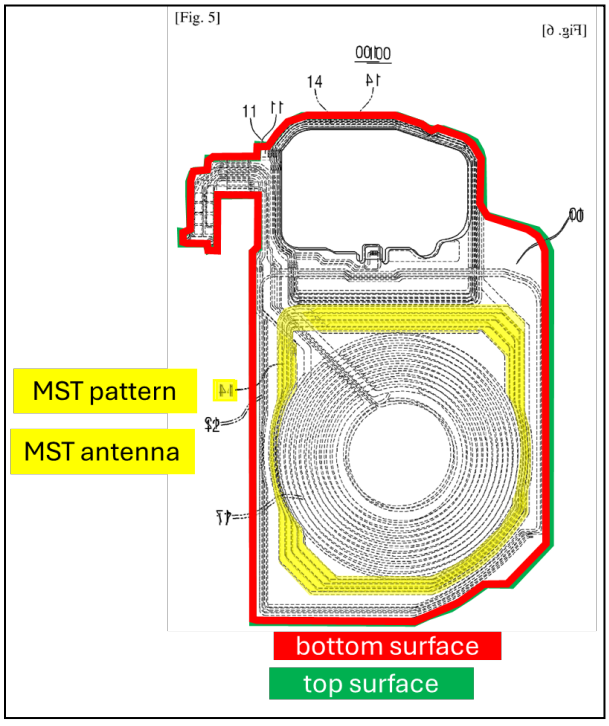
121. Further, at least part of the concentric **circular lines** of "**MST pattern**" on the "**top surface**" (outer antenna pattern) in Seong overlaps "**MST antenna**" on the "**bottom surface**" (outer coil) as shown in the annotated figures below:

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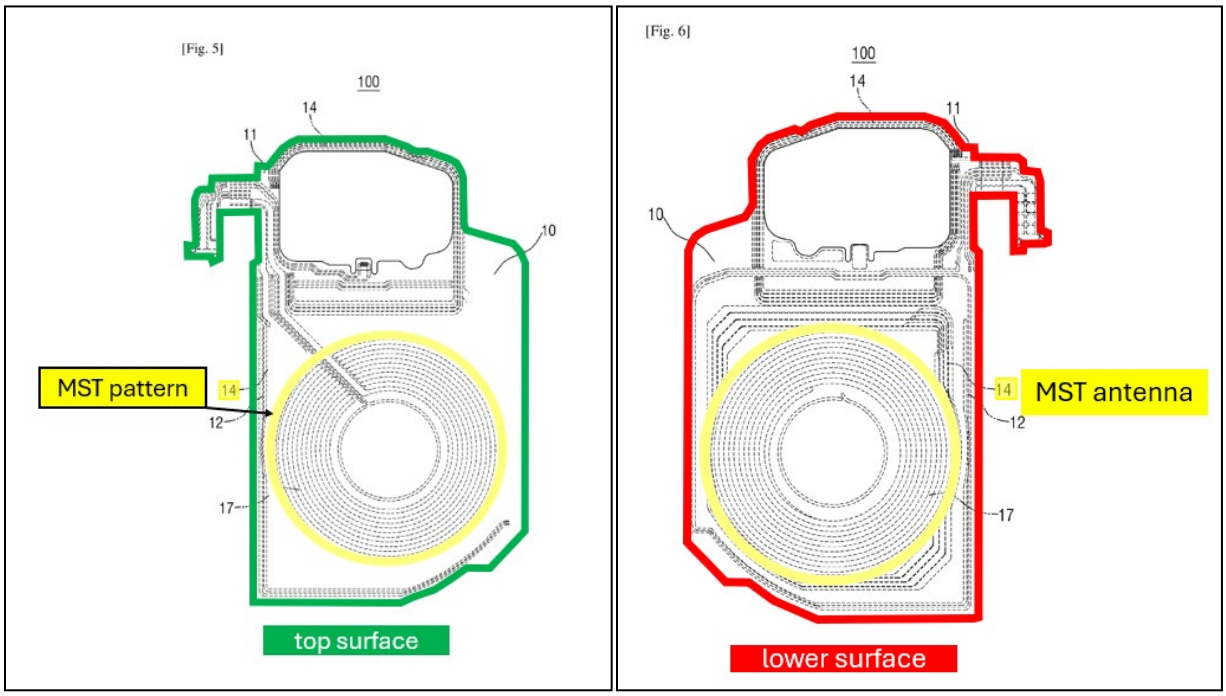
Ex1006, Figs. 5, 6.

122. This can be seen by overlaying Seong Figures 5-6 as shown in the annotated figure below:



Ex1006, Figs. 5-6 (inverted and combined).

123. This limitation is also met when Seongs' "**MST pattern**" and "**MST antenna**" are formed with concentric circular lines as shown in the annotated figures below:



Ex1006, Fig. 5 (modified based on Ex1006 ¶63 and Ex1012 ¶¶33, 179, 216, 238, 248-49, Figs. 43, 46, 48-49).

124. Further, Seong teaches, and the Seong-Kang-Cho combination renders obvious, "**MST pattern**" on the "**top surface** is connected to "**MST antenna**" on the "**bottom surface**" through vias. Seong teaches, and the Seong-Kang-Cho combination renders obvious, electrically connecting antenna patterns, including on different surfaces, using vias. Ground 1 Limitation [1d]. In my opinion, a POSA would have found it obvious to

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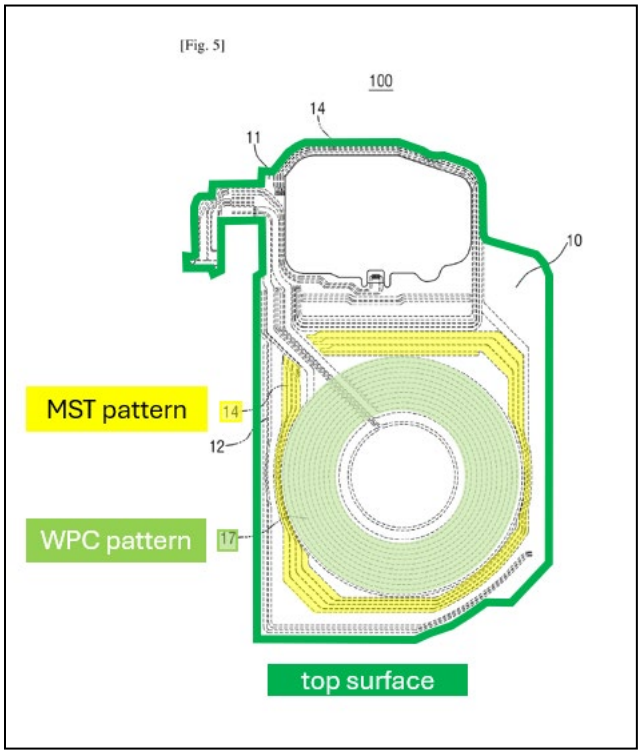
apply these teachings to Seong's outer coil and antenna pattern. Section X.A.1.

g. [1f]

Reference Number	Claim Limitation
[1f]	wherein at least part of the concentric circular lines of the outer antenna pattern generally surround at least part of the concentric circular lines of the inner antenna pattern,

125. In my opinion, Seong teaches this limitation.

126. At least part of the concentric **circular lines** of Seong's "**MST pattern antenna**" (outer antenna pattern) generally surround at least part of the concentric **circular lines** of "**WPC pattern**" (inner antenna pattern) as shown in the annotated figure below:



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Ex1006, Fig. 5.

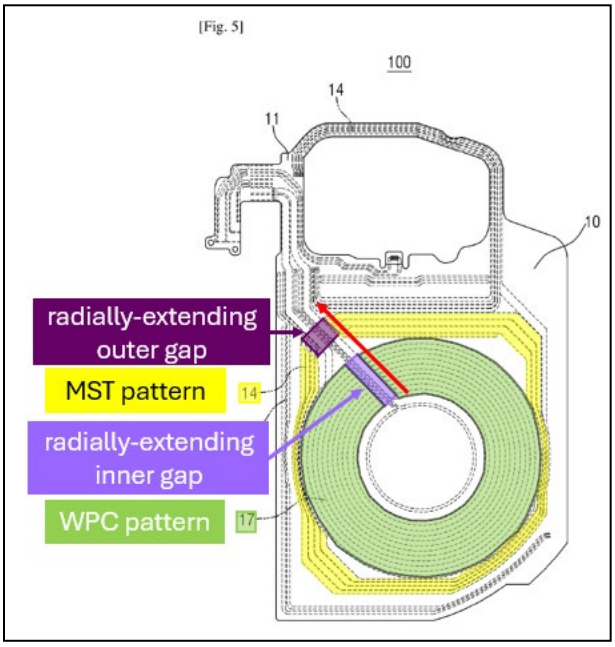
127. Further, Seong teaches, and the Seong-Kang-Cho combination renders obvious, "**MST pattern**" comprising a plurality of concentric **circular lines**. Ground 1 Limitation [1e].

h. [1g]

Reference Number	Claim Limitation
[1g]	wherein the radially-extending outer gap and the radially-extending inner gap are connected and aligned in a direction.

128. In my opinion, Seong teaches this limitation, or alternatively, the Seong-Kang-Cho combination renders it obvious.

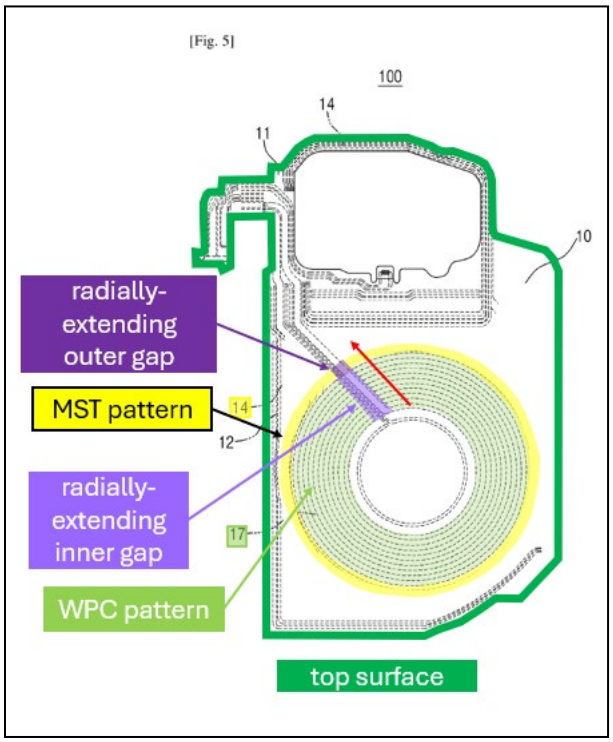
129. Seong's **radially-extending outer gap** and **radially-extending inner gap** are connected and aligned in a **direction** as shown in the annotated figure below:



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Ex1006, Fig. 5.

130. In addition, in my opinion, a POSA would have found obvious that this limitation is met when "**MST pattern 14**" on Seong's "**top surface**" is circular as shown in the annotated figure below:

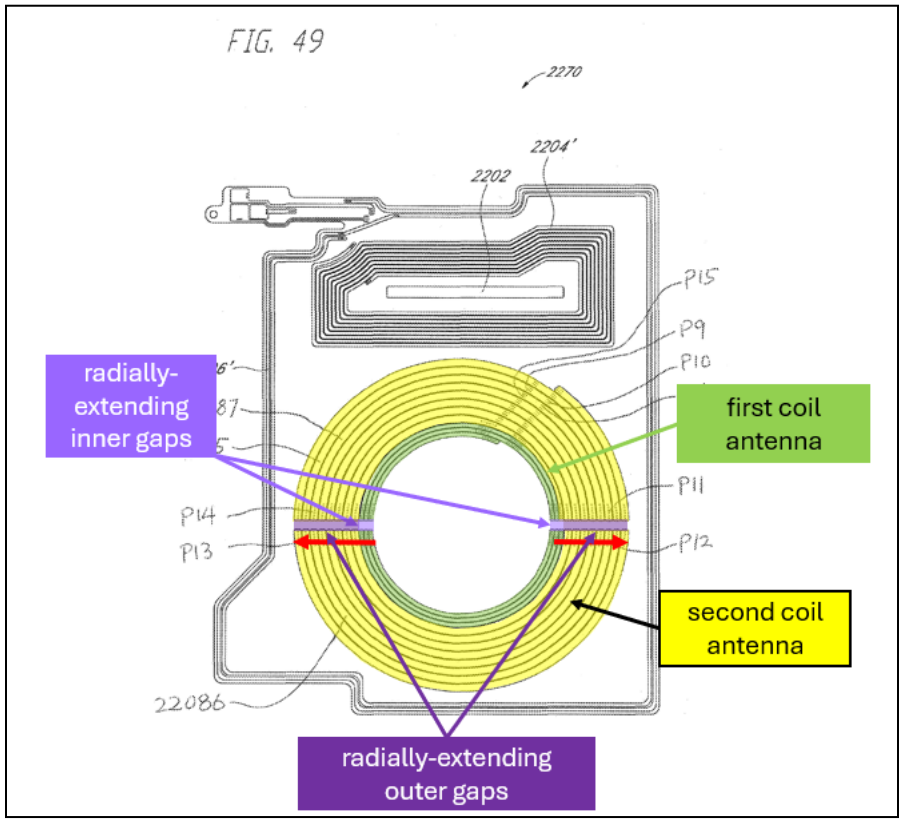


Ex1006, Fig. 5 (modified, Ground 1 Limitation [1e]).

131. In addition, in my opinion, a POSA would have understood a circular "**MST pattern**" in Seong to be obvious in view of Kang and Cho. Section X.A.1.

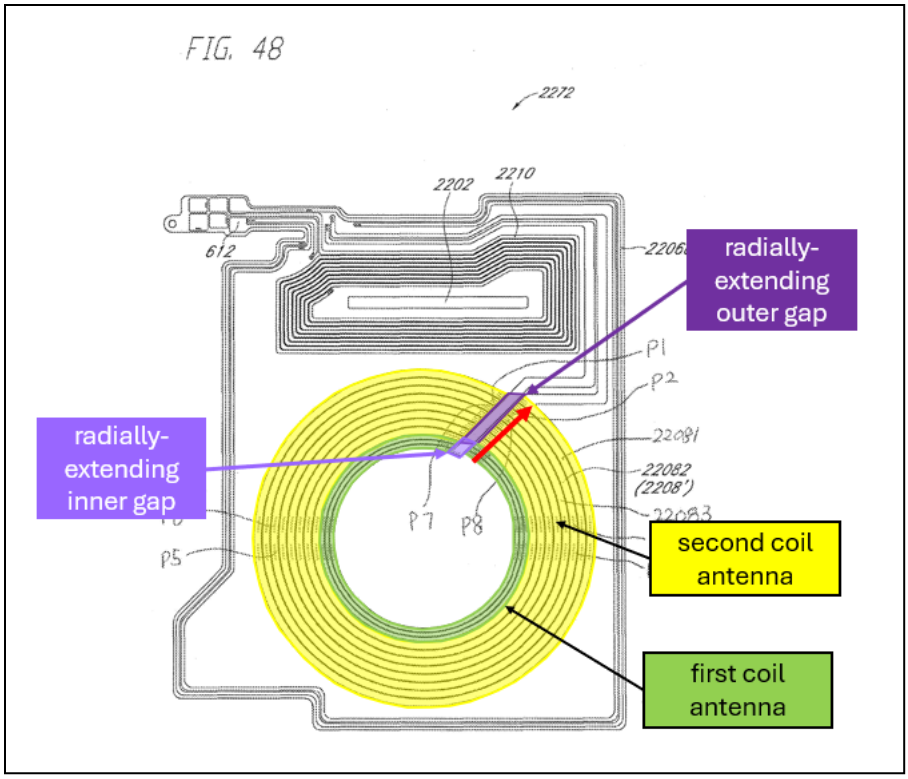
132. Kang teaches multiple ways of connecting and aligning radially-extending inner and outer gaps in a direction. Kang Figure 49 teaches the **radially-extending outer gap** on Kang's "**second coil antenna**" and the **radially-**

extending inner gap on Kang's "**first coil antenna**" are connected and aligned in a **direction** as shown in the annotated figure below:



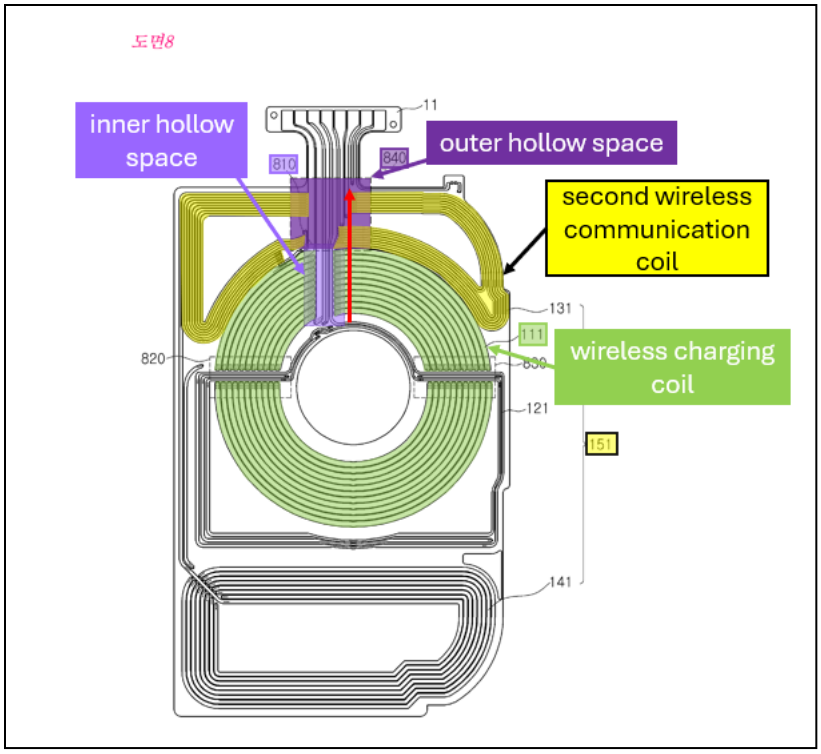
Ex1012, Fig. 49.

133. Kang Figure 48 teaches this too as shown in the annotated figure below:



Ex1012, Fig. 48.

134. In addition, in my opinion, a POSA would have found radially-extending inner and outer gaps that are connected and aligned in a radial direction as described above to be obvious in view of Cho. Section X.A.1. Cho teaches radially-extending **outer** "**hollow space 840**" in "**second wireless communication coil 151**" is connected and aligned in a **direction** with **inner** "**hollow space 810**" in "**wireless charging coil 111**" as shown in the annotated figure below:



Ex1010 ¶68, Fig. 8.

3. [2]

a. [2pre]

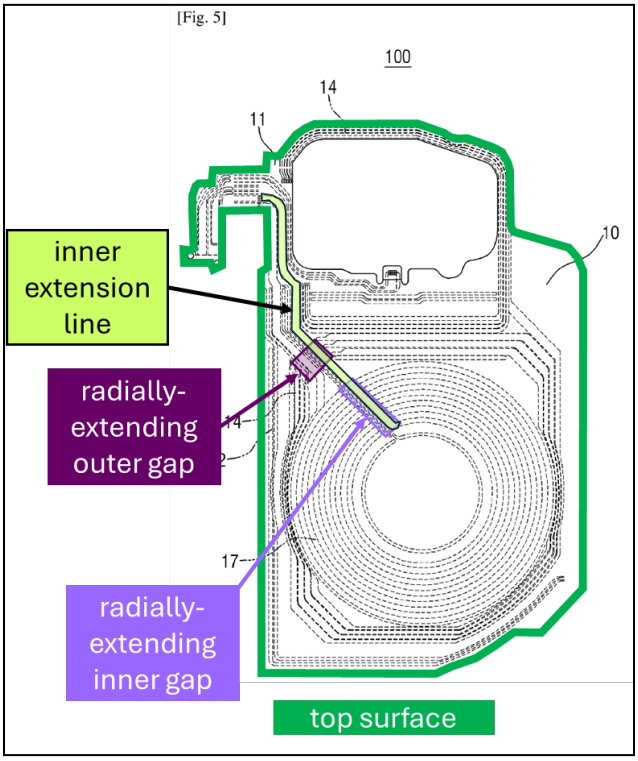
Reference Number	Claim Limitation
[2pre]	The smartphone antenna module of claim 1, further comprising an inner extension line formed on the second major surface and extending through the radially-extending outer gap and further through at least part of the radially-extending inner gap; and

135. In my opinion, the Seong-Kang-Cho combination renders claim 1 obvious, and further, Seong teaches the remaining limitations of this claim.

136. Seong teaches an **inner extension line** formed on the "**top surface**" (second major surface) and extending through the **radially-extending outer gap** and at least part of the **radially-extending inner gap** as shown

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in the annotated figure below:



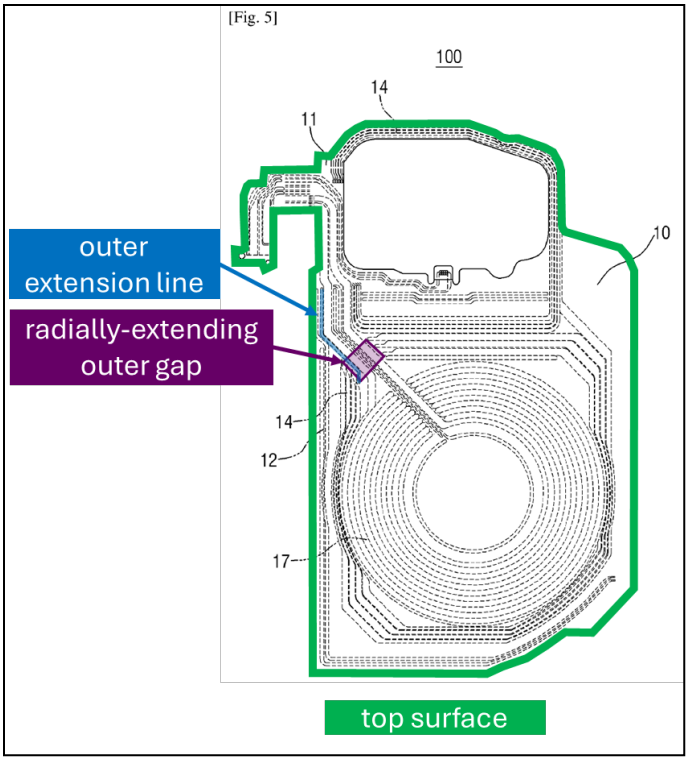
Ex1006, Fig. 5; *id.*, Figs. 11, 12, 15, ¶77.

b. [2a]

Reference Number	Claim Limitation
[2a]	an outer extension line formed on the second major surface and extending through at least part of the radially-extending outer gap.

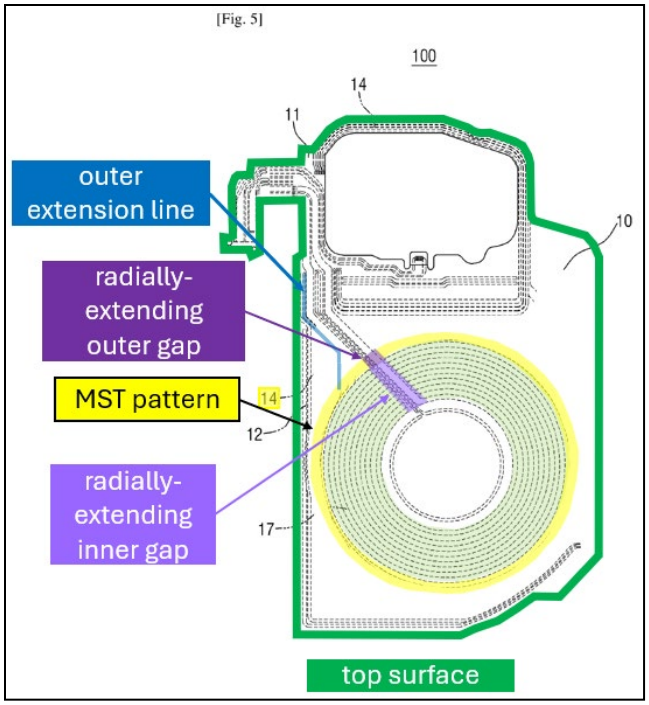
137. In my opinion, Seong teaches this limitation.

138. Seong teaches an **outer extension line** formed on "**top surface**" (second major surface) and extending through at least part of the **radially-extending outer gap** as shown in the annotated figure below:



Ex1006, Fig. 5; *id.*, Figs. 9, 15, ¶77.

139. This limitation is further met when "**MST pattern 14**" on Seong's "**top surface**" is circular as shown in the annotated figure below:



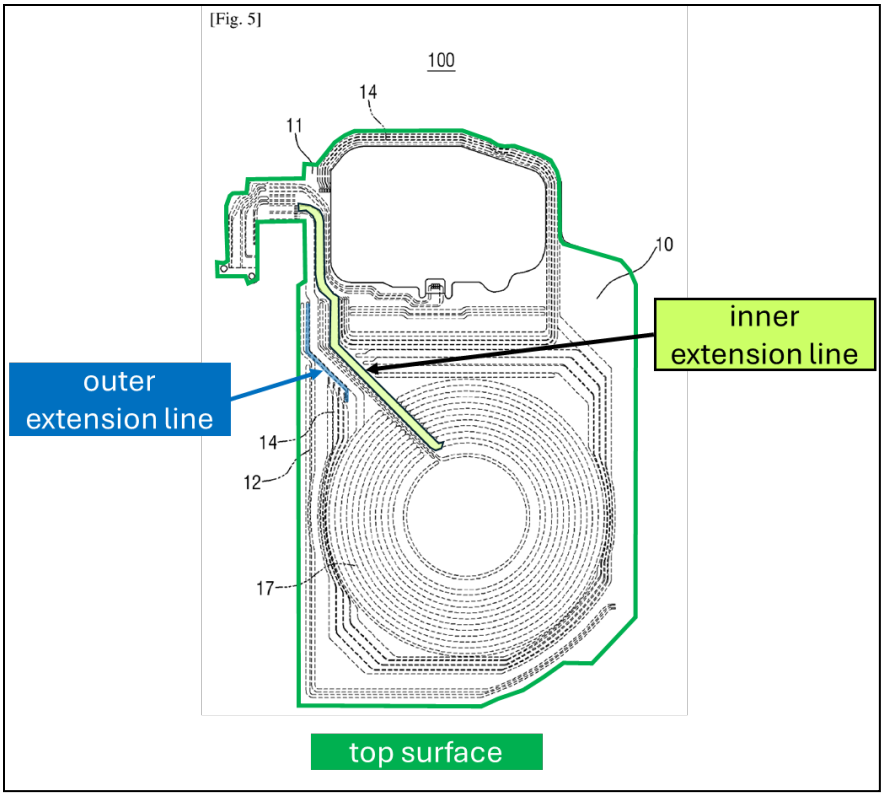
Ex1006, Fig. 5 (modified, Ground 1 Limitation [1e]/[1g]).

4. [3]

Reference Number	Claim Limitation
[3]	The smartphone antenna module of claim 2, wherein the inner extension line and the outer extension line extend generally in parallel, and wherein each of the inner extension line and the outer extension line formed on the second major surface comprises a portion that overlaps the outer coil formed on the first major surface.

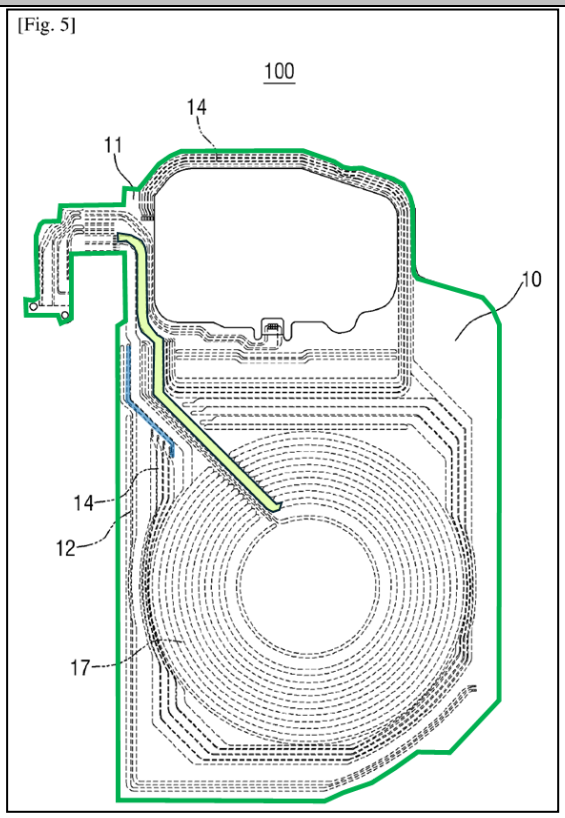
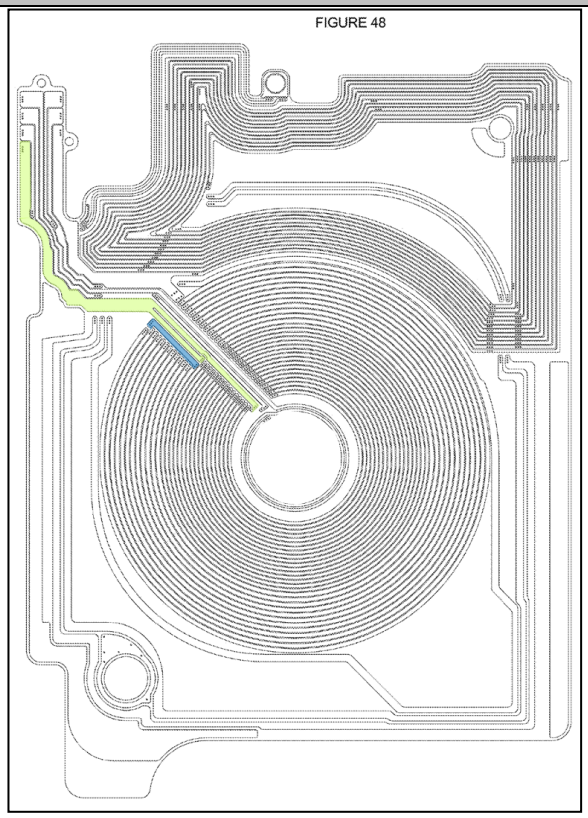
140. In my opinion, the Seong-Kang-Cho combination renders claim 2 obvious, and further, Seong teaches the remaining limitations of this claim.

141. Seong's **inner extension line** and **outer extension line** extend generally in parallel as shown in the annotated figure below:



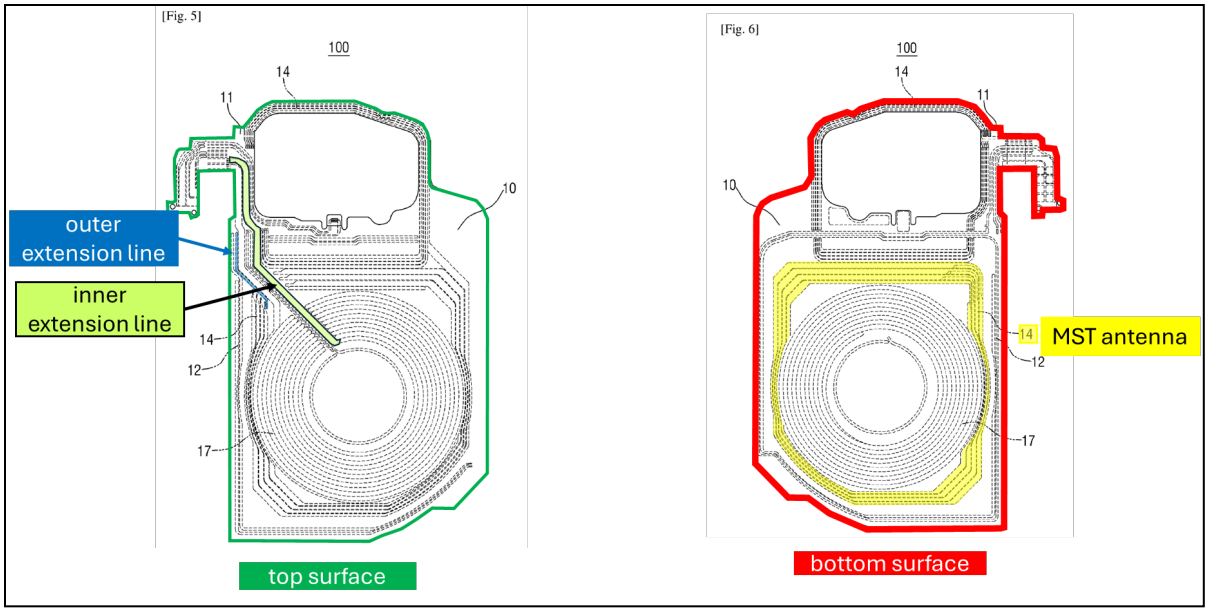
Ex1006, Fig. 5, ¶77.

142. This is at least as much disclosure as the ’564 Patent as shown in the annotated figures below:

Ex1006, Fig. 5	Ex1001, Fig. 48
	

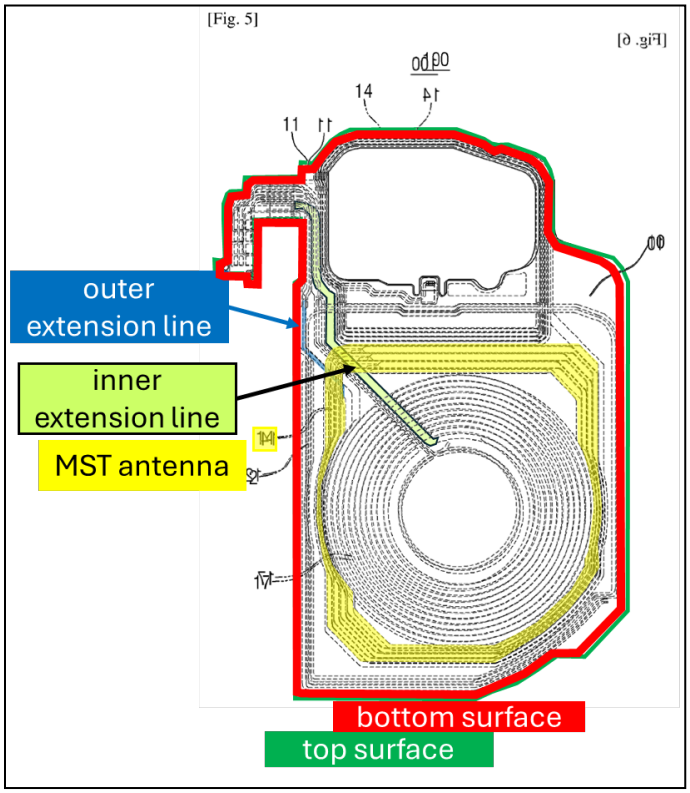
143. Further, in Seong, each of the **inner extension line** and **outer extension line** on the "**top surface**" (second major surface) comprises a portion that overlaps "**MST antenna**" formed on the "**bottom surface**" (first major surface) as shown in the annotated figures below:

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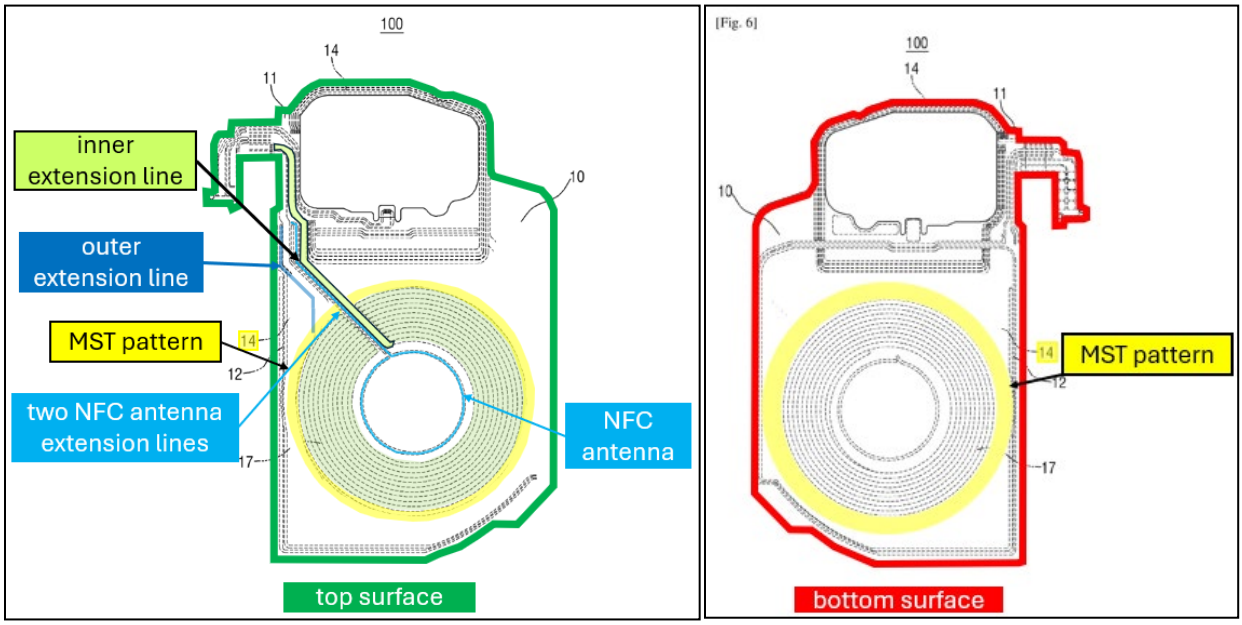
Ex1006, Figs. 5, 6, ¶77.

144. This can be seen by overlaying Seong Figures 5-6 as shown in the annotated figure below:



Ex1006, Figs. 5-6 (inverted and combined), ¶77.

145. This limitation is further met when "**MST pattern 14**" on Seong's "**top surface**" is circular as shown in the annotated figures below:



Ex1006, Figs. 5-6 (modified, Ground 1 Limitation [1e]/[1g]).

5. [4]/[14]

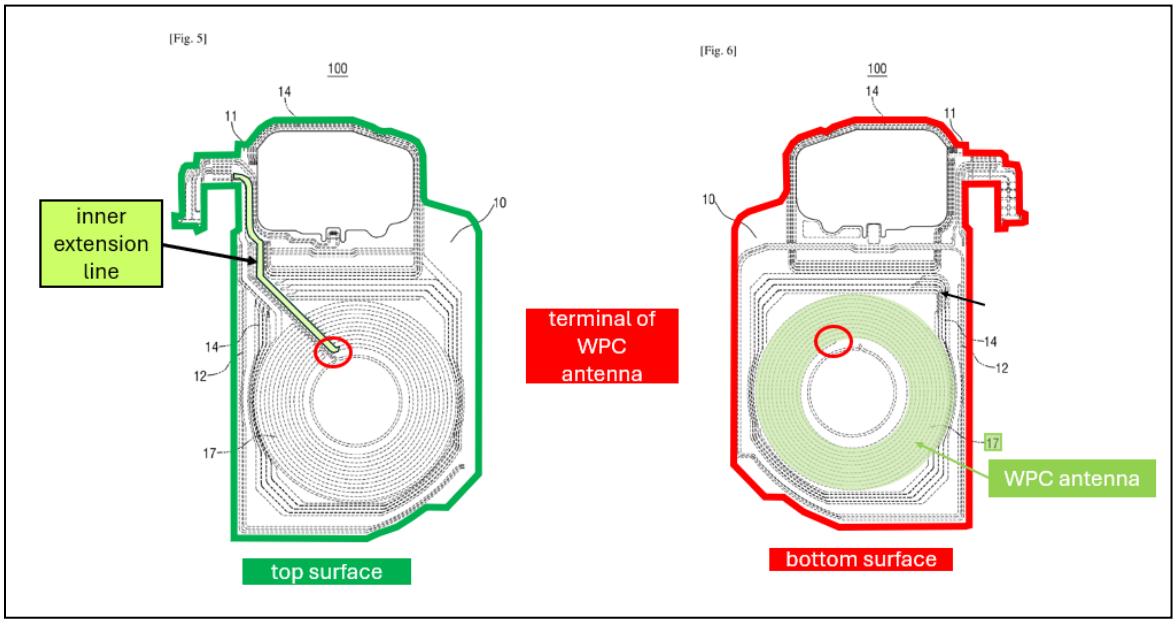
Reference Number	Claim Limitation
[4]	The smartphone antenna module of claim 2, wherein the inner extension line is electrically connected to a terminal of the inner coil, wherein at least part of the concentric circular lines of the inner antenna pattern is in a C shape.
[14]	The smartphone of claim 13, wherein the inner extension line is electrically connected to a terminal of the inner coil, wherein at least part of the concentric circular lines of the inner antenna pattern is in a C shape.

146. In my opinion, the Seong-Kang-Cho combination renders claims 2 and 13 obvious and Seong further teaches, and the combination renders obvious

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the remaining limitations of these claims.

147. Seong's **inner extension line** is electrically connected to **a terminal** of "**WPC antenna**" by a via as shown in the annotated figure below:

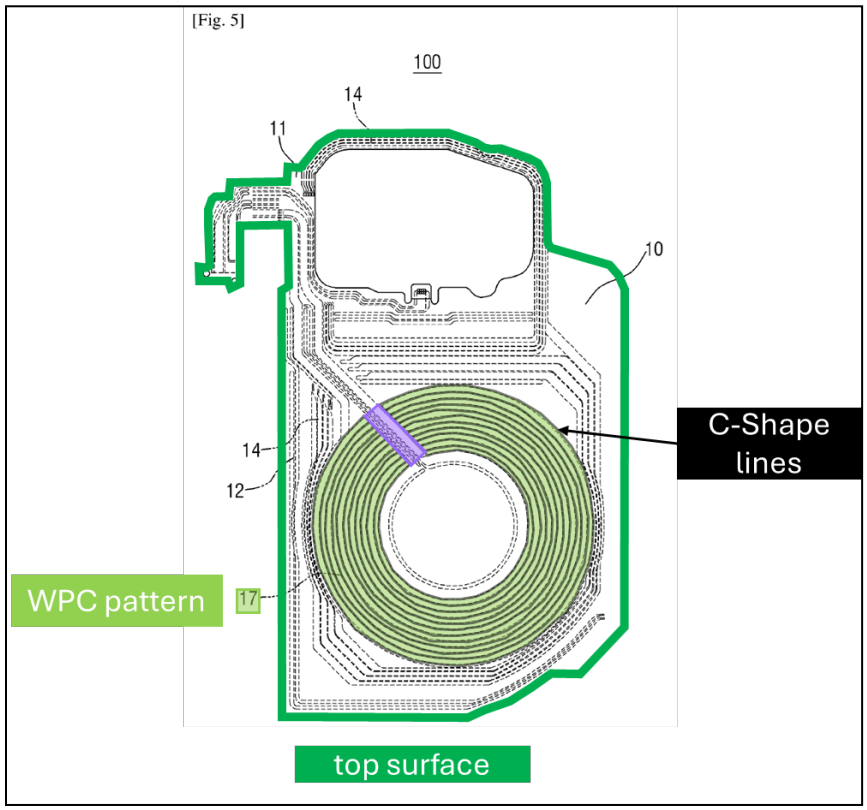


Ex1006, Figs. 5-6; *id.*, Figs. 11, 12, 15, ¶77 (Seong's coils, including WPC, are connected to "their respective terminals").

148. As Seong Figure 5 depicts, Seong's **inner extension line** accomplishes this. Seong teaches, and the Seong-Kang-Cho combination renders obvious, "**WPC pattern**" on the "**top surface** is connected to the "**WPC antenna**" on the "**bottom surface**" through vias. (as common sense would dictate, in order avoid rendering the C shaped concentric circular lines of the inner antenna pattern non-functional open circuited line segments). Ground 1 Limitation [1d]. In my opinion, a POSA would have understood

the **inner extension line** electrically connects to a "**WPC antenna**" terminal through vias too. Ex1006 ¶¶4, 33-34, 77, Figs. 5-6.

149. Further, at least part of the concentric circular lines of Seong's "**WPC pattern**" (inner antenna pattern) is in a C-shape as shown in the annotated figure below:



Ex1006, Figs. 5; Ground 1 Limitation [1d].

6. [5]/[15]

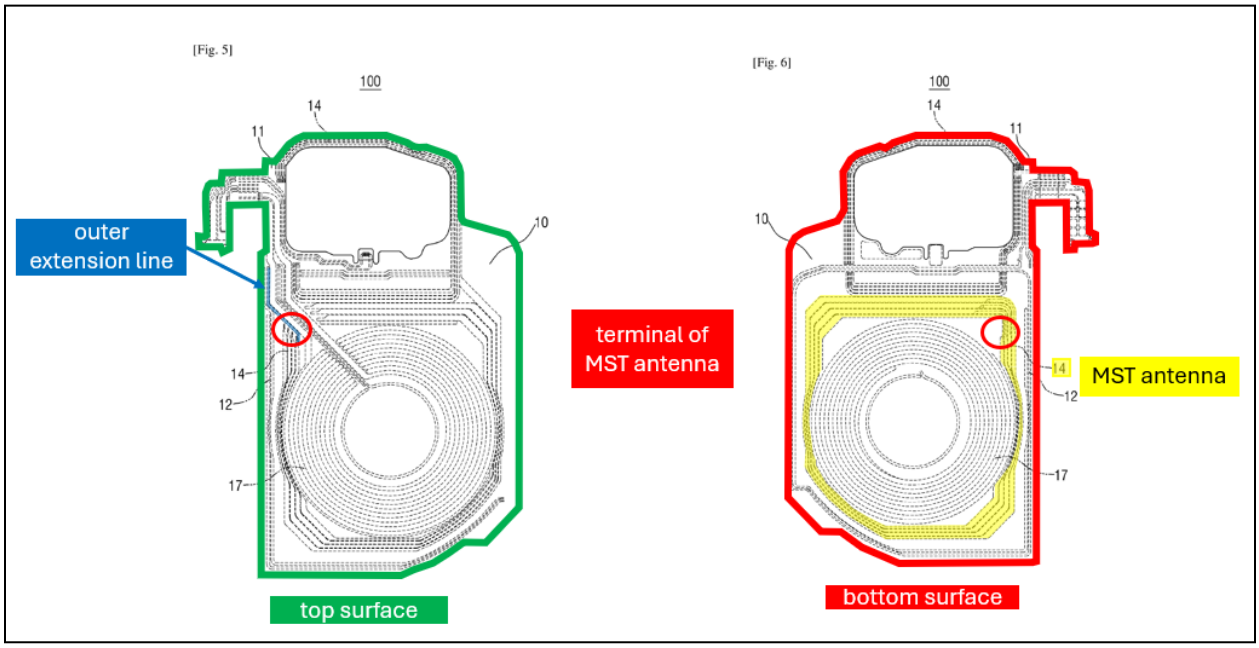
Reference Number	Claim Limitation
[5]	The smartphone antenna module of claim 2, wherein the outer extension line is electrically connected to a terminal of the outer coil, wherein at least part of the concentric circular lines of the outer antenna pattern is in a C shape.

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[15]	The smartphone of claim 13, wherein the outer extension line is electrically connected to a terminal of the outer coil, wherein at least part of the concentric circular lines of the outer antenna pattern is in a C shape.

150. In my opinion, the Seong-Kang-Cho combination renders claims 2 and 13 obvious and Seong further teaches, and the combination renders obvious, the remaining limitations of these claims.

151. Seong's **outer extension line** is electrically connected to a "**MST antenna**" **terminal** as shown in the annotated figure below:



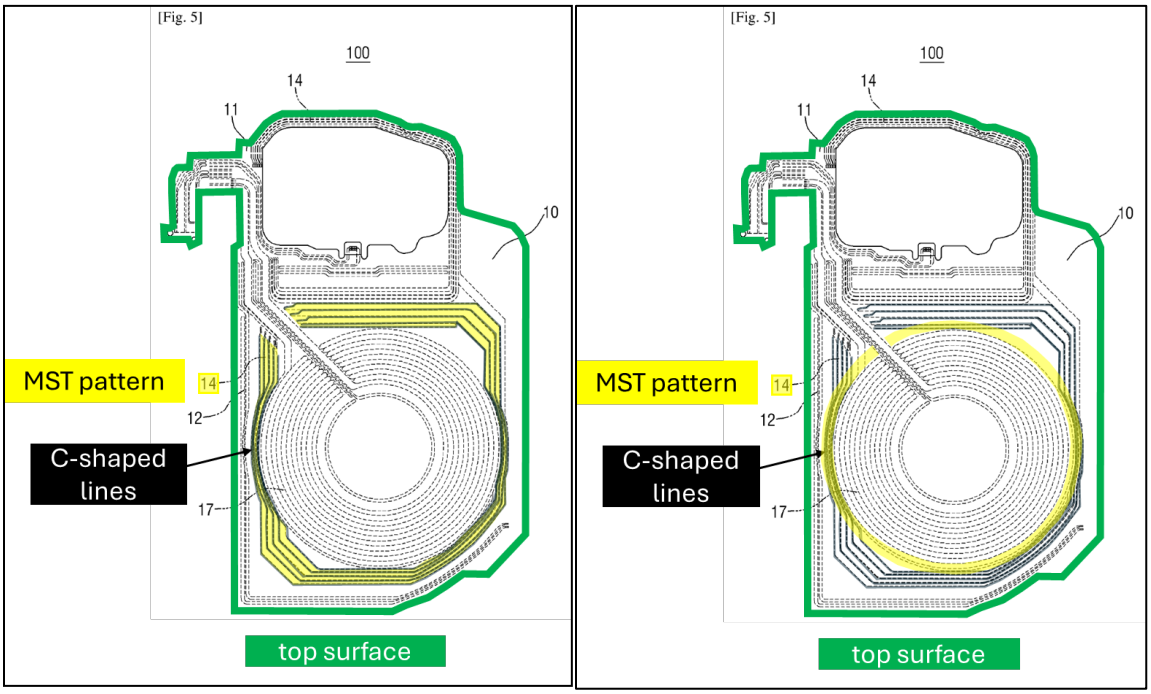
Ex1006, Fig. 5-6; *id.*, Figs. 9, 15, ¶77.

152. As Figure 5 depicts, Seong's **outer extension line** accomplishes this. Seong teaches, or the Seong-Kang-Cho combination renders obvious, "**MST pattern**" on the "**top surface** is connected to the "**MST antenna**" on the "**bottom surface**" through vias. (as common sense would dictate,

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in order avoid rendering the C shaped concentric circular lines of the inner antenna pattern non-functional open circuited line segments). Ground 1 Limitation [1e]. In my opinion, a POSA would have understood the **outer extension line** electrically connects to a "**MST antenna**" terminal through vias too. Ex1006 ¶¶4, 33-34, 77, Figs. 5-6.

153. Further, at least part of the concentric circular lines of Seong's "**MST pattern**" (outer antenna pattern) is in a C-shape as shown in the annotated figure below:



Ex1006, Figs. 5 (figure on right modified based on Ex1006 ¶63 and Ex1012 ¶¶33, 179, 216, 238, 248-49, Figs. 43, 46, 48-49); Ground 1 Limitation [1e].

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7. [6]/[17]

Reference Number	Claim Limitation
[6]	The smartphone antenna module of claim 2, wherein at least one of the inner extension line and the outer extension line is electrically connected to the first antenna pattern formed on the first major surface through at least one via.
[17]	The smartphone of claim 13, wherein at least one of the inner extension line and the outer extension line is electrically connected to the first antenna pattern formed on the first major surface through at least one via.

154. In my opinion, the Seong-Kang-Cho combination renders claims 2 and 13 obvious, and Seong further teaches, and the combination renders obvious, the additional limitations of these claims.

155. In my opinion, Seong teaches, and the Seong-Kang-Cho combination renders obvious, at least one of the **inner extension line** and **outer extension line** extension lines is electrically connected to the first antenna pattern on the "**bottom surface**" through at least one via.

156. Seong teaches, and the Seong-Kang-Cho combination renders obvious, the **inner extension line** and **outer extension line** are electrically connected to "**WPC antenna**" (inner coil) and "**MST antenna**" (outer coil), respectively, through vias. Ground 1 Limitations [4]/[14]/[5]/[15]; Section X.A.1. And Seong's "**WPC antenna**" and "**MST antenna**" comprise the first antenna pattern on "**bottom surface**" (first major surface). Ground 1 Limitations [1b]; Section X.A.1.

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8. [7]/[18]

Reference Number	Claim Limitation
[7]	The smartphone antenna module of claim 2, wherein the inner extension line is referred to as a first inner extension line and is electrically connected to a first terminal of the inner coil, wherein the smartphone antenna module further comprises a second inner extension line formed on the second major surface, wherein the second inner extension line is electrically connected to a second terminal of the inner coil and extends through at least part of the radially extending outer gap.
[18]	The smartphone of claim 13, wherein the inner extension line is referred to as a first inner extension line and is electrically connected to a first terminal of the inner coil, wherein the smartphone antenna module further comprises a second inner extension line formed on the second major surface, wherein the second inner extension line is electrically connected to a second terminal of the inner coil and extends through at least part of the radially-extending outer gap.

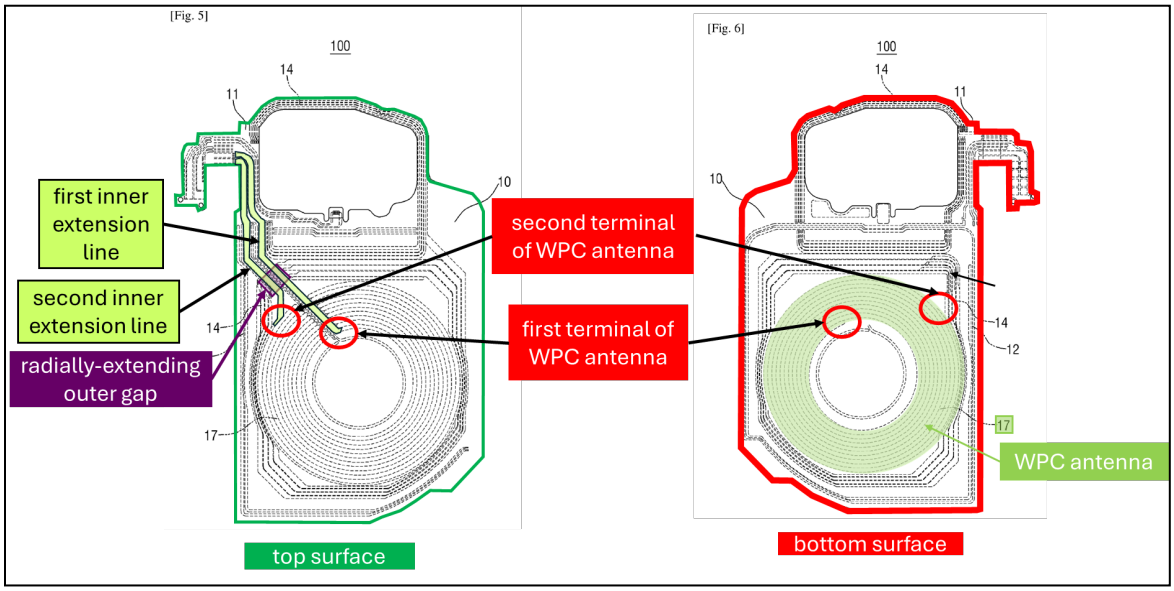
157. In my opinion, the Seong-Kang-Cho combination renders claims 2 and 13 obvious and Seong further teaches, or alternatively, the combination renders obvious, the remaining limitations of this claim.

158. Seong's smartphone antenna module comprises a **first inner extension line** electrically connected to a **first terminal** of "**WPC antenna**" through vias. Ground 1 Limitations [4]/[14].

159. Further, Seong teaches and the combination renders obvious, that Seong's smartphone antenna module comprises a **second inner extension line** on the "**top surface**" (second major surface) electrically connected to a **second terminal** of "**WPC antenna**" through vias, and the **second inner**

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extension line extends through at least part of the **radially-extending outer gap** as shown in the annotated figure below:



Ex1006, Figs. 5-6, ¶77; Ground 1 Limitations [1e]/[4]/[14].

9. [8]/[16]

Reference Number	Claim Limitation
[8]	The smartphone antenna module of claim 1, wherein the inner coil and the outer coil are electrically connected in parallel.
[16]	The smartphone of claim 13, wherein the inner coil and the outer coil are electrically connected in parallel.

160. In my opinion, the Seong-Kang-Cho combination renders claims 1 and 13 obvious and further renders these claims obvious.

161. Seong's "**MST antenna**" and "**WPC antenna**" "are connected to respective terminals … 16, and 18." Ex1006 ¶77.

162. Seong does not, however, teach how the MST and WPC patterns are

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electrically connected. Kang teaches electrically connecting inner and outer coils in parallel. Ex1012 ¶¶150, 214, 217, 237, Figs. 24A-24B. In my opinion, it would have been obvious to electrically connect Seong's WPC and MST patterns in parallel in view of Kang. Section X.A.1.

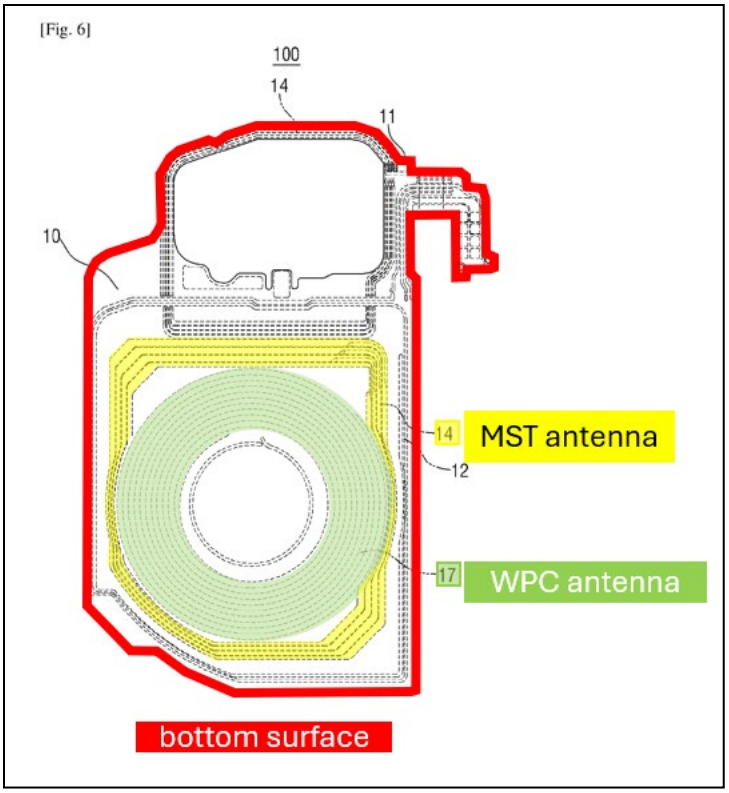
10. [9]/[19]

Reference Number	Claim Limitation
[9]	The smartphone antenna module of claim 1, wherein the inner coil includes a wire line having a width different from that of a wire line of the outer coil, wherein the inner coil has a first number of turns, and the outer coil has a second number of turns, wherein the first number of turns is greater than the second number of turns.
[19]	The smartphone of claim 13, wherein the inner coil includes a wire line having a width different from that of a wire line of the outer coil, wherein the inner coil has a first number of turns, and the outer coil has a second number of turns, wherein the first number of turns is greater than the second number of turns.

163. In my opinion, the Seong-Kang-Cho combination renders claims 1 and 13 obvious and Seong further teaches the additional limitations of this claim.

164. Seong's "**WPC antenna**" includes a wire line having a width different from that of a wire line of the "**MST antenna**" as shown in the annotated figure below:

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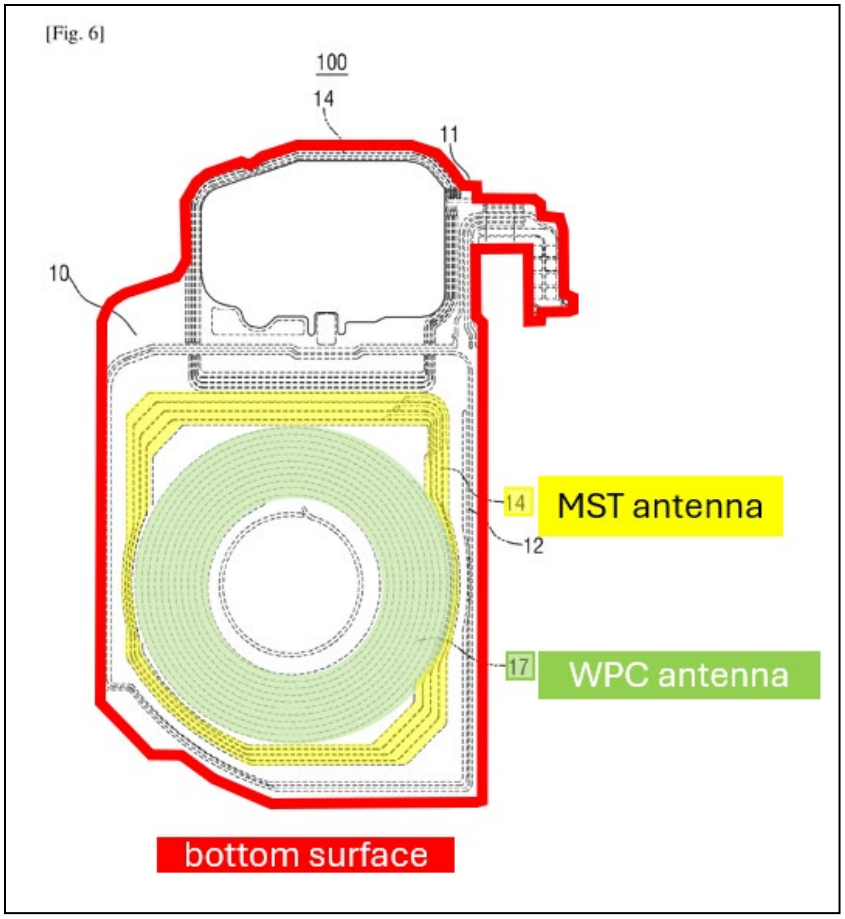


Ex1006, Fig. 6.

165. Seong's coil's wire lines' widths may vary, as Seong Figure 6 depicts. Ex1006 ¶63.

166. Further, Seong's "**WPC antenna**" (inner coil) has a first number of turns, and "**MST antenna**" (outer coil) has a second number of turns, wherein the first number of turns is greater than the second number of turns as shown in the annotated figure below:

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Ex1006, Fig. 6.

167. As shown above, Seong depicts "**WPC antenna**" having approximately 11 turns, and "**MST antenna**" having approximately 4 turns. Further, Seong teaches "shape and layout arrangement of the antenna patterns may be varied," including the number of coil turns. Ex1006 ¶63.

11. [10]/[20]

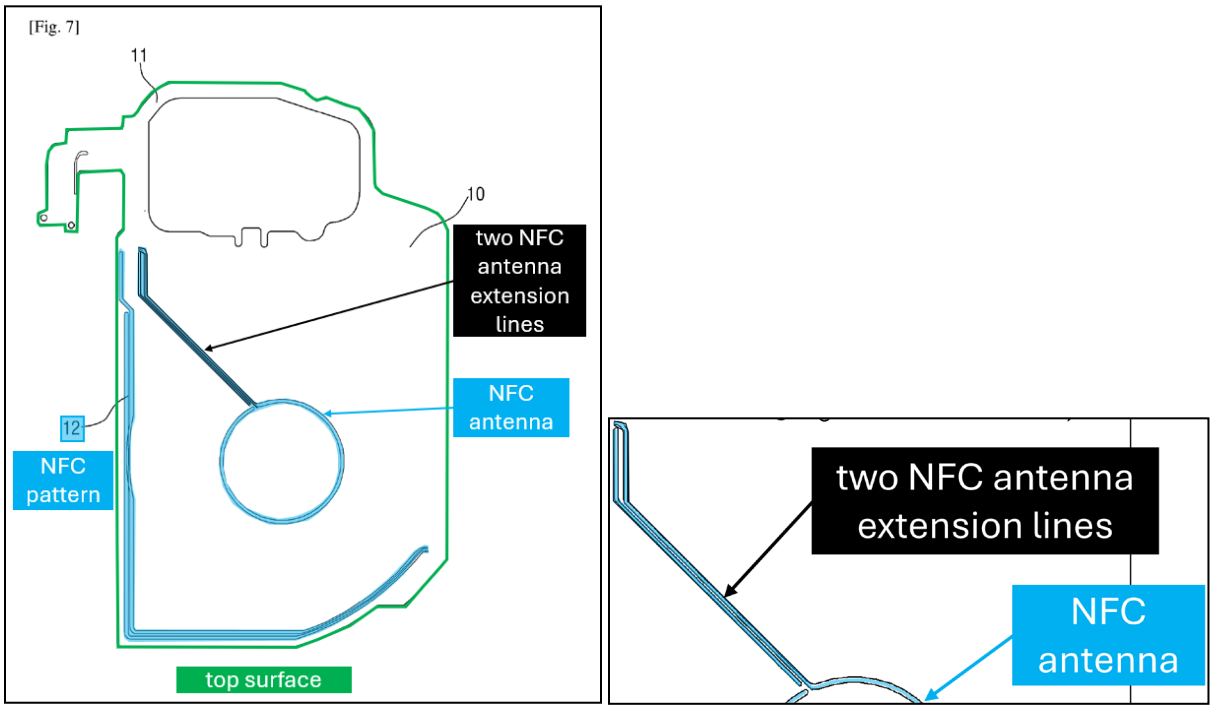
Reference Number	Claim Limitation
[10]	The smartphone antenna module of claim 1, further comprising two additional extension lines formed on the second major surface and extending through both the radially-extending inner gap and the radially-extending outer gap.

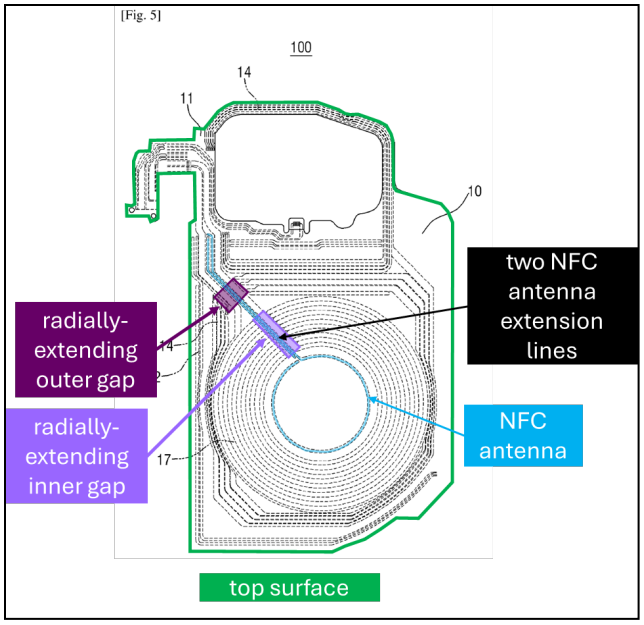
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[20]	The smartphone claim 13, further comprising two additional extension lines formed on the second major surface and extending through both the radially-extending inner gap and the radially-extending outer gap.

168. In my opinion, the Seong-Kang-Cho combination renders claims 1 and 13 obvious, and Seong further teaches the additional limitations of this claim.

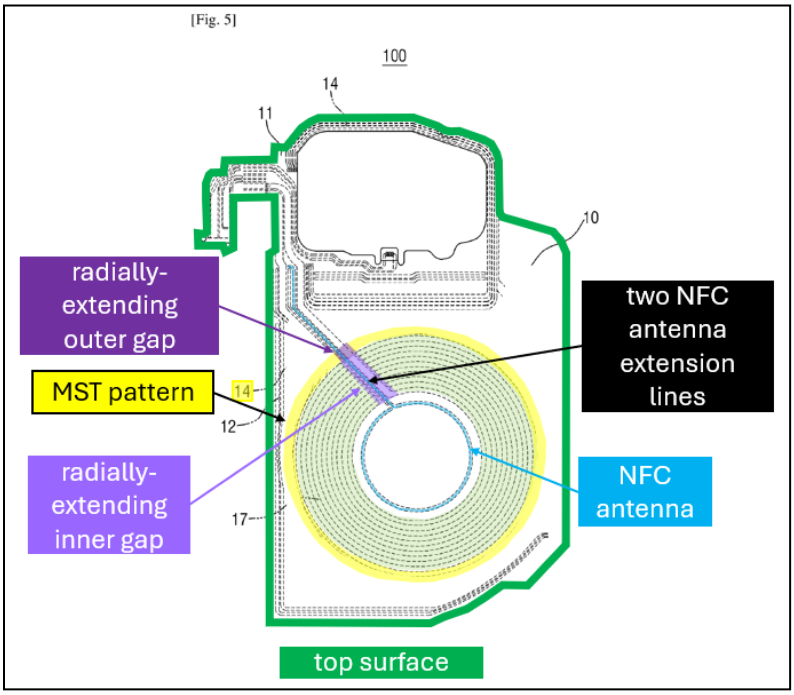
169. Seong teaches "**an NFC antenna**" and depicts two "**NFC antenna**" extension lines (two additional extension lines) formed on the "**top surface**" and extending through both the **radially-extending inner gap** and the **radially-extending outer gap** as shown in the annotated figures below:





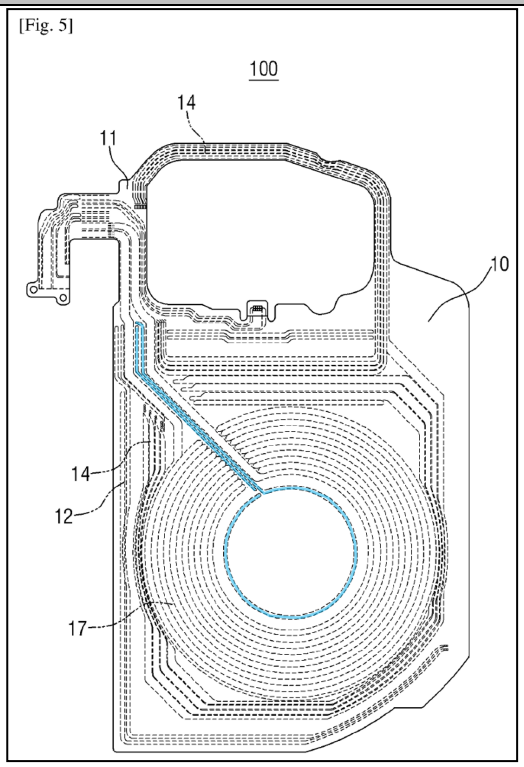
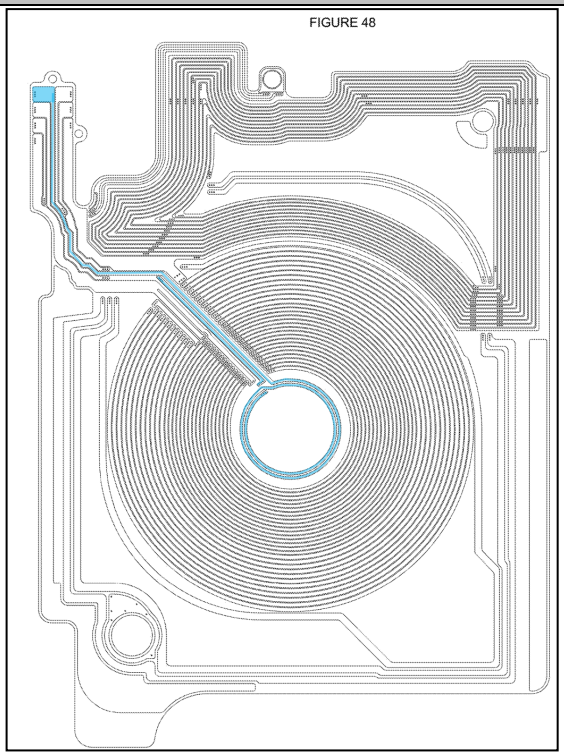
Ex1006, Figs. 5, 7, ¶¶77, 93, Cl. 13.

170. This limitation is further met when "**MST pattern 14**" on Seong's "**top surface**" is circular as shown in the annotated figure below:



Ex1006, Fig. 5 (modified, Ground 1 Limitation [1e]/[1g]).

171. Seong's depicted **NFC antenna** and **NFC antenna extension lines** are essentially identical to those in the '564 Patent as shown in the annotated figures below:

Ex1006, Fig. 5	Ex1001, Fig. 48
	

12. [11]/[21]

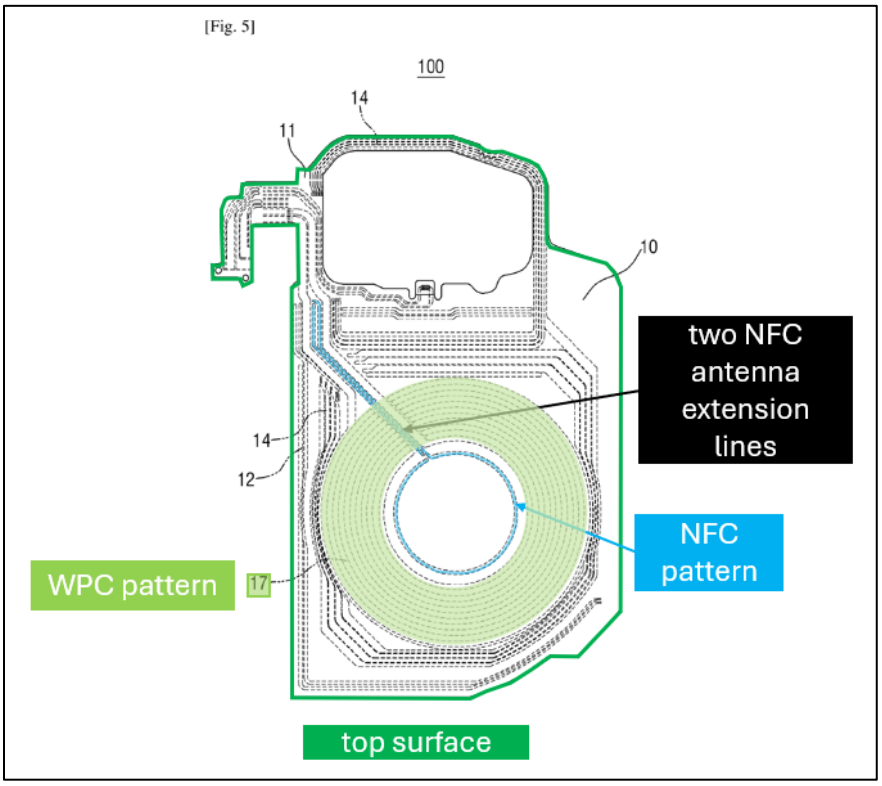
Reference Number	Claim Limitation
[11]	The smartphone antenna module of claim 10, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein each of the two additional extension lines is electrically connected to a terminal of the third antenna pattern.
[21]	The smartphone of claim 20, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein

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	each of the two additional extension lines is electrically connected to a terminal of the third antenna pattern.

172. In my opinion, the Seong-Kang-Cho combination renders claims 1 and 13 obvious, and Seong further teaches the additional limitations of this claim.

173. Seong's "**WPC pattern**" (second antenna pattern) on the "**top surface**" (second major surface) comprises "**NFC pattern**" (third antenna pattern) that is generally surrounded by "**WPC pattern**":

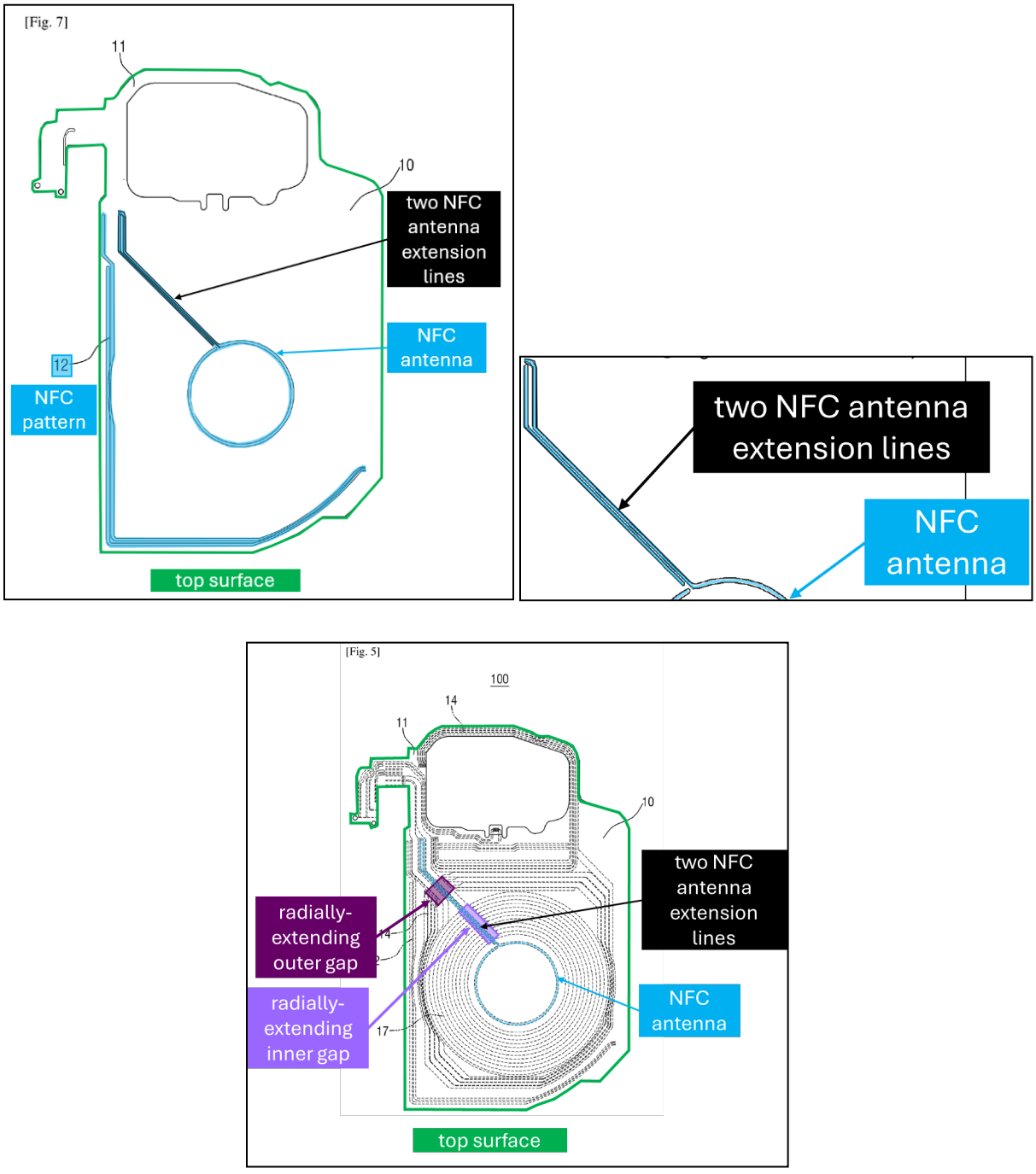


Ex1006, Figs. 5, ¶¶77, 93, Cl. 13; Ground 1 Limitations [10]/[20].

174. Seong teaches "**an NFC antenna**" and depicts two "**NFC antenna**" extension lines (two additional extension lines) formed on the "**top surface**" and extending through both the **radially-extending inner gap**

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and the **radially-extending outer gap** as shown in the annotated figures below:



Ex1006, Figs. 5, 7, ¶¶77, 93, Cl. 13.

13. [12]/[22]

Reference Number	Claim Limitation
[12]	The smartphone antenna module of claim 10, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein at least one of the two additional extension lines contacts the third antenna pattern on the second major surface.
[22]	The smartphone of claim 20, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein at least one of the two additional extension lines contacts the third antenna pattern on the second major surface.

175. In my opinion, the Seong-Kang-Cho combination renders claims 10 and 20 obvious and Seong further teaches, or alternatively the combination renders obvious, the additional limitations of these claims.

176. For the same reasons as Ground 1 Limitations [10]/[20]/[11]/[21], Seong's "**WPC pattern**" (second antenna pattern) on the "**top surface**" (second major surface) comprises "**NFC antenna**" generally surrounded by "**WPC antenna**," wherein at least one of the two "**NFC antenna**" extension lines contacts "**NFC antenna**" on the "**top surface**."

14. [13pre]/[13a]/[13b]/[13c]/[13d]

Reference Number	Claim Limitation
[13pre]	A smartphone comprising a display module comprising a display surface;
[13a]	a rear cover comprising a rear surface facing away from the display surface;
[13b]	a battery placed between the display module and the rear cover; and

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[13c]	the smartphone antenna module of claim 2 placed between the battery and the rear cover,
[13d]	wherein at least one of the inner coil and the outer coil are configured for wireless battery charging.

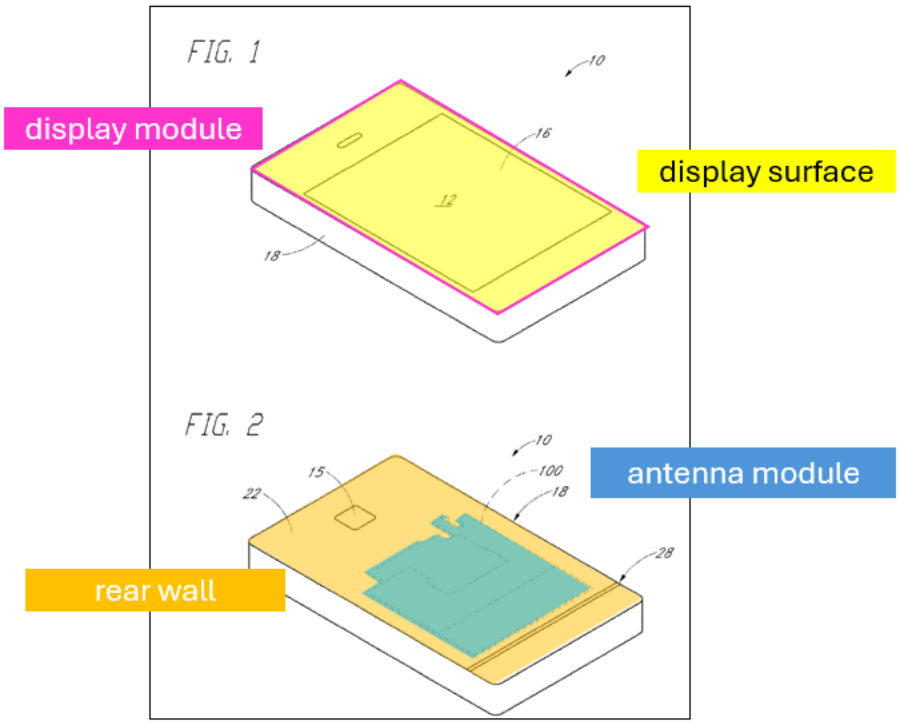
177. In my opinion, the Seong-Kang-Cho combination renders claim 2 obvious and further renders this claim obvious.

178. Seong teaches a "smartphone[]" comprising a "battery" and an "antenna structure" "provid[ing] … wireless charging." Ex1006, Abstract, ¶¶3, 5, 12, 28, 53, 64, 75, 77, 80, Abstract. Seong's outer coil is configured for wireless battery charging and, in my opinion, a POSA would have understood Seong's "smartphone[]" includes a display module comprising a display surface, a rear cover comprising a rear surface facing away from the display surface, a battery placed between the display module and the rear cover, and an antenna module placed between the battery and the rear cover, because it is the most logical and common-sense arrangement; a battery between the antenna module and the rear cover would interfere with or block the wireless-charging signal. *Id.* ¶¶75, 77, 80.

179. In addition, this limitation would have been obvious in view of Kang. Kang teaches configuring the inner and outer coils for wireless battery charging: "the third coil antenna is … configured for wireless charging of the smartphone." Ex1012 ¶79. Kang also teaches "[t]he second coil antenna may function as another antenna, for example, a wireless power

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charging antenna." *Id.* ¶¶202, 217, 239, 296 ("two coils among the multiple [can be] electrically connected in the same antenna module"). Further, Kang teaches "**display module**" comprising "**display surface**," "**rear wall**" facing away from the "**display surface**," "battery" placed between the "**display module**" and the "**rear wall**," and "**antenna module**" placed between the "battery" and the "**rear wall**" as shown in the annotated figure below:



Ex1012, ¶¶22, 178, 179, Figs. 1, 2.

180. In my opinion, a POSA would have understood Kang locates its "**antenna module**" between the "battery" and the "**rear wall**" because placing the

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"**antenna module**" next to the "**rear wall**" is the most logical and common-sense arrangement; a battery between the antenna module and the rear cover would interfere with or block the wireless-charging signal. Further, Kang's Figure 2 illustrates the "**antenna module**" flush with the "**rear wall**," leaving no space for other components, including the "battery."

181. In my opinion, a POSA would have been motivated to incorporate Kang's teachings of locating the wireless-charging antenna module between the smartphone's battery and rear cover and that the inner and outer coils can be configured for wireless battery charging with Seong to improve Seong's antenna module's performance and flexibility. This would have been a simple design choice of where to locate the antenna module (including the claimed location, which would have given the wireless-charging antenna module a higher likelihood of success as compared with locating the battery between the rear cover and the antenna module[9]) and what

[9] A POSA would have known that closer proximity between a smartphone's wireless charging coils and the charging coils of a wireless charger (achieved by placing the smartphone wireless charging coils as close to its back surface as possible)

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functionality to use for which of Seong's coils.

182. In my opinion, a POSA would have reasonably expected success.[10] Seong uses its antenna module for wireless charging and teaches "shape and arrangement of the antenna patterns may vary." Ex1006 ¶63. Kang teaches "[e]ach coil can be used" for MST, NFC and wireless charging and "two coils among the multiple [can be] electrically connected in the same antenna module." Ex1012 ¶¶216-17, 238-39, 296.

B. Ground 2: Ahn Renders Claims 1-22 Obvious In View Of 721Lee

1. A POSA Would Have Been Motivated To Combine The Teachings Of Ahn and 721Lee

183. Ahn and 721Lee overcome limited space in smartphones with space-efficient WPC, NFC, and MST antennas, optimizing shape and layout, placing coils on both sides of a substrate. Section VIII. In my opinion, a POSA reading Ahn would have been motivated to incorporate 721Lee's

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would tend to improve wireless charging performance by improving charging efficiency.

[10] A POSA would have reasonably expected success for the same reason that a POSA would have known that closer proximity of the wireless charging coils of the smartphone and those of the charger would tend to improve charging efficiency.

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teachings. Both references teach antenna patterns on both sides of a substrate in a smartphone, including WPC, NFC, and MST antennas. Ex1007, ¶¶113, 120, Figs. 3-4, 6-9; Ex1011, Figs. 10A-B. If Ahn is found to not expressly teach a claimed limitation, as discussed below, in my opinion, it would have been obvious to a POSA to adopt well-known, predictable, and finite approaches taught by 721Lee to Ahn to achieve wireless-communication functions in a space-efficient module.

184. Ahn teaches running extension lines through disconnected coil regions to connect second and third coil wirings to connection pads. Ex1007 ¶¶73, 124, Figs. 3-4, 10. In addition, in my opinion, a POSA would have found this arrangement obvious in view of 721Lee.

185. Lead wirings must "traverse" coil wirings without (electrically) contacting them, and running lead wirings through disconnected coil regions was a well-known solution. Reading Ahn, in my opinion, a POSA would have been motivated to look to references including 721Lee furthering the same space-efficient goal for antenna modules. Ex1007, Figs. 3-4, 10; Ex1011, Figs.10B, 14C. Ahn and 721Lee teach similar ways of achieving that goal—coils on both sides of a substrate, those coils surrounding each other, and extension lines running to those coils through radially-extending gaps. Ex1007, ¶¶72-73, 124, Figs. 4, 10; Ex1011, ¶140, Figs. 10B, 14C. Further,

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721Lee teaches inner and outer gaps ("interval[s]" of inner and outer coils, which "have the opened loop form") and explains gaps beneficially allow concentric coils to "be connected to input/output terminals" using extension lines as shown in the annotated figure below:

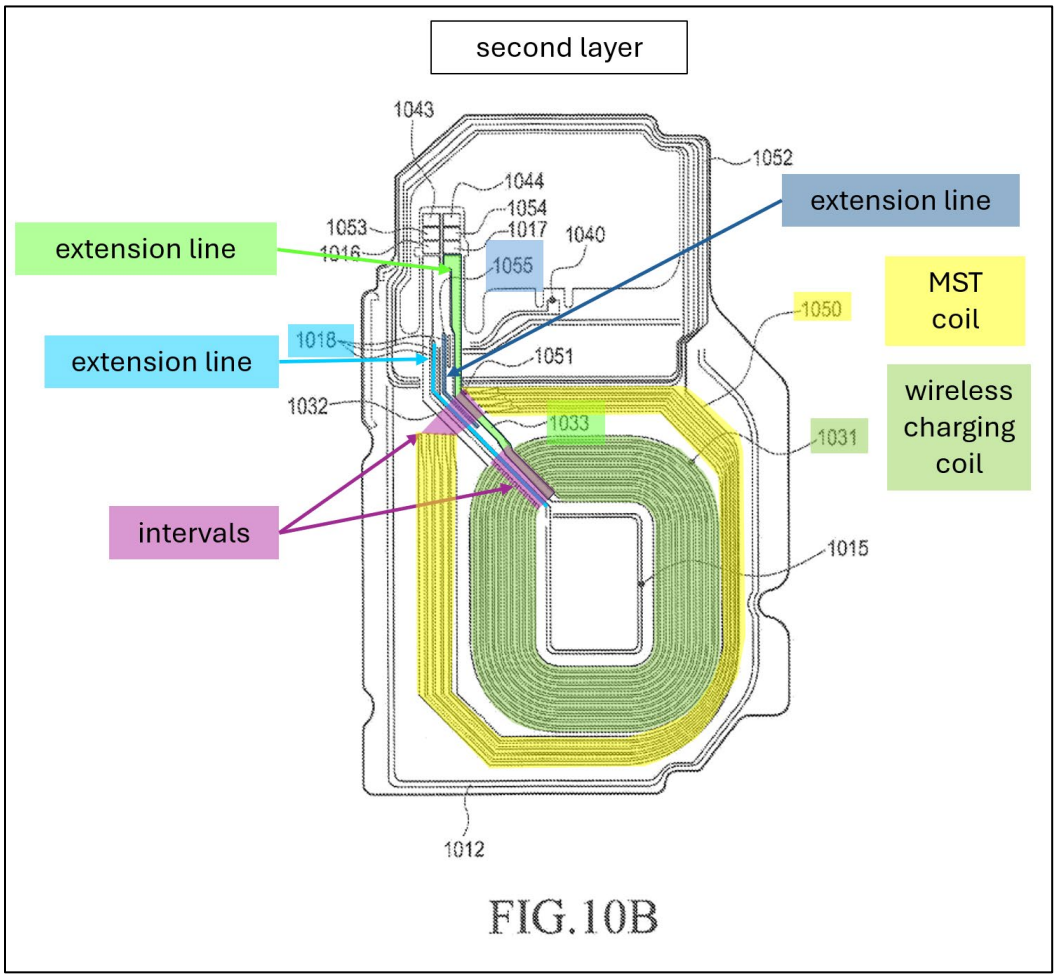


FIG.10B

Ex1011 ¶140, Fig. 10B.

186. In my opinion, a POSA would have been motivated to incorporate 721Lee's gaps teachings with Ahn to achieve this benefit and further optimize space-efficiency by running extension lines to concentric coils

through gaps. Running extension lines through outer coils was known to improve space efficiency by up to 70% (Ex1014 ¶31), including by letting the coils be arranged in a space-efficient, concentric manner, as 721Lee teaches. Ex1011, ¶140, Figs. 10B, 14C.

187. In my opinion, a POSA would have reasonably expected success. Ahn uses an extension line traversing a radially-extending inner gap to connect the inner antenna coil to the external connection pad and explains the second and third coils also need to connect to the connection pad. Ex1007, ¶¶77, 124. Ahn teaches various antenna shapes and layouts are possible. Ex1007, ¶¶111, 126. Running other extension lines through antenna coil gaps would have been a straightforward implementation of a known antenna-pattern layout to achieve predictable results of a space-efficient operable antenna.

2. [1]

a. [1pre]

Reference Number	Claim Limitation
[1pre]	A smartphone antenna module comprising:

188. In my opinion, to the extent the preamble is limiting, Ahn teaches it.

189. Ahn teaches a smartphone "antenna" "coil assembly" as shown in the annotated figures below:

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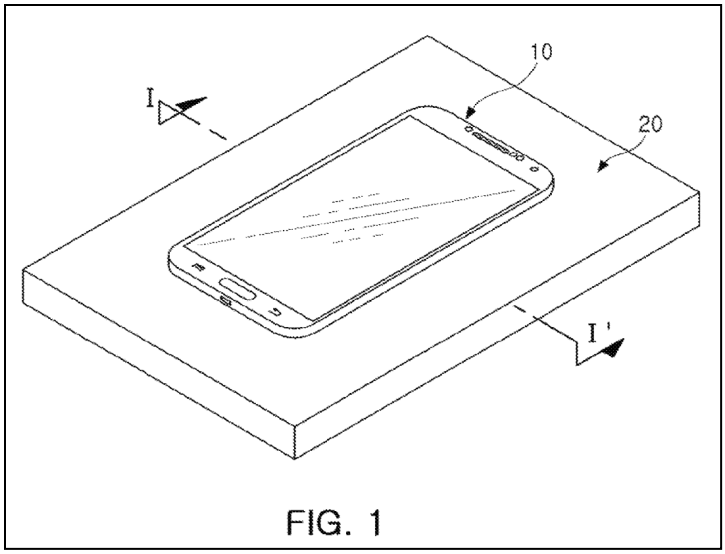


FIG. 1

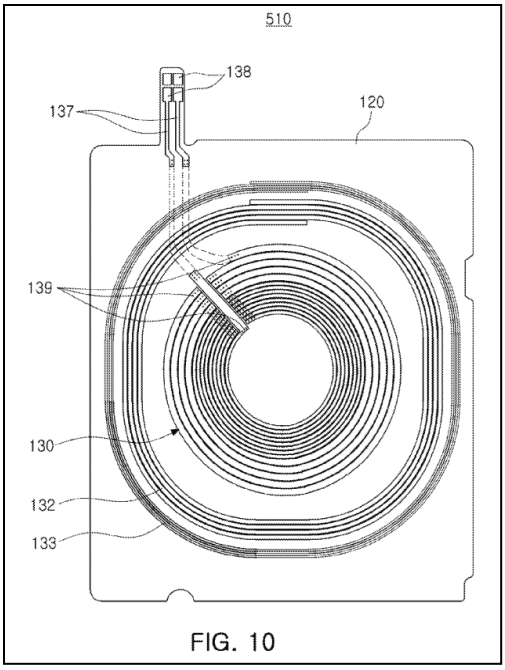


FIG. 10

Ex1007, Abstract, ¶¶23, 47-48, 125, Cl. 18, Figs. 1, 10.

190. In my opinion, a POSA would have understood that this is a smartphone antenna module. For example, it is a discrete assembly comprising multiple antennas.

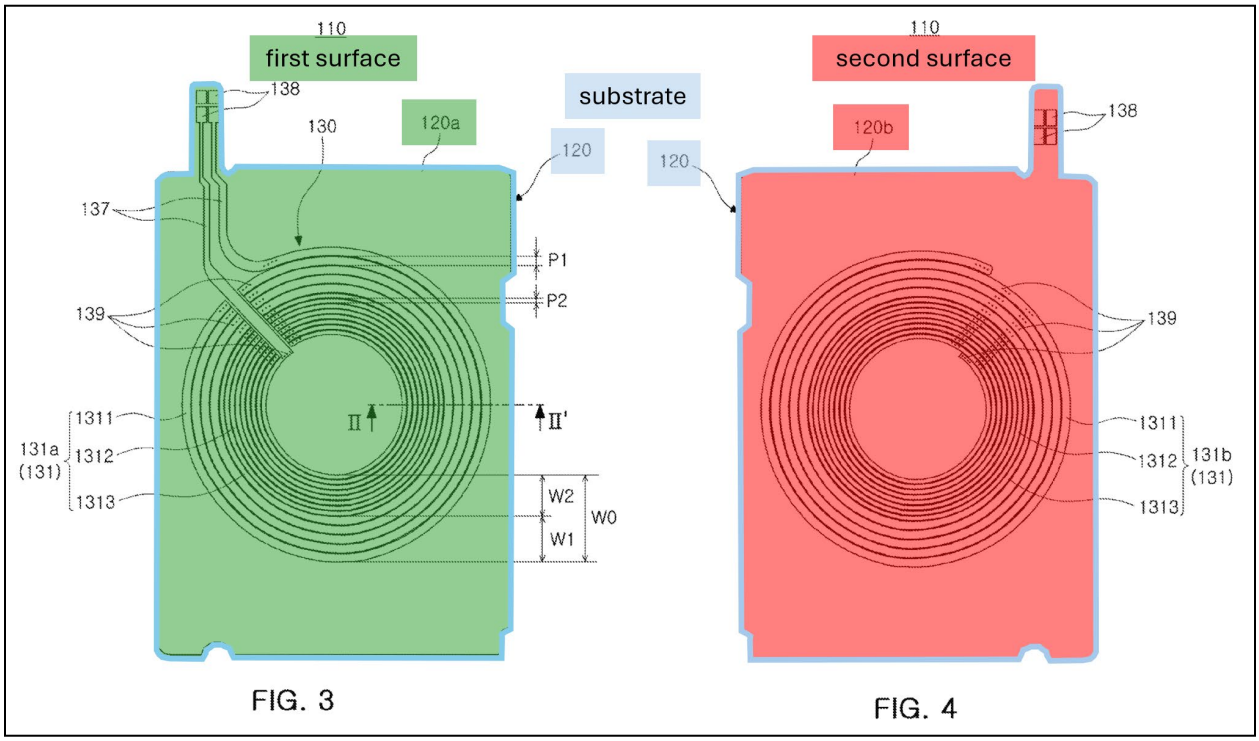
b. [1a]

Reference Number	Claim Limitation
[1a]	a substrate having a first major surface and a second major surface facing away from the first major surface;

191. In my opinion, Ahn teaches this limitation.

192. In Ahn, "substrate 120" has "**second surface 120b**" (first major surface) and "**first surface 120a**" (second major surface). Ex1007 ¶71, Figs. 3-4. Ahn's "**first surface 120a**" and "**second surface 120b**" face away from

each other—they are "opposite surfaces of the substrate" as shown in the annotated figure below:



Ex1007 ¶¶27-28, 71, Figs. 3-4.

193. Ahn Figure 10 also depicts the "**first surface**" of "**substrate 120**" as shown in the annotated figure below:

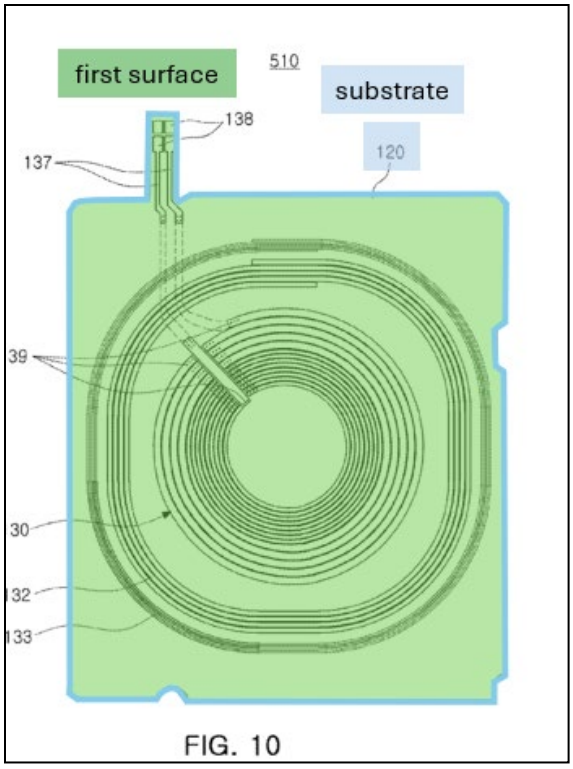


FIG. 10

Ex1007, Fig. 10.

194. Figure 10's "substrate 120" has opposing surfaces. Ahn describes "substrate 120," which Ahn depicts in Figure 10, as having a "**first surface 120a**" and a "**second surface 120b**." Ex1007, ¶¶27-28, 71, 107, 113, 120. This is explained further in Section X.B.2.d, below.

c. [1b]

Reference Number	Claim Limitation
[1b]	a first antenna pattern formed on the first major surface and comprising an inner coil and an outer coil surrounding the inner coil;

195. In my opinion, Ahn teaches this limitation.

196. Ahn teaches "second spiral wiring 131b" (first antenna pattern) on the

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"**second surface**" (first major surface) comprising "**second section 1312**" (inner coil) and "**first section 1311**" (outer coil), which surrounds "**second section 1312**" (inner coil) as shown in the annotated figure below:

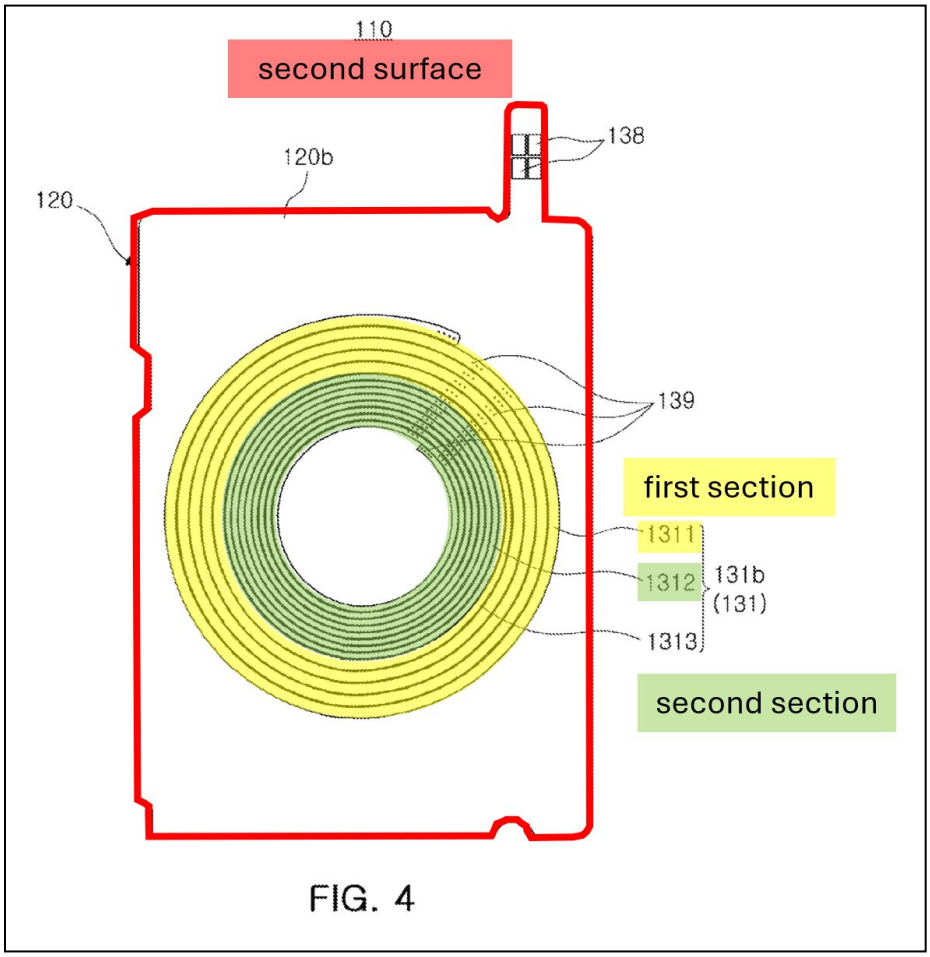


FIG. 4

Ex1007 ¶¶71, 76-77, Fig. 4.

197. In my opinion, a POSA would have understood that "second spiral wiring 131b" comprises coils. For example, Ahn describes "second spiral wiring 131b" as a "coil shape" and as a subset of "coil assembly 110." Ex1007 ¶¶68-69. Ahn also teaches that its coil wirings may be used as antennas. Ex1007 ¶125.

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d. [1c]

Reference Number	Claim Limitation
[1c]	a second antenna pattern formed on the second major surface and comprising an inner antenna pattern, and an outer antenna pattern;

198. In my opinion, Ahn teaches this limitation or alternatively, the Ahn-721Lee combination renders it obvious.

199. Ahn teaches "coil assembly 510" (second antenna pattern) on the "**first surface**" (second major surface) comprising "**first coil wiring 130**" (inner antenna pattern) and "**second coil wiring 132**" (outer antenna pattern) as shown in the annotated figure below:

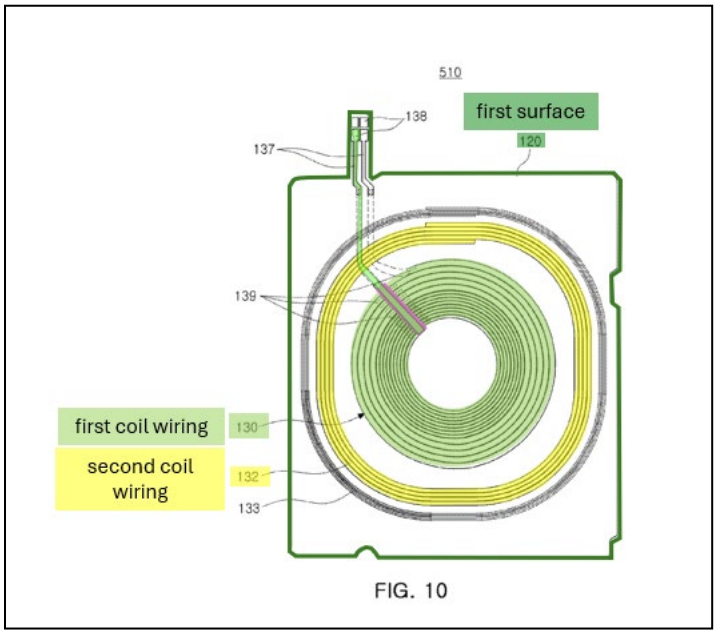


FIG. 10

Ex1007 ¶¶71, 123, 125-26, Fig. 10.

200. Ahn teaches antenna patterns from Figures 4 and 10 may be disposed on opposing surfaces of "substrate 120." Ex1007, ¶¶122-23 (antenna

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patterns for Figure 10's "substrate 120" "may have the same structure described … [for] FIG. 3," i.e., coils on opposing surfaces, as Figures 3-4 depict), Figs. 3-4.

201. In addition, in my opinion, a POSA would have found using Figure 4's coil patterns on the back surface of Figure 10's "substrate 120" obvious. Ahn teaches combining "coil wiring … structure[s]" of Figures 10 and 3. Ex1007, ¶¶122-23. Ahn illustrates Figure 10 with "interlayer connection conductors 139," which a POSA would have understood to be vias; Ahn teaches that elements 139 are used for electrically connecting coils on opposing surfaces of "substrate 120" depicted in Figure 10, as common sense would dictate. Both the presence of the "interlayer connection conductors 139" and the gaps (partial disconnections) in "first coil wiring 130" show that "substrate 120" in Figure 10 includes conducting structures on both opposing surfaces, as shown in Figs. 3 and 4, otherwise, the gaps (partial disconnections) in "first coil wiring 130" would create open circuits, rendering the "first coil wiring 130" non-functional. Ex1007, ¶74, Fig. 10. In my opinion, a POSA would have been motivated to look at other Ahn embodiments, including Figures 3-4, illustrating coil patterns on both surfaces. Ex1007, Figs. 3-4, ¶¶113, 120 (describing same for Figs. 8-9), Figs. 6-9. Because Ahn teaches Figures 3 and 10 may have

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"the same structure," a POSA would have naturally tried combining the embodiments of Figures 4 (Figure 3's opposing side) and 10. "[F]eatures of the examples described [in the specification] may be combined in various ways." Ex1007 ¶45. In my opinion, a POSA would have reasonably expected success combining Ahn Figures 10 and 4 because it would have been a straightforward application of known coil structures taught by Ahn and because Ahn teaches that its "components" can be "combined in a different manner," "replaced," or "supplemented." Ex1007 ¶129.

202. In addition, in my opinion, a POSA would have found forming the antenna patterns from Figures 4 and 10 on opposing surfaces of "**substrate 120**" to have been obvious in view of 721Lee. 721Lee teaches antenna patterns on multiple surfaces, each comprising an **inner ring portion** and an **outer ring portion** as shown in the annotated figure below:

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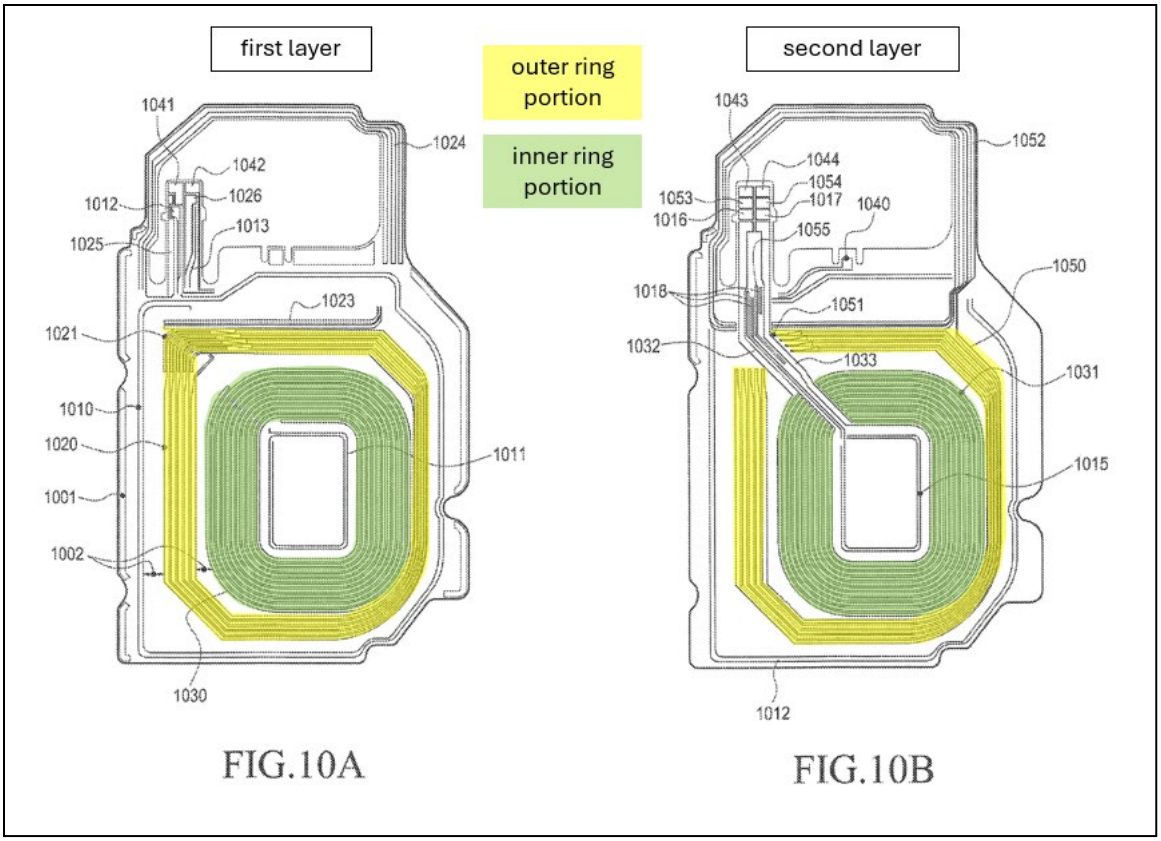


FIG.10A FIG.10B

721Lee, Figs. 10A-B.

203. In my opinion, a POSA would have been motivated to incorporate 721Lee's teaching of antenna patterns on multiple surfaces with Ahn because Ahn already teaches this with several embodiments. Ahn, ¶¶113, 120, Figs. 3-4, 6-9. Further, combining Ahn's Figures 4 and 10 on opposing surfaces of "substrate 120" would have been obvious to try in view of 721Lee, and a POSA would reasonably expect success based on the similarities between the antenna patterns of Ahn's Figures 4 and 10, and 721Lee's Figures 10A-B. Section VII.A.1.

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e. [1d]

Reference Number	Claim Limitation
[1d]	the inner antenna pattern comprising a plurality of concentric circular lines and defining a radially-extending inner gap into which the plurality of concentric circular lines of the inner antenna pattern does not extend, wherein at least part of the concentric circular lines of the inner antenna pattern overlaps the inner coil formed on the first major surface and is connected to the inner coil through vias; and

204. In my opinion, Ahn teaches this limitation.

205. Ahn's "**first coil wiring 130**" (inner antenna pattern) comprises a plurality of **concentric circular lines** defining a "**partially disconnected**" portion (radially-extending inner gap) into which the plurality of **concentric circular lines** of "**first coil wiring 130**" does not extend as shown in the annotated figure below:

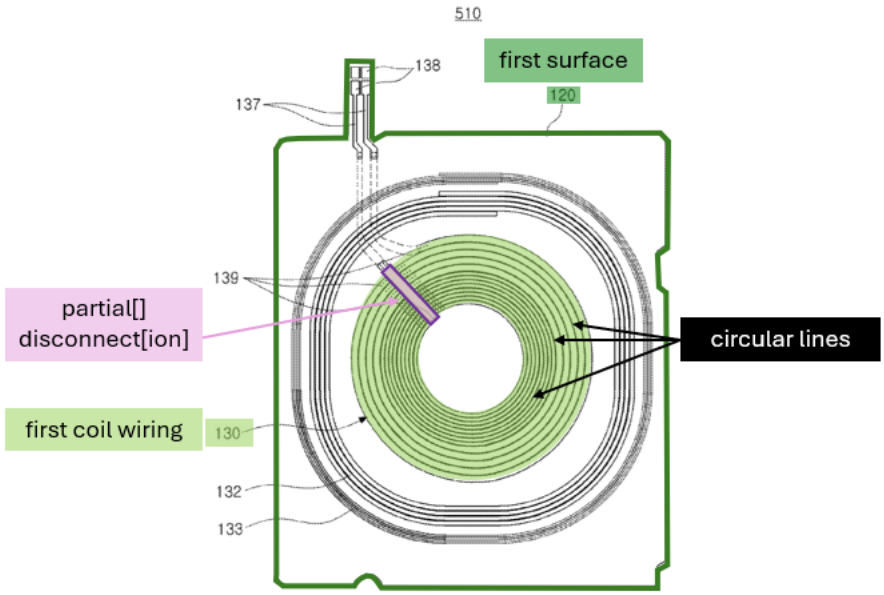


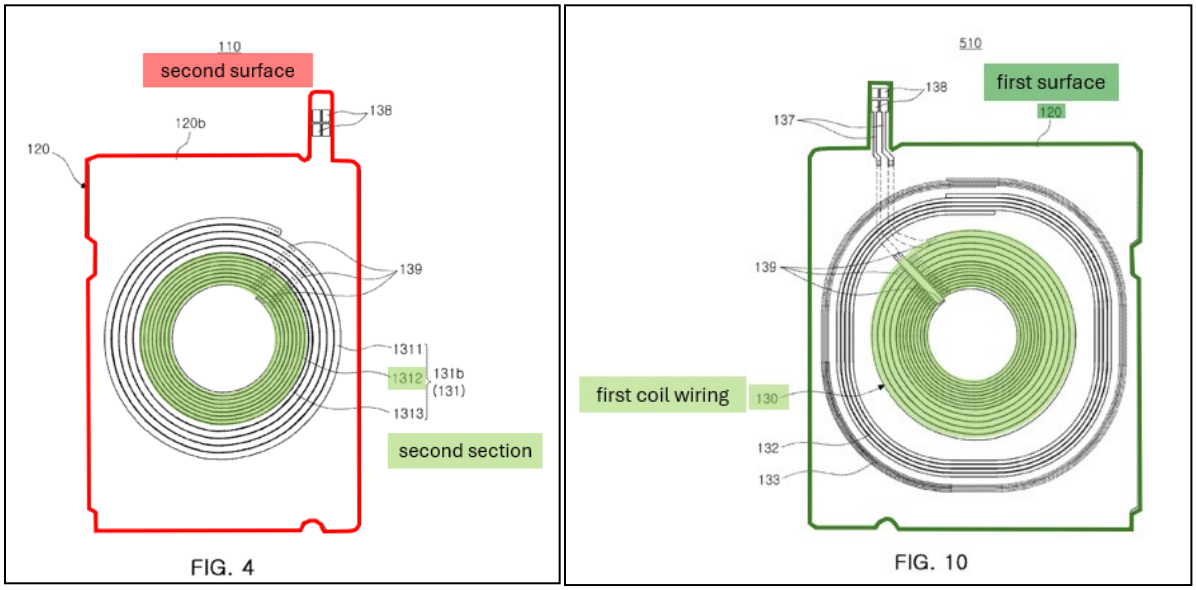
FIG. 10

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Ex1007 ¶72, Fig. 10.

206. Ahn teaches an inner gap is formed when the spiral wiring of "**first coil wiring 130**" is "**partially disconnected**." Ex1007 ¶¶72-73, 124-125, Fig. 10. The inner gap's purpose is so "lead wirings 137 may be disposed … through the disconnected region" in a "diameter (radial) direction," thereby connecting both ends of "**first coil wiring 130**" to "connection pads 138." Ex1007 ¶73.

207. At least part of the concentric **circular lines** of "**first coil wiring 130**" on Ahn's "**first surface 120**" (inner antenna pattern) overlaps the "**second section 1312**" formed on "**second surface**" (inner coil), as can be seen by comparing Ahn's first and second surfaces as shown in the annotated figures below:

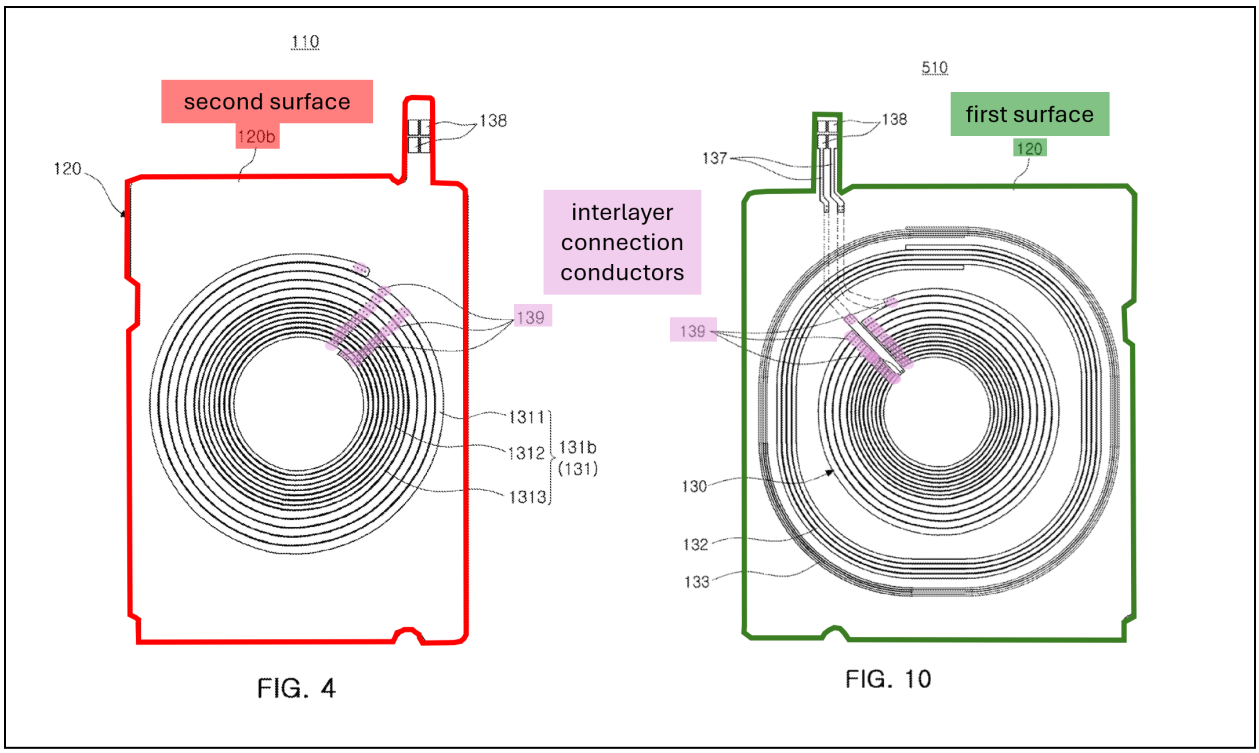


Ex1007, Figs. 4, 10.

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208. Ahn teaches and further renders obvious forming the antenna patterns from Figures 4 and 10 on opposing surfaces of "substrate 120." Ground 2 Limitation [1c].

209. Ahn teaches "first coil wiring 130" on "first surface 120" (inner antenna pattern) is connected to "second section 1312" on "second surface" (inner coil) through "interlayer connection conductors 139" (plurality of vias) as shown in the annotated figure below:



Ex1007 ¶¶13, 71, 74, 108, 113, 120, Figs. 4, 10, Cl. 8; Ground 2 Limitation [1c].

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f. [1e]

Reference Number	Claim Limitation
[1e]	the outer antenna pattern comprising a plurality of concentric circular lines and defining a radially-extending outer gap into which the plurality of concentric circular lines of the outer antenna pattern does not extend, wherein at least part of the concentric circular lines of the outer antenna pattern overlaps the outer coil formed on the first major surface and is connected to the outer coil through vias,

210. In my opinion, the Ahn-721Lee combination renders this limitation obvious.

211. Ahn teaches "both ends of the **second wiring coil 132** … ***need*** to be connected to the **connection pads 138**, which is ***omitted in FIG. 10 for convenience***" as shown in the annotated figure below:

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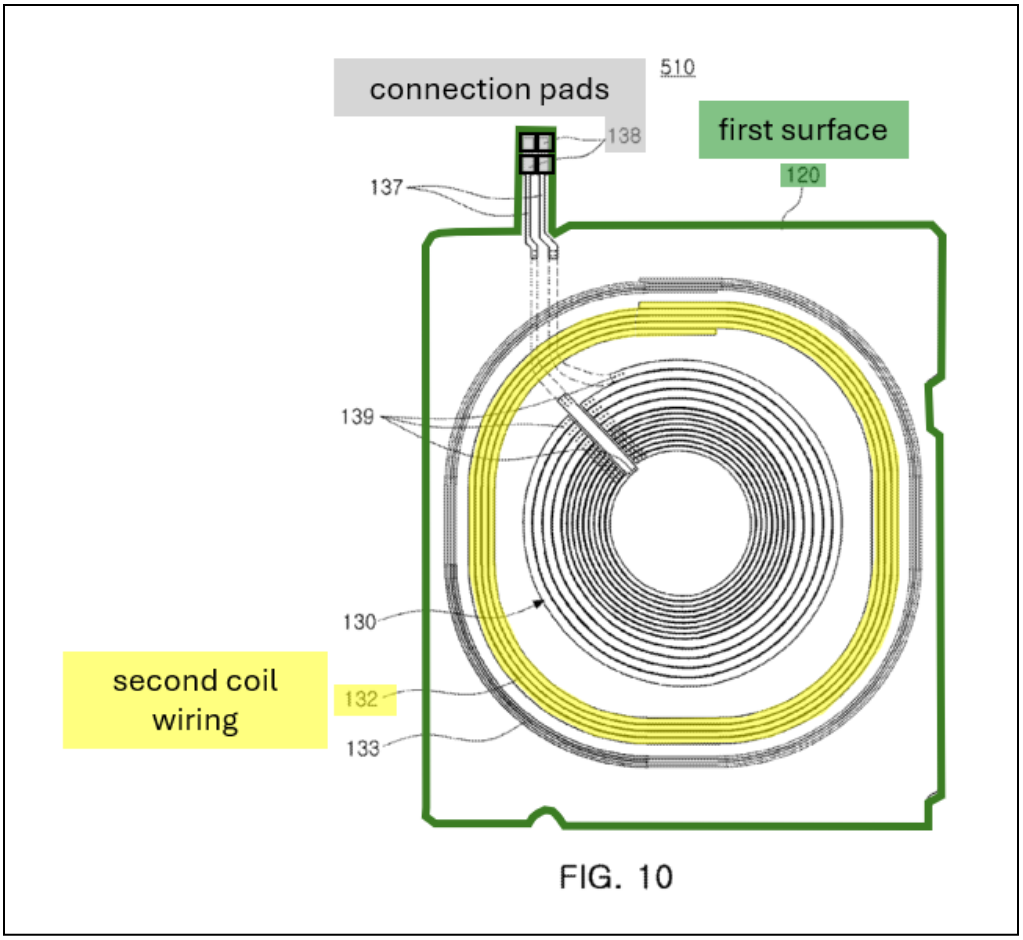


FIG. 10

Ex1007 ¶124, Fig. 10.

212. In my opinion, a POSA reading Ahn would have understood, as explained for Ground 2 Limitation [1d] regarding Ahn's "**partial[] disconnect[ion]**" of "**first coil wiring 130**," which lets both ends of "**first coil wiring 130**" be connected to connection pads 138 (Ex1007 ¶¶72-73, Fig. 10), and using a **partial disconnection** of "**second coil wiring 132**" (radially-extending outer gap), into which the plurality of **concentric circular lines** of "**second coil wiring 132**" does not extend, would effectuate Ahn's teaching that both ends of "**second coil wiring 132**" are connected to connection pads

138 (*id.* ¶124). The **partial disconnection** of "**second coil wiring 132**" allows space for wired connections to "**first coil wiring 130**" because "**first coil wiring 130**" is surrounded by "**second coil wiring 132**" as shown in the annotated figure below:

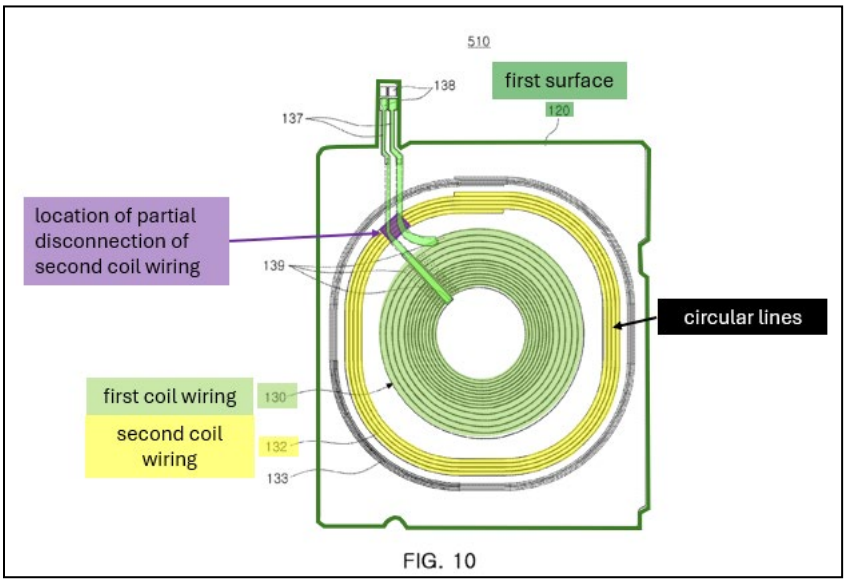


FIG. 10

Ex1007, Fig. 10.

213. Further, in my opinion, a POSA would have found a partial disconnection of "**second coil wiring 132**" to have been obvious in view of 721Lee. 721Lee teaches "**MST coil 1050**" (outer antenna pattern) has an "**interval of the MST coil 1050**" (radially-extending outer gap) through which "**MST patterns 1055**" extend as shown in the annotated figure below:

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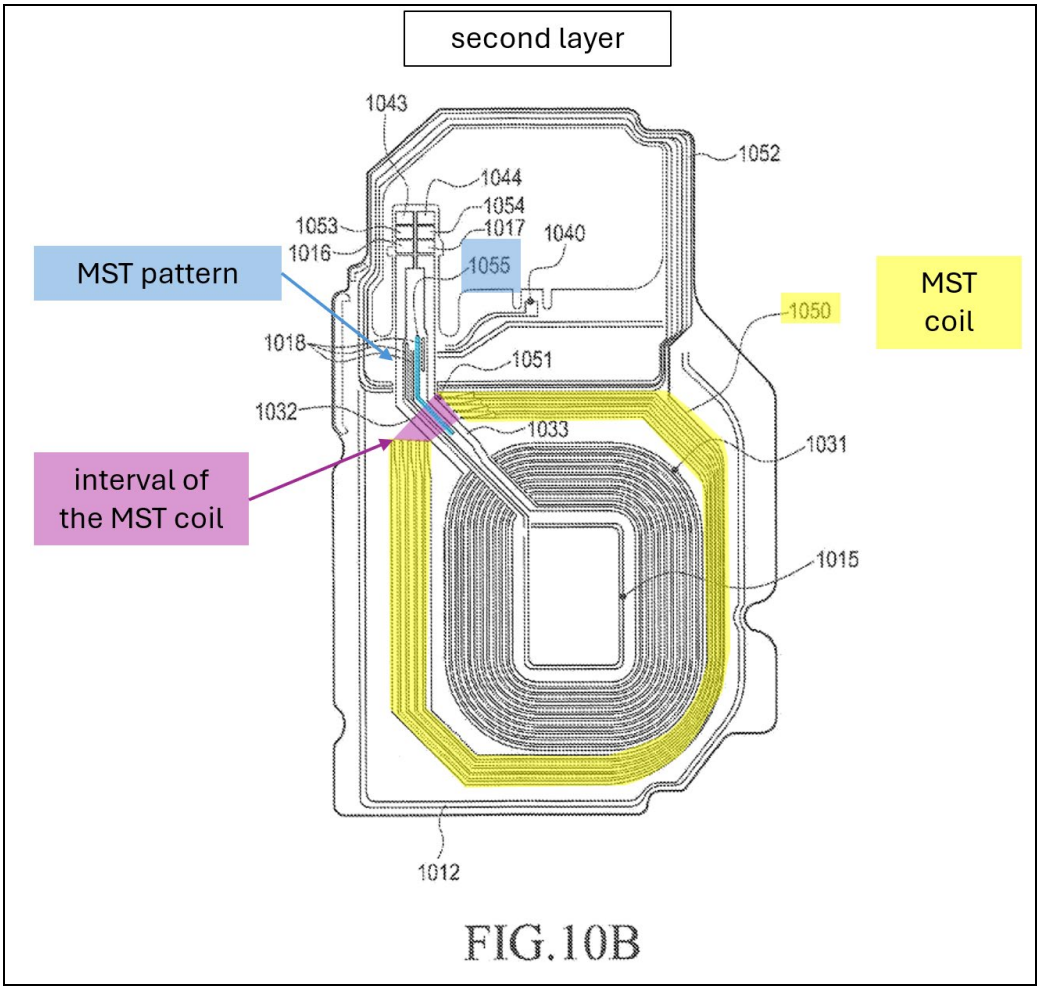


FIG.10B

Ex1011 ¶140, Fig. 10B.

214. This outer gap beneficially lets "wireless charging coil 1031" (inner coil) "be connected to the input/output terminals through the interval of the MST coil 1050." Ex1011 ¶140.

215. It would have been obvious to incorporate 721Lee's radial-gap teachings with Ahn. Section X.B.1.

216. Ahn teaches at least part of the concentric **circular lines** of "**second coil wiring 132**" on "**first surface 120a**" (outer antenna pattern) overlaps the

"**first section 1313**" on "**second surface**" (outer coil). Ahn teaches and further renders obvious forming the antenna patterns from Figures 4 and 10 on opposing surfaces of "substrate 120," as can be seen by comparing Ahn's first and second surfaces as shown in the annotated figures below:

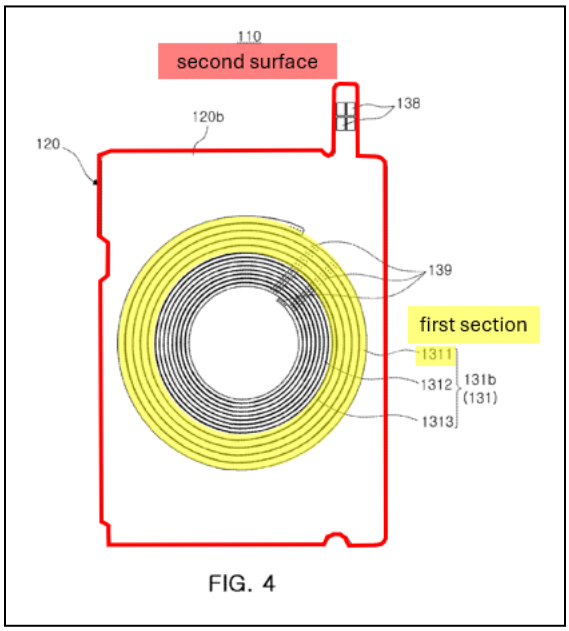


FIG. 4

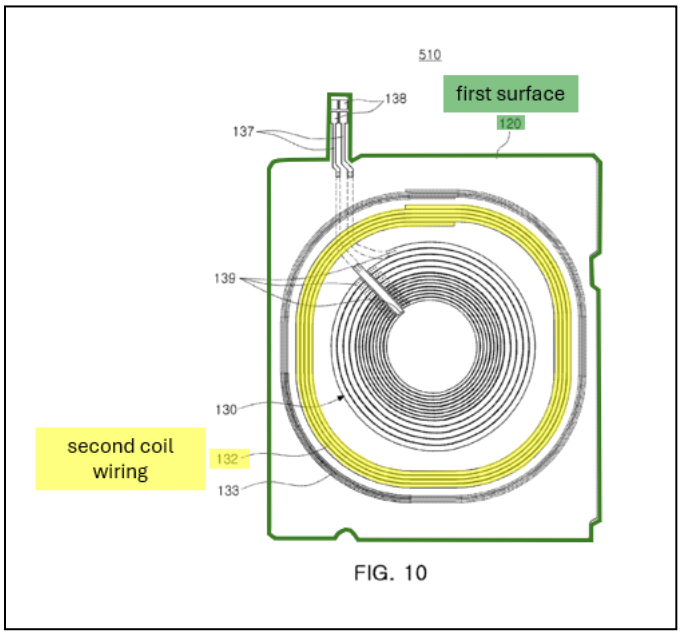


FIG. 10

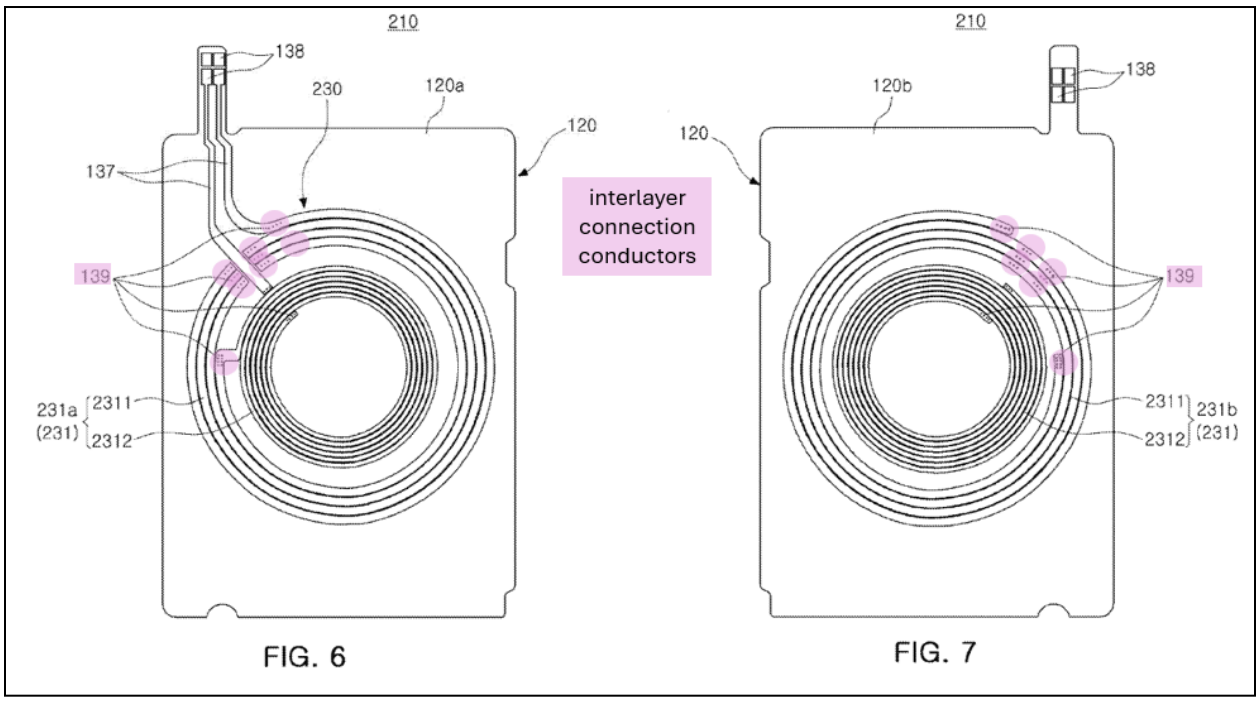
Ex1007, Figs. 4, 10; Ground 2 Limitations [1c]/[1d].

217. As illustrated, "**second coil wiring 132**" on "**first surface 120a**" (outer antenna pattern) overlaps with "**first section 1311**" on "**second surface**" (outer coil) because both extend near the outer-most boundary of "substrate 120." In addition, in my opinion, a POSA would have found this limitation obvious. Ahn's antenna configurations may be varied and, in my opinion, a POSA would have understood that adjusting the shape and size of "**second coil wiring 132**" and "**first section 1311**," such that

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they overlap, would have improved the space efficiency of the layout. Ex1008, ¶¶4, 44-45; *id.* Figs 6-7 (illustrated below depicting overlapping outer coils on either side).

218. Ahn teaches "**second coil wiring 132**" on "**first surface 120a**" (outer antenna pattern) is connected to "**first section 1311**" on "**second surface**" (outer coil) through "**interlayer connection conductors 139**" (plurality of vias) as shown in the annotated figure below:



Ex1007, Figs. 6-7.

219. It would have been obvious to combine on opposing sides the antenna pattern from Figure 10 and other illustrated antenna patterns, including those on Figures 6-7. Ex1007, ¶¶45, 122-23, 129; Ground 2 Limitation [1c].

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220. Ahn illustrates several antenna patterns with "**interlayer connection conductors 139**" which electrically connect coils on opposing surfaces. Ex1007, ¶¶13, 74, 108, 113, 120, Cl. 8, Figs. 3-4, 6-7, 10. Any of Ahn's antenna patterns may incorporate "**interlayer connection conductors 139**" on outer coils and outer antenna patterns because Ahn teaches "features of the examples described [in the specification] may be combined in various ways." Ex1007 ¶45. Ahn teaches "[s]uitable results may be achieved … if components in a described system … are combined in a different manner, and/or replaced or supplemented by other components." Ex1007 ¶129.

g. [1f]

Reference Number	Claim Limitation
[1f]	wherein at least part of the concentric circular lines of the outer antenna pattern generally surround at least part of the concentric circular lines of the inner antenna pattern,

221. In my opinion, Ahn teaches this limitation.

222. In Ahn, at least part of the concentric **circular lines** of Ahn's "**second coil wiring**" generally surround at least part of the concentric **circular lines** of the "**first coil wiring**" as shown in the annotated figure below:

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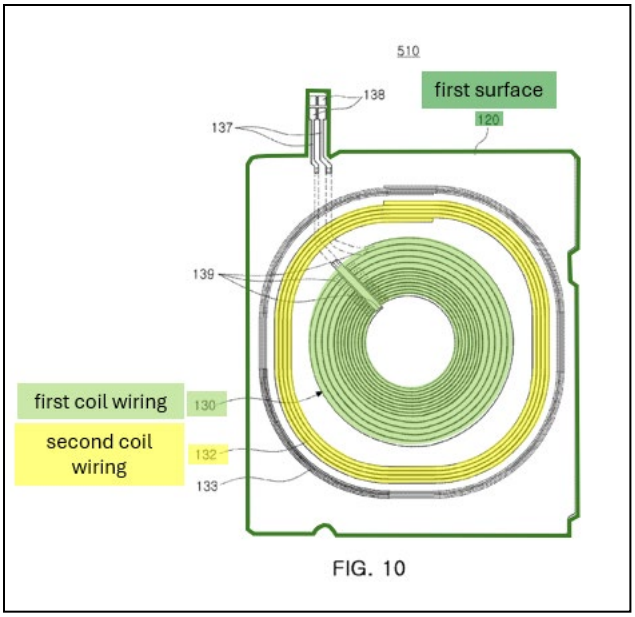


FIG. 10

Ex1006, Fig. 10.

h. [1g]

Reference Number	Claim Limitation
[1g]	wherein the radially-extending outer gap and the radially-extending inner gap are connected and aligned in a direction.

223. In my opinion, the Ahn-721Lee combination renders this limitation obvious.

224. In my opinion, the Ahn-721Lee combination renders obvious, the **partial disconnection** of "**second coil wiring 132**" and the "**partial[] disconnect[ion]**" of "**first coil wiring 130**" are connected and aligned in a **direction** as shown in the annotated figure below:

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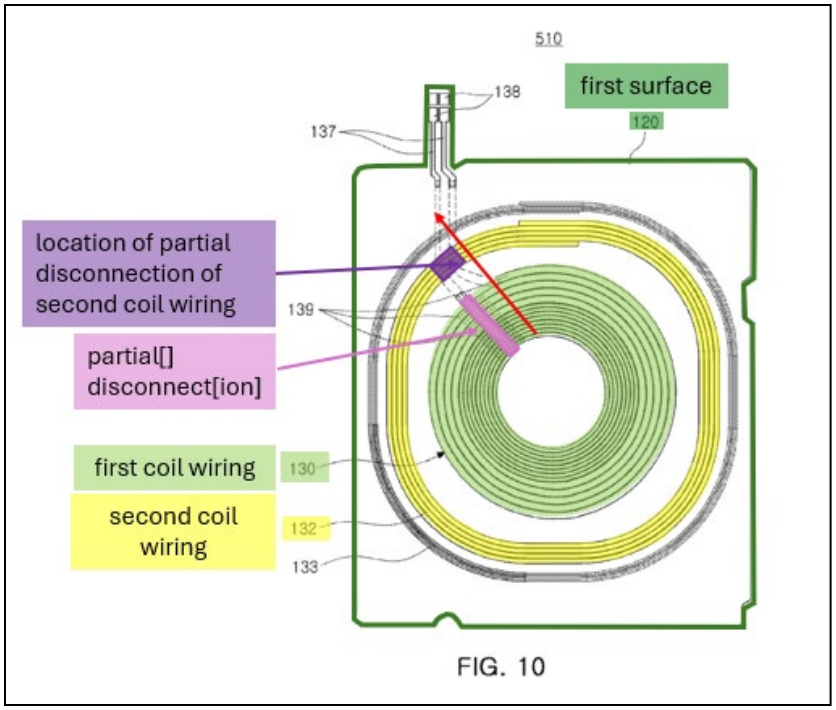


FIG. 10

Ex1007, Fig. 10 (modified in view of Ahn and 721Lee); Ground 2 Limitations [1d]/[1e].

225. Further, if this limitation requires the radially-extending inner and outer gaps be directly adjacent and/or if a **partial disconnection** of "**second coil wiring 132**" and the "**partial[] disconnect[ion]**" of "**first coil wiring 130**" are not connected and aligned, in my opinion, a POSA would have found this obvious. Ahn teaches "**second coil wiring 132**" and "**first coil wiring 130**" may vary in width, turns, shapes, and configurations. Ex1007 ¶¶44, 77, 105, 126. In my opinion, a POSA would have understood a directly adjacent arrangement was possible and would have been motivated to further Ahn's space-efficiency goal (Ex1007 ¶¶4, 65, 68) by arranging the

inner and outer coils such that their gaps were tightly connected and aligned.

226. Ahn teaches and it would have been obvious, to incorporate Ahn's Figures 3-4 teachings with Ahn's Figure 10 teachings. Ground 2 Limitation [1a].

3. [2]

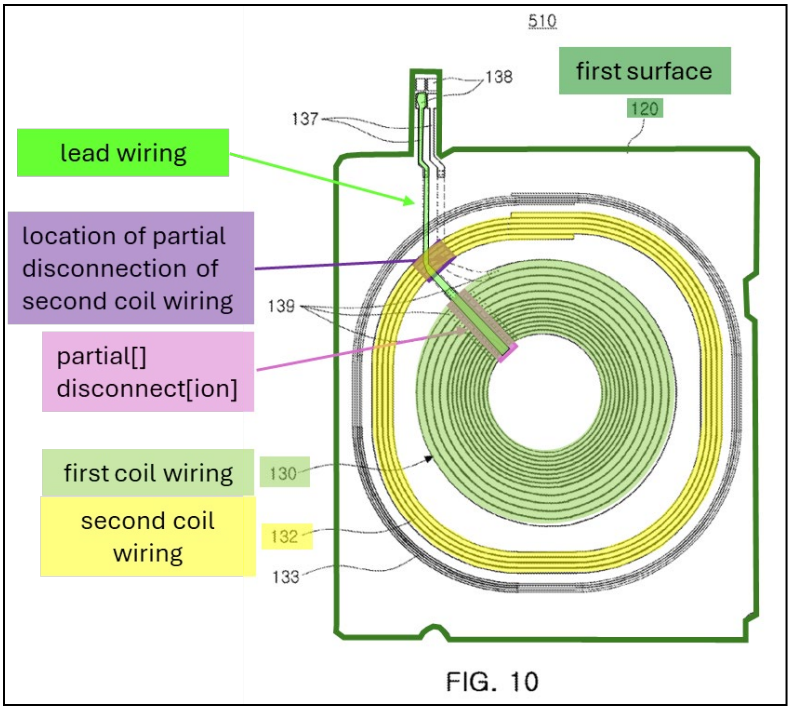
a. [2pre]

Reference Number	Claim Limitation
[2pre]	The smartphone antenna module of claim 1, further comprising an inner extension line formed on the second major surface and extending through the radially-extending outer gap and further through at least part of the radially-extending inner gap; and

227. In my opinion, the Ahn-721Lee combination renders claim 1 obvious and further renders obvious the remaining limitations of this claim.

228. Ahn's "**lead wirings 137**" "connect[] one end of the first spiral wiring 131*a* disposed at the center (e.g., the innermost turn) of the first spiral wiring 131*a* and one of the connection pads 138 to each other" (i.e., an inner extension line formed on Ahn's "**first surface**" (second major surface)), and "**lead wirings 137**" "traverse the spiral wiring 131*a* through the **disconnected region** in a diameter (radial) direction of the first spiral wiring 131*a*" as shown in the annotated figure below:

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Ex1007 ¶73, Fig. 10 (modified in view of Ahn and 721Lee).

229. As shown above, the Ahn-721Lee combination renders obvious, Ahn's "**lead wirings 137**" extending through the **partial disconnection** of "**second coil wiring 132**" and the at least part of the "**partial[] disconnect[ion]**" of "**first coil wiring 130**." Ground 2 Limitations [1f]/[1g].

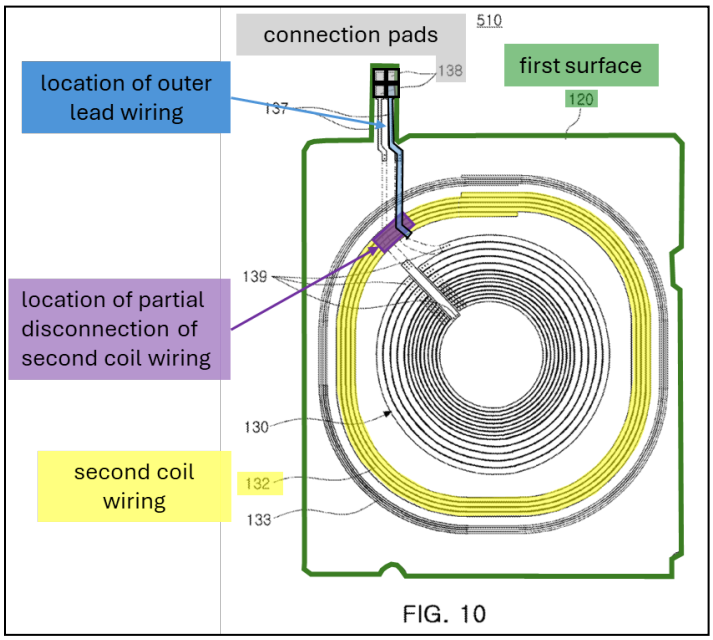
b. [2a]

Reference Number	Claim Limitation
[2a]	an outer extension line formed on the second major surface and extending through at least part of the radially-extending outer gap.

230. In my opinion, the Ahn-721Lee combination renders this limitation obvious.

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231. Ahn teaches both ends of "**second coil wiring 132**" and "**first coil wiring 130**" on "**first surface 120**" (second major surface) "***need*** to be connected to the connection pads 138." Ex1007, ¶124. For "**first coil wiring 130**," Ahn uses "**lead wirings 137**" running through the "**partial[] disconnect[ion]**" to accomplish this connection for "**first coil wiring 130**." Ground 2 Limitation [1h]. In my opinion, a POSA would have understood that "**second coil wiring 132**" must be connected to the "connection pads 138" and it would have been logical to do so in the same way, i.e., by an **outer lead wiring** through the **radially-extending outer gap** as shown in the annotated figure below:



Ex1007, Fig. 10 (modified based on ¶124 to illustrate **outer lead wiring** and **radially-extending outer gap**).

232. In addition, this limitation would have been obvious in view 721Lee.

233. In 721Lee, "**MST patterns 1055**" formed on the "second layer" electrically connect "**MST coil 1050**" to "MST input/output terminals 1053 and 1054" and extend along the radial direction through the "**interval of the MST coil 1050**." Ex1011 ¶140.

234. It would have been obvious to incorporate 721Lee's teachings of an outer antenna pattern comprising a radially-extending outer gap through which extension lines run with Ahn. Section X.B.1; Ground 2 Limitation [1g]. For similar reasons, in my opinion, a POSA would have been motivated to run an outer extension line (like Ahn's "lead wirings 137") through at least part of a radially-extending outer gap, as 721Lee teaches, to connect Ahn's second coil wiring 132 to connection pads 138 and would have reasonably expected success.

4. [3]

Reference Number	Claim Limitation
[3]	The smartphone antenna module of claim 2, wherein the inner extension line and the outer extension line extend generally in parallel, and wherein each of the inner extension line and the outer extension line formed on the second major surface comprises a portion that overlaps the outer coil formed on the first major surface.

235. In my opinion, the Ahn-721Lee combination renders claim 2 obvious and further renders obvious the remaining limitations of this claim.

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236. Ahn teaches, and the Ahn-721Lee combination renders obvious, "**lead wirings 137**" for "**first coil wiring 130**" and "**second coil wiring 132**" extend "in a **diameter (radial) direction**" and generally in parallel because they extend together in the same direction as shown in the annotated figure below:

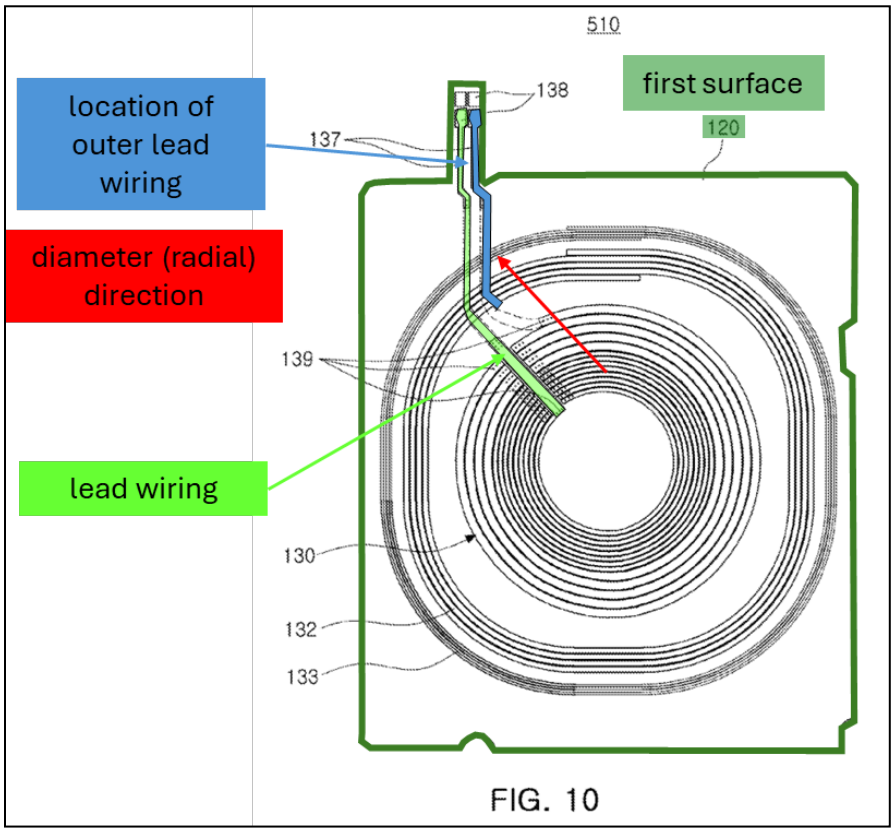


FIG. 10

Ex1007, ¶¶69, 72-74, Fig. 10 (modified based on ¶¶124, 126 to illustrate the location of **outer lead wiring**); Ground 2 Limitations [1h]/[1i].

237. Further, 721Lee teaches both extension lines extend generally in parallel as shown in the annotated figure below:

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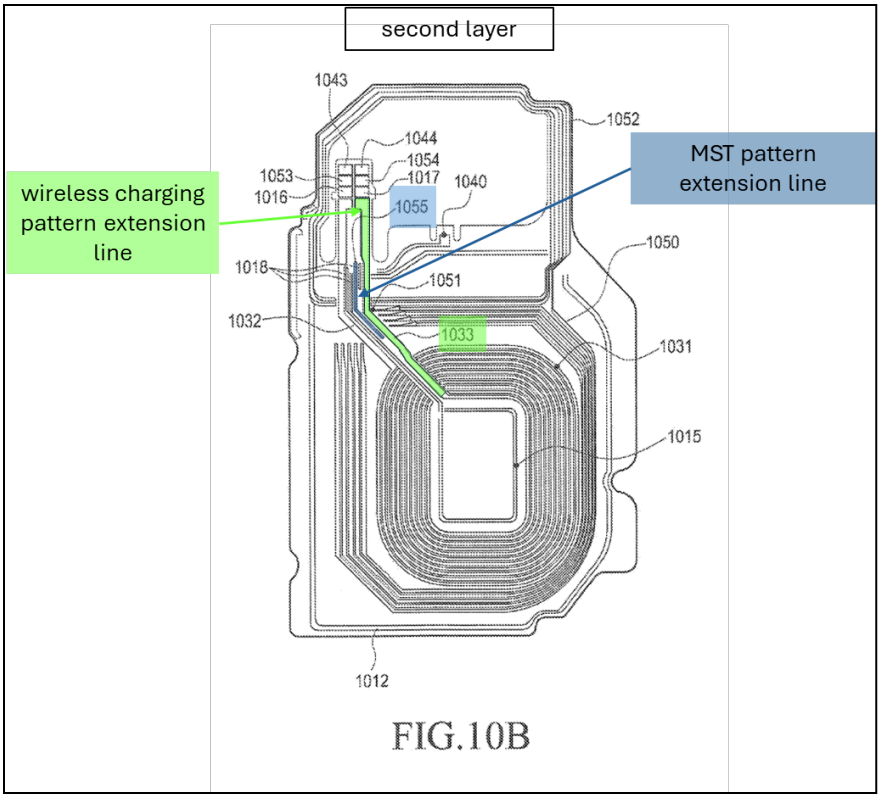
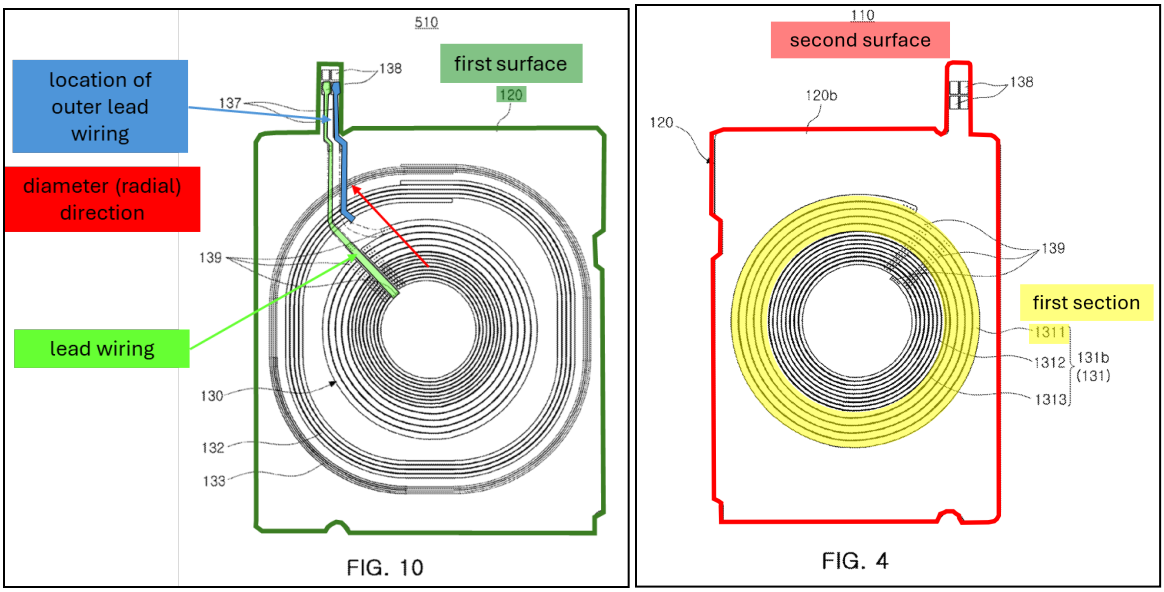


FIG.10B

Ex1011, Fig. 10B.

238. It would have been obvious to incorporate 721Lee's radially-extending gap and extension-lines teachings with Ahn. Section X.B.1.

239. Additionally, Ahn teaches each of the "**lead wirings 137**" and **outer lead wiring** overlap "**first section 1311**" on the "**second surface**." As can be seen by comparing Figures 10 and 4, Ahn teaches locating its coils up to the edges of the substrate, such that Ahn's second major surface extension lines overlap Ahn's first major surface outer coil ("**first section 1311**") as shown in the annotated figure below:



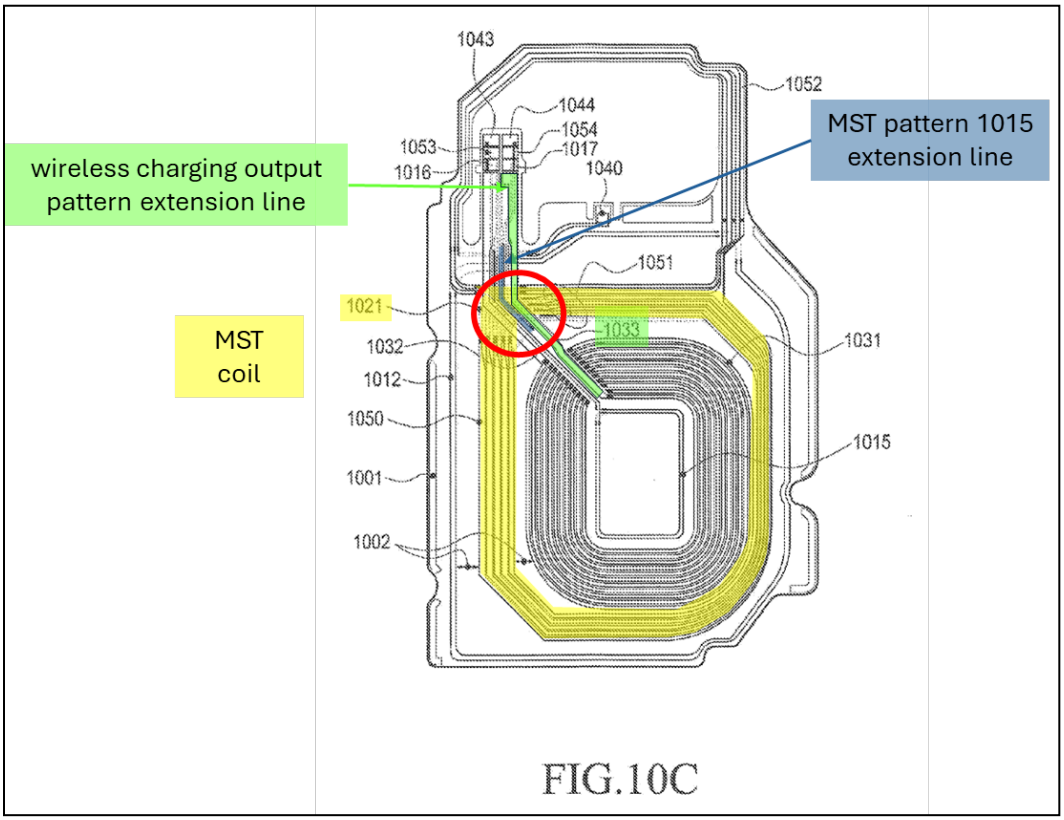
Ex1007, Figs. 4, 10 (modified to illustrate location of **outer lead wiring**).

240. In addition, in my opinion, a POSA would have found the overlapping extension lines obvious. Ahn teaches the invention may vary in configuration and layout. Ex1007 ¶¶44, 77, 105, 126. There were a finite number of predictable configurations and layouts for Ahn's coils and overlapping Ahn's coils and extension lines on opposing surfaces would have furthered Ahn's space-efficiency goal by increasing compactness, reducing unused substrate space. Ex1007, ¶¶4, 65, 68, 99-100, 127.

241. Further, this limitation would have been obvious in view of 721Lee. 721Lee Figure 10C overlays the two different surfaces shown in 721Lee Figures 10A-10B, showing 721Lee's "**MST patterns 1055**" extension line (outer extension line) and "**wireless charging output pattern**" (inner extension line) extension line (collectively, the claimed extension lines on

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the second major surface) **overlap** with "**MST coil 1021**" (outer coil on first major surface) as shown in the annotated figure below:



Ex1007, Fig.10C, ¶144.

242. It would have been obvious to incorporate 721Lee's overlapping pattern design and gap teachings with Ahn to improve compactness and reduce unused substrate space. Section X.B.1.

5. [4]/[14]

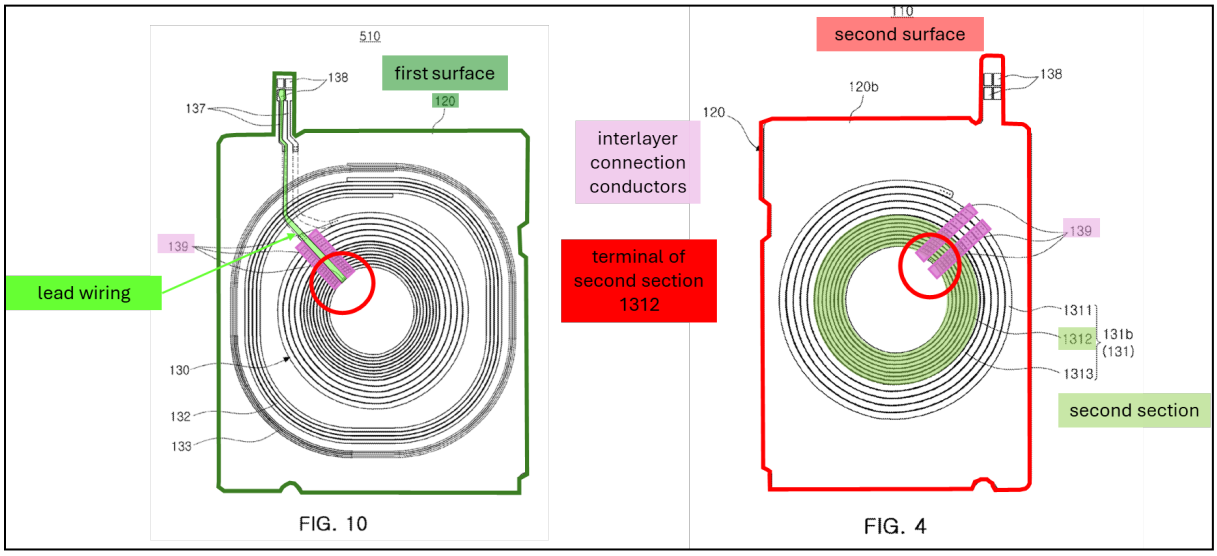
Reference Number	Claim Limitation
[4]	The smartphone antenna module of claim 2, wherein the inner extension line is electrically connected to a terminal of the inner coil, wherein at least part of the concentric circular lines of the inner antenna pattern is in a C shape.

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[14]	The smartphone of claim 13, wherein the inner extension line is electrically connected to a terminal of the inner coil, wherein at least part of the concentric circular lines of the inner antenna pattern is in a C shape.

243. In my opinion, the Ahn-721Lee combination renders claims 2 and 13 obvious and further renders obvious the remaining limitations of these claims.

244. Ahn teaches "**lead wirings 137**" electrically connected to a "**second section 1312**" **terminal** as shown in the annotated figure below:



Ex1007 ¶¶69, 72-74, Fig. 10.

245. As Ahn depicts in Figure 10, Ahn's **inner extension line** accomplishes this.

246. Ahn teaches "**first coil wiring 130**" on "**first surface 120**" is connected to "**second section 1312**" on "**second surface**" through vias. Ground 1 Limitation [1d]. In my opinion, a POSA would have understood the **inner**

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extension line electrically also connects to a terminal of the "**second section 1312**" through vias.

247. Further, at least part of the concentric circular lines of Ahn's "**first coil wiring**" (inner antenna pattern) is in a C-shape as shown in the annotated figure below:

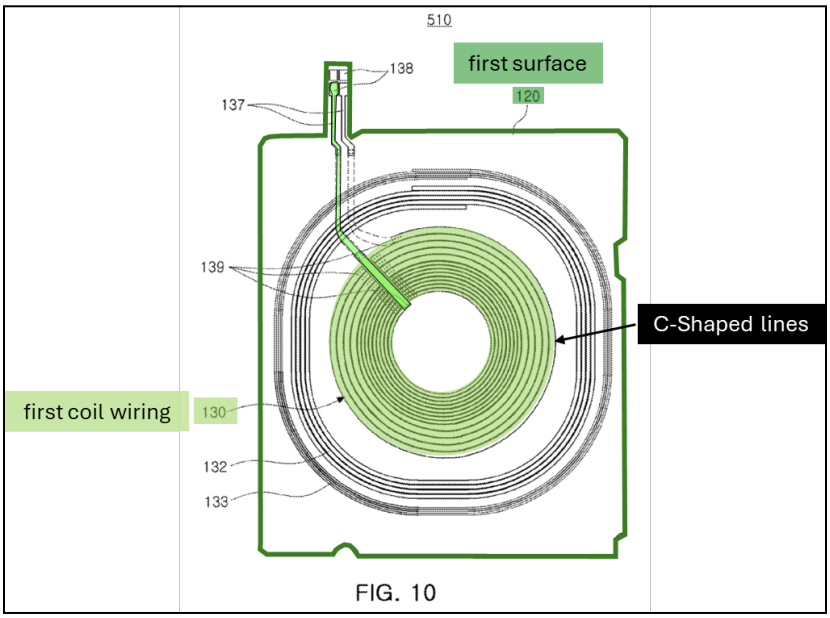


FIG. 10

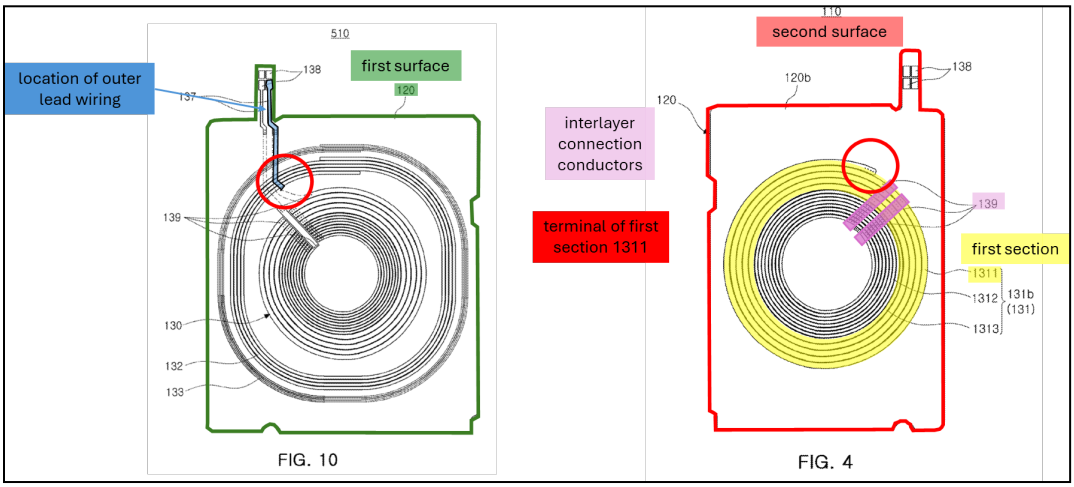
Ex1007 Fig. 10; Ground 2 Limitation [1d].

6. [5]/[15]

Reference Number	Claim Limitation
[5]	The smartphone antenna module of claim 2, wherein the outer extension line is electrically connected to a terminal of the outer coil, wherein at least part of the concentric circular lines of the outer antenna pattern is in a C shape.
[15]	The smartphone of claim 13, wherein the outer extension line is electrically connected to a terminal of the outer coil, wherein at least part of the concentric circular lines of the outer antenna pattern is in a C shape.

248. In my opinion, the Ahn-721Lee combination renders claims 2 and 13 obvious and further renders obvious the remaining limitations of these claims.

249. Ahn teaches "**lead wirings 137**" electrically connected to a "**second coil wiring 132**" **terminal** as shown in the annotated figure below:



Ex1007, Fig. 10 (modified based on ¶124 to illustrate **outer lead wiring**).

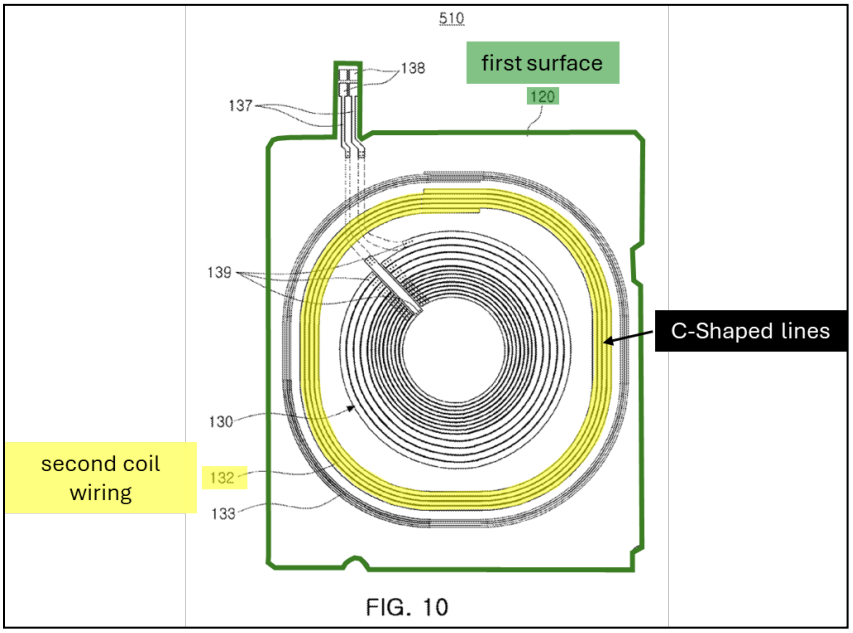
250. As Ahn depicts in Figure 10, Ahn's **outer lead wiring** accomplishes this.

251. Ahn teaches "**second coil wiring 132**" on "**first surface 120**" is connected to "**first section 1313**" on "**second surface**" through vias. Ground 1 Limitation [1e]. In my opinion, a POSA would have understood the **outer lead wiring** electrically connects to a terminal of the "**first section 1313**" through vias too.

252. At least part of the concentric circular lines of Ahn's "**second coil wiring**" (outer antenna pattern) is in a C-shape as shown in the annotated figure

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below:



Ex1007 Fig. 10; Ground 2 Limitation [1e].

7. [6]/[17]

Reference Number	Claim Limitation
[6]	The smartphone antenna module of claim 2, wherein at least one of the inner extension line and the outer extension line is electrically connected to the first antenna pattern formed on the first major surface through at least one via.
[17]	The smartphone of claim 13, wherein at least one of the inner extension line and the outer extension line is electrically connected to the first antenna pattern formed on the first major surface through at least one via.

253. In my opinion, the Ahn-721Lee combination renders claims 2 and 13 obvious and Ahn further teaches the remaining limitations of these claims.

254. Ahn teaches, and the Ahn-721Lee combination renders obvious, at least one of "**lead wirings 137**" and **outer lead wiring** is electrically connected

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to the first antenna pattern on the "**second surface**" through at least one via. Ahn teaches, and the Ahn-721Lee combination renders obvious, the **inner extension line** and **outer extension line** are electrically connected to the "**second section 1312**" and "**first section 1311**," respectively, through vias. Ground 2 Limitations [4]/[14]/[5]/[15]. And, Ahn's "**second section 1312**" and "**first section 1311**" comprise the first antenna pattern on "**second surface**" (first major surface). Ground 2 Limitations [1b].

8. [7]/[18]

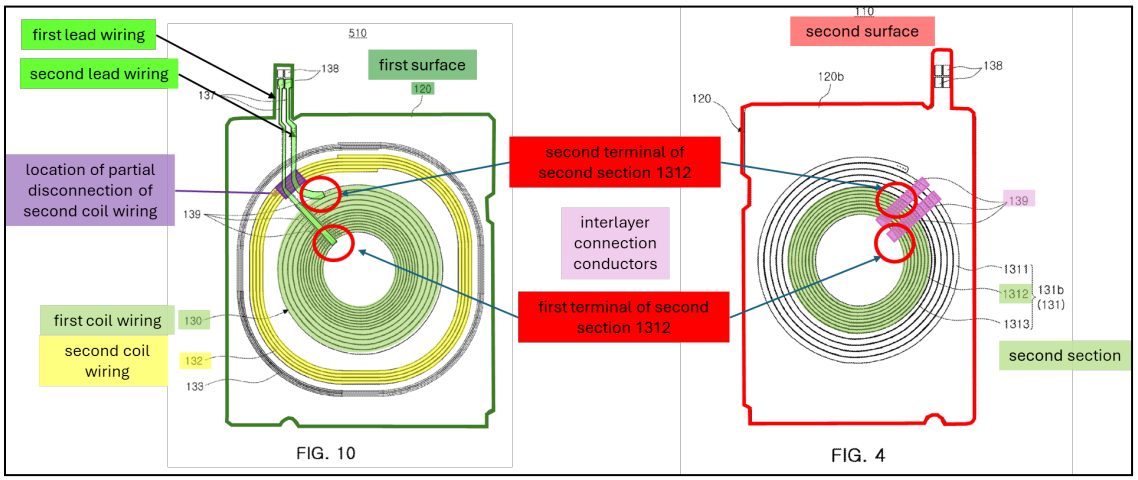
Reference Number	Claim Limitation
[7]	The smartphone antenna module of claim 2, wherein the inner extension line is referred to as a first inner extension line and is electrically connected to a first terminal of the inner coil, wherein the smartphone antenna module further comprises a second inner extension line formed on the second major surface, wherein the second inner extension line is electrically connected to a second terminal of the inner coil and extends through at least part of the radially extending outer gap.
[18]	The smartphone of claim 13, wherein the inner extension line is referred to as a first inner extension line and is electrically connected to a first terminal of the inner coil, wherein the smartphone antenna module further comprises a second inner extension line formed on the second major surface, wherein the second inner extension line is electrically connected to a second terminal of the inner coil and extends through at least part of the radially-extending outer gap.

255. In my opinion, the Ahn-721Lee combination renders claims 2 and 13 obvious and further renders obvious the remaining limitations of these claims.

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256. Ahn teaches and the Ahn-721Lee combination renders obvious a **first inner extension line** electrically connected to a **first terminal** of "**second section 1312**" though vias. Ground 2 Limitation [4]/[14].

257. For the same reasons as Ground 2 Limitations [4]/[14], the Ahn-721Lee combination renders obvious Ahn's smartphone antenna module comprises a **second inner extension line** on the "**first surface**" (second major surface) that electrically connects to a **second terminal** of "**second section 1312**" through vias, and the **second inner extension line** extends through at least part of the **partial disconnection of second coil wiring** as shown in the annotated figure below:



Ex1007, Figs. 4, 10 (modified based on ¶¶72-73, 124 to illustrate **partial disconnection** of "**second coil wiring 132**").

9. [8]/[16]

Reference Number	Claim Limitation
[8]	The smartphone antenna module of claim 1, wherein the inner coil and the outer coil are electrically connected in parallel.
[16]	The smartphone of claim 13, wherein the inner coil and the outer coil are electrically connected in parallel.

258. In my opinion, the Ahn-721Lee combination renders claims 1 and 13 obvious and Ahn further teaches, and the Ahn-721Lee combination renders obvious the remaining limitations of these claims.

259. Ahn teaches that its "first and second spiral wirings disposed on opposite surfaces of the substrate may be connected to each other in series or in parallel." Ex1007, ¶¶113, 120. Further, "features of the examples described [in the specification] may be combined in various ways," and "[s]uitable results may be achieved … if components in a described system … are combined in a different manner, and/or replaced or supplemented by other components." Ex1007 ¶¶45, 129.

260. In addition, in my opinion, a POSA would have found an electrical connection between "**second section 1312**" (inner coil) and "**first section 1311**" (outer coil) to have been obvious. There were only two electrical connection possibilities (in parallel or in series), and Ahn teaches electrically connecting wirings in parallel (Ex1007, ¶¶113, 120), so it would have been obvious to try and a simple design choice to electrically

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connect "**second section 1312**" and "**first section 1311**" in parallel.

261. In addition, this limitation would have been obvious in view of 721Lee. 721Lee teaches "two coils … may be connected in parallel." 721Lee ¶152; *id.* ¶134 ("sub coils are connected in parallel" but "may be connected in series").

262. In my opinion, a POSA reading Ahn and 721Lee would have understood electrically connecting coils in series or in parallel was a design choice, and would have been motivated to try connecting Ahn's inner and outer coils in parallel, which would have yielded predictable results. 721Lee teaches antennas with coils electrically connected in parallel have a lower recognition rate at higher distances than antennas with coils electrically connected in series, which means parallel connected coils may be more secure, and thus preferable for high-security applications for which only close-distance transactions are desired, including NFC and payment transactions. 721Lee ¶¶158-59. In my opinion, a POSA would have reasonably expected success because electrically connecting two coils in parallel was a well-known, straightforward electrical-connection method Ahn and 721Lee teach. Ex1007 ¶¶113, 120, Figs. 8-9.

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10. [9]/[19]

Reference Number	Claim Limitation
[9]	The smartphone antenna module of claim 1, wherein the inner coil includes a wire line having a width different from that of a wire line of the outer coil, wherein the inner coil has a first number of turns, and the outer coil has a second number of turns, wherein the first number of turns is greater than the second number of turns.
[19]	The smartphone of claim 13, wherein the inner coil includes a wire line having a width different from that of a wire line of the outer coil, wherein the inner coil has a first number of turns, and the outer coil has a second number of turns, wherein the first number of turns is greater than the second number of turns.

263. In my opinion, the Ahn-721Lee combination renders claims 1 and 13 obvious and Ahn further teaches the remaining limitations of these claims.

264. In Ahn, "**second section 1312**" (inner coil) includes a wire line having a width different from that of a wire line of "**first section 1311**" (outer coil) as shown in the annotated figure below:

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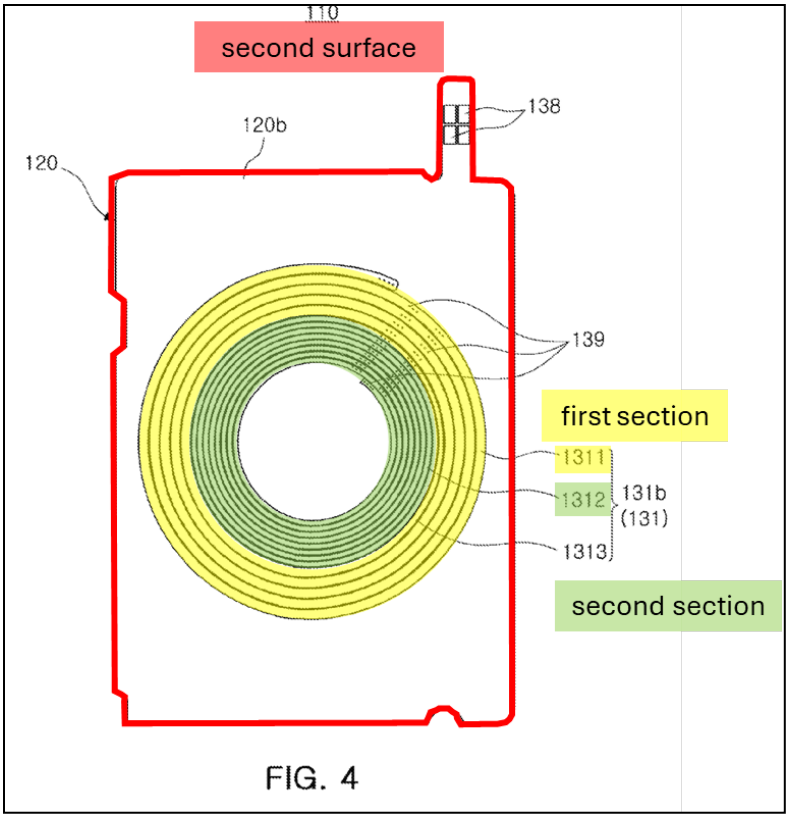


FIG. 4

Ex1007, Fig. 4, ¶¶44, 76-77, 105, 126 (Ahn's coils "may have different widths").

265. Further, in Ahn, "**second section 1312**" (inner coil) has a first number of turns that is greater than that of "**first section 1311**" (outer coil) as shown in the annotated figure below:

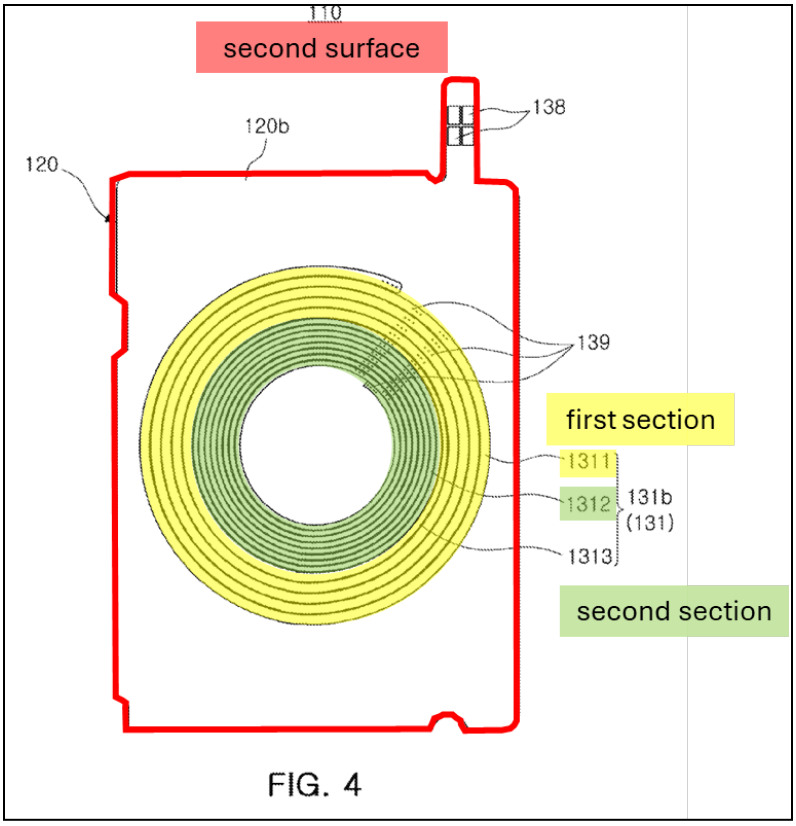


FIG. 4

Ex1007, Fig. 4, ¶¶8, 22, 44, 76-77, 82, 85-87, 89-90, 98, 105, 109, 126, Cls. 3, 17.

266. As shown above, Ahn depicts "**second section 1312**" (inner coil) having approximately 13 turns, and "**first section 1311**" (outer coil) having approximately 5 turns. Ex1007, Fig. 10.

11. [10]/[20]

Reference Number	Claim Limitation
[10]	The smartphone antenna module of claim 1, further comprising two additional extension lines formed on the second major surface and extending through both the radially-extending inner gap and the radially-extending outer gap.
[20]	The smartphone claim 13, further comprising two additional extension lines formed on the second major surface and extending through both the radially-extending inner gap and the radially-extending outer gap.

267. In my opinion, the Ahn-721Lee combination renders claims 1 and 13 obvious and further renders obvious the remaining limitations of these claims.

268. Ahn's "**third coil wiring 133**" may be "disposed at the center of the **first coil wiring 130**," and "both ends" of "**third coil wiring 133**" "***need*** to be connected to the **connection pads 138**," Ex1007 ¶¶124, 126, which a POSA, in my opinion, would have understood is accomplished by running two **additional extension lines** (one for each end of "**third coil wiring 133**") from "**connection pads 138**" to "**third coil wiring 133**." In my opinion, a POSA would have also understood that the two **additional extension lines** are connected to "**connection pads 138**" in the same way as Ahn illustrates for the inner "lead wirings 137" for "**first coil wiring 130**"—through a **partial disconnection** of "**second coil wiring 132**" and the "**partial[] disconnect[ion]**" of "**first coil wiring 130**" as shown in the annotated figure below:

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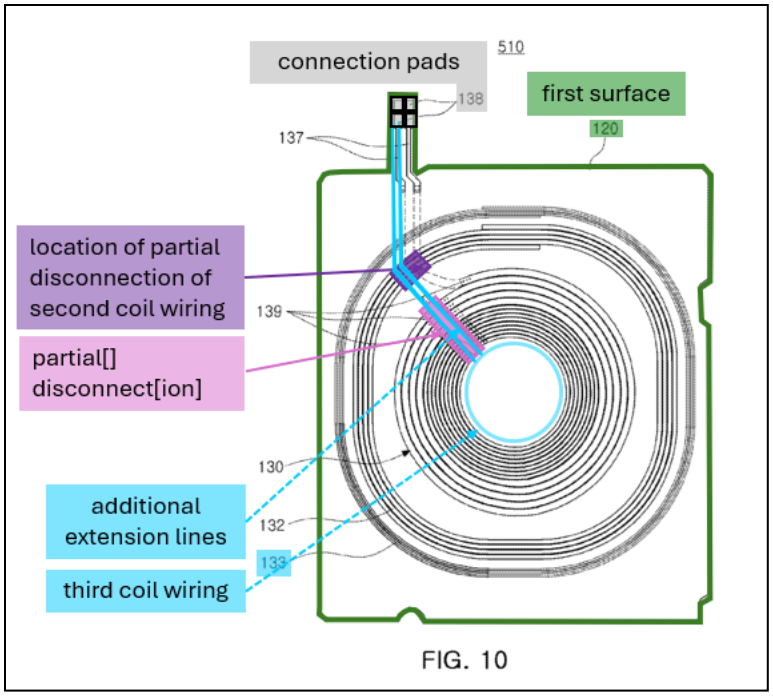


FIG. 10

Ex1007, Fig. 10 (modified based on ¶¶124, 126 to illustrate "**third coil wiring 133**" and its two **additional extension lines**); Ground 2 Limitation [2pre].

269. In addition, in my opinion, a POSA would have found this limitation to be obvious in view 721Lee.

270. 721Lee teaches "**NFC pattern 1018**" (additional extension lines) is connected to the "**NFC coil 1015**" and traverses the "**interval of the MST coil 1050**" as shown in the annotated figure below:

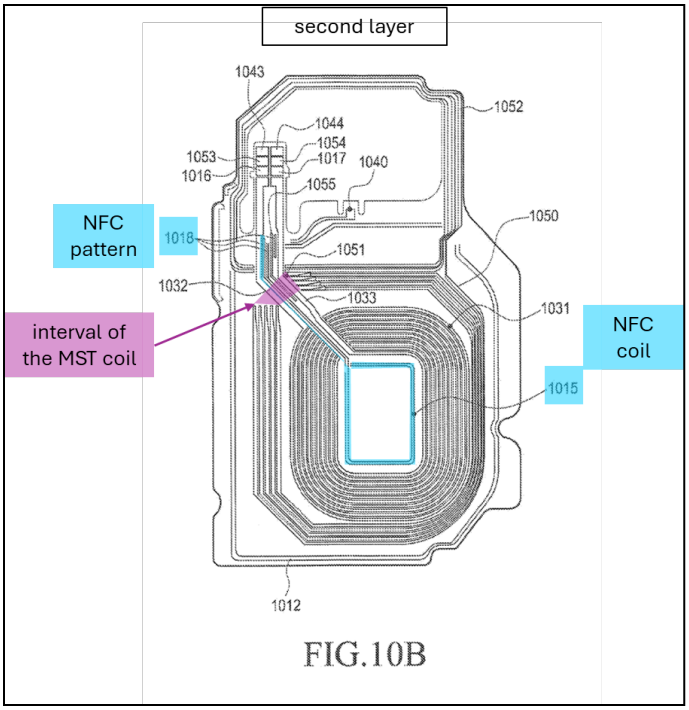


FIG.10B

Ex1011 ¶142, Fig. 10B.

271. It would have been obvious to incorporate 721Lee's radially-extending gap teachings with Ahn. Section X.B.1. In the Ahn-721Lee combination, the two additional extension lines formed on Ahn's "**first surface**" (second major surface) extend through both the **partial disconnection** of "**second coil wiring 132**" and the "**partial[] disconnect[ion]**" of "**first coil wiring 130**." Ground 2 Limitation [1g].

12. [11]/[21]

Reference Number	Claim Limitation
[11]	The smartphone antenna module of claim 10**,** wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein each of the two additional extension lines is electrically connected to a terminal of the third antenna pattern.
[21]	The smartphone of claim 20, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein each of the two additional extension lines is electrically connected to a terminal of the third antenna pattern.

272. In my opinion, the Ahn-721Lee combination renders claims 10 and 20 obvious and further renders obvious the remaining limitations of these claims.

273. Ahn's "coil assembly 510" (second antenna pattern) further comprises a "**third coil wiring 133**" (third antenna pattern) generally surrounded by "**first coil wiring 130**" (inner antenna pattern) as shown in the annotated figure below:

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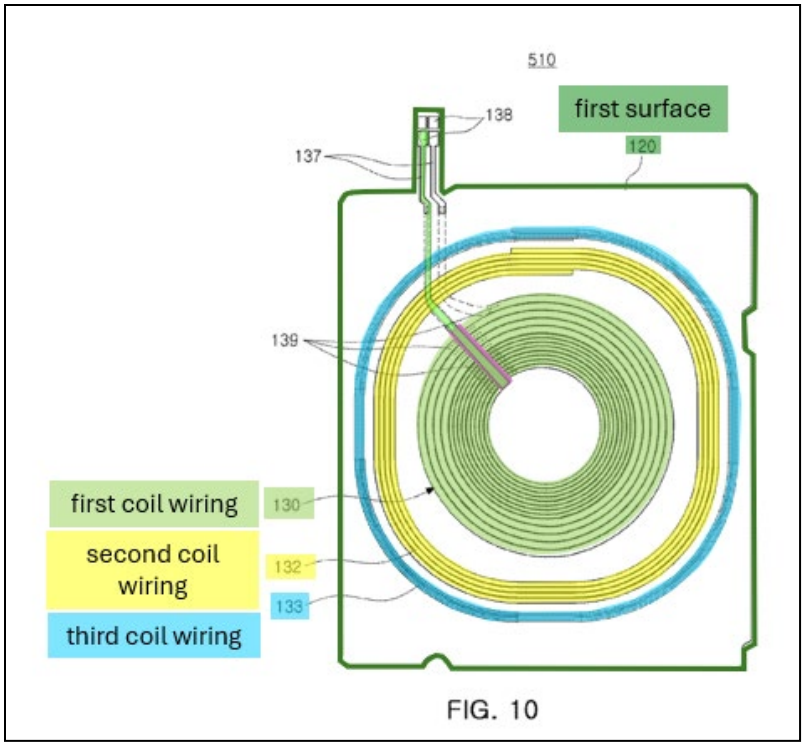
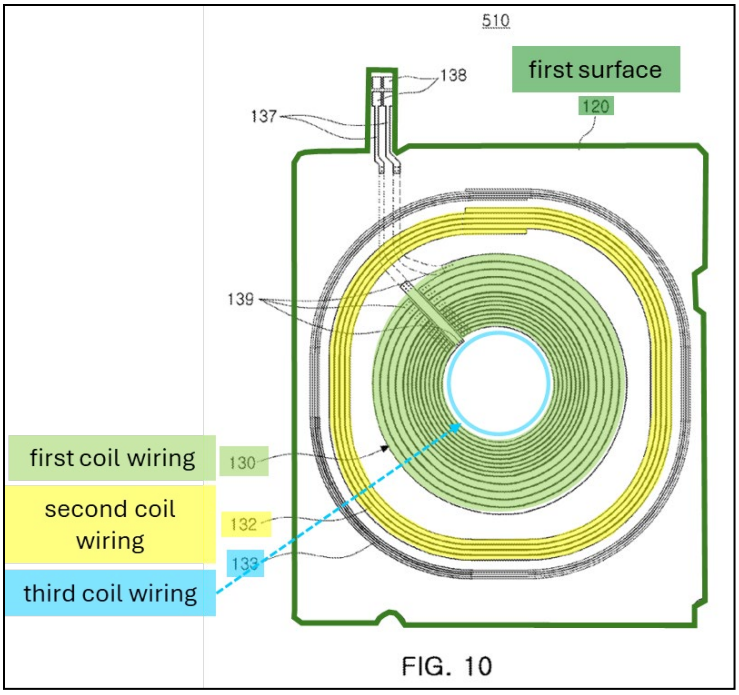


FIG. 10

Ex1007 ¶¶71, 123, 125-26, Fig. 10.

274. While Ahn depicts "**third coil wiring 133**" disposed outside of "**second coil wiring 132**," Ahn teaches "**third coil wiring 133**" "may … be disposed at the center of the **first coil wiring 130**" as shown in the annotated figure below:



Ex1007 Fig. 10 (modified per ¶¶71, 123, 125-26).

275. For the same reasons as Ground 2 Elements [10]/[20], Ahn teaches two **additional extension lines** electrically connected to a terminal of "**third coil wiring 133**."

13. [12]/[22]

Reference Number	Claim Limitation
[12]	The smartphone antenna module of claim 10, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein at least one of the two additional extension lines contacts the third antenna pattern on the second major surface.
[22]	The smartphone of claim 20, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein at least one of the two additional extension lines contacts the third antenna pattern on the second major surface.

276. In my opinion, the Ahn-721Lee combination renders claims 10 and 20 obvious and Ahn further teaches, and the Ahn-721Lee combination renders obvious the remaining limitations of these claims.

277. For the same reasons as Ground 2 Limitations [10]/[20]/[11]/[21], Ahn teaches "coil assembly 510" (second antenna pattern) on the "**first surface**" (second major surface) comprises a "**third coil wiring**" (third antenna pattern) generally surrounded by "**first coil wiring**" (inner antenna pattern) wherein at least one of the two **additional extension lines** contacts "**third coil wiring**" on the "**first surface**." E.g., Ex1007 ¶¶124, 126.

14. [13pre]/[13a]/[13b]/[13c]/[13d]

Reference Number	Claim Limitation
[13pre]	A smartphone comprising a display module comprising a display surface;
[13a]	a rear cover comprising a rear surface facing away from the display surface;
[13b]	a battery placed between the display module and the rear cover; and
[13c]	the smartphone antenna module of claim 2 placed between the battery and the rear cover,
[13d]	wherein at least one of the inner coil and the outer coil are configured for wireless battery charging.

278. In my opinion, the Ahn-721Lee combination renders claim 2 obvious, and the combination further renders obvious the remaining limitations of this claim.

279. Ahn teaches a smartphone "configured to wirelessly transmit power" as

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shown in the annotated figure below:

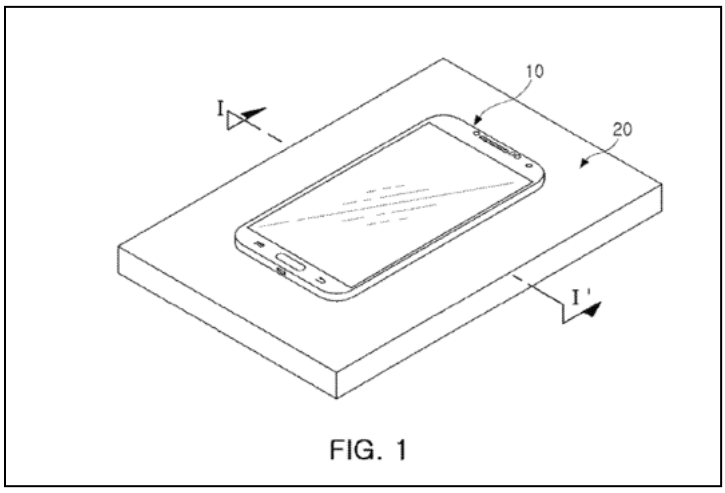


FIG. 1

Ex1007 ¶¶3-4, 48-49, Figs. 1-2.

280. Ahn's outer coil is configured for wireless battery charging. In my opinion, a POSA would have understood Ahn's "smartphone[]" with a "wireless charging" antenna module includes a display module comprising a display surface, a rear cover comprising a rear surface facing away from the display surface, a battery placed between the display module and the rear cover, and an antenna module placed between the battery and the rear cover because it is the most logical and common-sense arrangement; a battery between the antenna module and the rear cover would interfere with or block the wireless-charging signal.

281. In addition, this limitation would have been obvious in view of 721Lee. 721Lee teaches a "**display**" module, a rear "**cover**" facing away from the "**display**" surface, "**a battery**" placed between the "**display**" and the

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"cover," and **an antenna module** placed between the "**battery**" and the "**cover**" as shown in the annotated figure below:

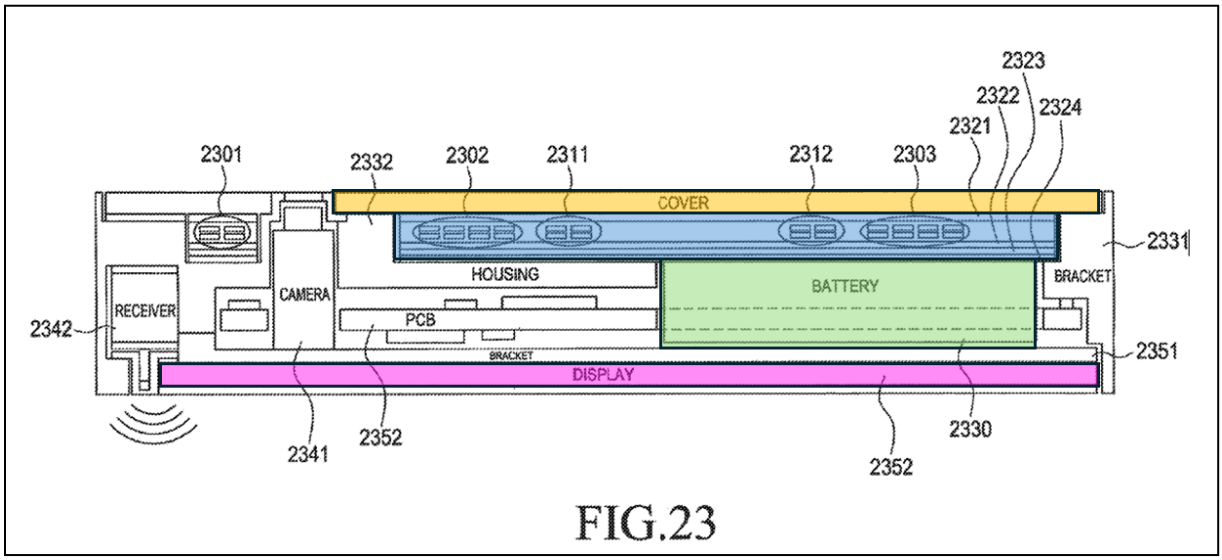


FIG.23

Ex1007, ¶¶189-190, Figs. 23-23.

282. Further, Ahn's outer and inner coils are configured for wireless battery charging (they "may be used to transmit and receive power for wireless charging."). Ex1007 ¶¶48-49, 52, 125, Fig. 2; Ground 2 Limitation [1a]; Therefore, a POSA would have understood "**first section 1311**" and "**second section 1312**" are configurable for wireless battery charging.

C. Ground 3: 005Lee Renders Claims 1-22 Obvious In View Of Seong And Cho

1. A POSA Would Have Been Motivated To Combine The Teachings Of 005Lee, Seong, and Cho

283. These references overcome limited space in smartphones with space-efficient WPC, NFC, and MST antennas, optimizing shape and layout,

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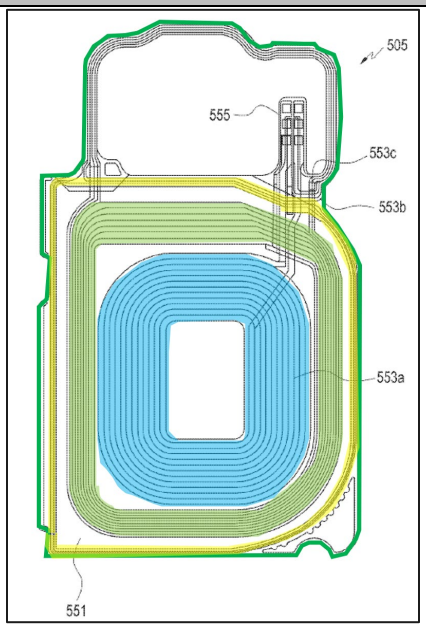
including placing coils on both sides of a substrate. Section VIII. In my opinion, a POSA reading 005Lee would have been motivated to incorporate Seong's and Cho's teachings. All these references teach antenna patterns on both sides of a substrate in a smartphone, including WPC, NFC, and MST antennas. Ex1008, 17:4-9, Figs. 4A-4B, 43D; Ex1006, ¶¶4, 33-34, 77, Figs. 5-6; Ex1010 Cl. 2, 10; ¶¶66-67, 73. If 005Lee is found to not teach a claimed limitation, as discussed below, in my opinion, it would have been obvious to a POSA to adopt well-known, predictable, and finite approaches taught by Seong and/or Cho to achieve wireless-communication functions in a space efficient module.

284. ***First***, in my opinion, a POSA reading 005Lee would have been motivated to incorporate Seong's Figure 6 "bottom surface" coil teachings. 005Lee teaches forming coils on opposing sides of a substrate. Ex1008, 17:4-9 ("Each of the conductive patterns" "can be formed on one surface" "or the other surface."), 27:58-67 ("first and second coils" "can be formed in" "different layers (or surfaces) of the flexible printed circuit board"), Figs. 4A-4B, 43D (coils on both substrate sides). However, 005Lee provides detailed coil layouts only for one substrate side. Ex1008, Fig. 5B. In my opinion, a POSA would have been motivated to look for similar references teaching possible coil layouts for 005Lee's substrate's other side,

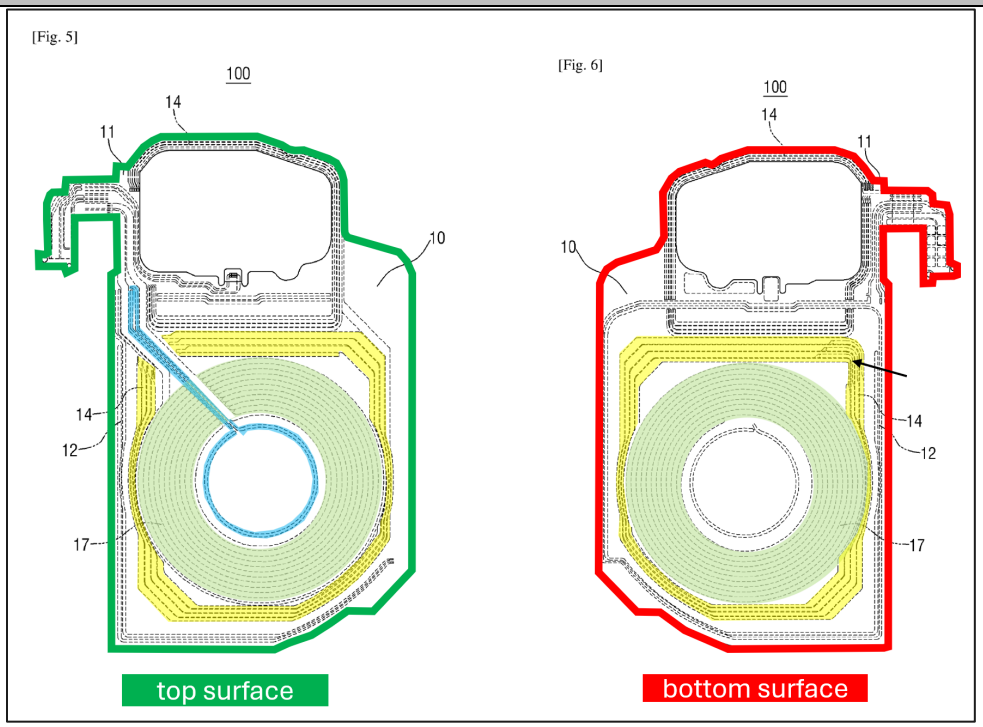
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including Seong.

285. As explained in Ground 1, like 005Lee, Seong teaches space-efficient coils, including an innermost **NFC pattern**, surrounded by an **inner MST coil** and an **outer WPC coil**, formed on both substrate sides as shown in the annotated figure below:

005Lee (Ex1008) Fig. 5B


Seong (Ex1006) Figs. 5-6



Ex1008, Fig. 5B; Ex1006, ¶¶4, 33-34, 77, Figs. 5-6.

286. Given their similarities, in my opinion, a POSA would have been motivated to implement 005Lee's teachings of forming coils on both substrate surfaces with Seong's Figure 6, which shows coils on a substrate's bottom surface, opposite similar patterns on the top surface, as shown in Seong Figure 5 and 005Lee Figure 5B. Ex1006, Figs. 5-6; Ex1008, Fig. 5B; Ground 1. This would have combined known elements according to known methods (forming known coil patterns on both substrate sides, as 005Lee and Seong teach) to achieve predictable wireless-communication results furthering both references' space-

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efficiency goal.

287. In my opinion, a POSA would have reasonably expected success. As noted, 005Lee teaches forming coils on both substrate sides and teaches using various coil shapes, and Seong provides concrete examples of how to implement such coils. Forming coils on both substrate sides was common, and Seong's disclosure provides details a POSA would have used to effectively implement 005Lee's teachings.

288. ***Second***, in my opinion, a POSA would have found it obvious to run 005Lee's extension lines through coil gaps, in view of Seong. 005Lee runs extension lines between its "connection piece" and its "conductive patterns" to electrically connect them "to the control circuit." Ex1008, 17:52-57, Fig. 5B. 005Lee Figure 5B depicts extension lines crossing its conductive patterns. *Id.* In my opinion, a POSA would have understood 005Lee teaches gaps in its conductive patterns for extension lines because extension lines cannot touch conductive patterns without causing short-circuiting. Further, in my opinion, a POSA would have found this approach obvious. Reading 005Lee, in my opinion, a POSA would have been motivated to look to references, including Seong, furthering the same space-efficient goals by running extension lines past conductive patterns without touching. Ex1006, Abstract, Fig. 5; Ground 1. 005Lee and Seong

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teach similar ways of achieving this (concentric coils on multiple surfaces with extension lines). Ex1008, Fig. 5B; Ex1006, Fig. 5. Running extension lines through coil gaps was well-known and improves space efficiency by letting the coils be arranged in a space-efficient, concentric manner. Ex1006, Fig. 5; Ex1014 ¶31 (coil gaps improve space efficiency by up to 70%).

289. In my opinion, a POSA would have reasonably expected success. 005Lee teaches using extension lines connecting coils to "connection piece 555." Ex1008, 17:52-57, Fig. 5B. 005Lee teaches using various antenna shapes and layouts. Ex1008, 17:67-18:4, 19:28-35. Incorporating Seong's coil-gaps teachings would have been a straightforward implementation of a known coil-pattern layout to achieve predictable results of space-efficient concentric coils.

290. ***Third***, in my opinion, a POSA would have been motivated to incorporate Cho's teachings of electrically connecting inner and outer coils in parallel with 005Lee. Cho's "wireless communication coil" comprises a "first coil portion" and a "second coil portion[,]" which "may be connected in series or in parallel." Ex1010 ¶¶90, 91. There are only two electrical connection possibilities—in parallel or in series, as Cho teaches—so it would have been obvious to try and a simple design choice to electrically connect

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005Lee's inner and outer conductive patterns in parallel to yield predictable results.

291. In my opinion, a POSA would have reasonably expected success because electrically connecting two coils in parallel was a well-known, straightforward electrical-connection method as Cho teaches. Ex1010 ¶¶90, 91.

292. ***Fourth***, in my opinion, a POSA would have been motivated to incorporate Seong's and Cho's teaching of connecting coils on opposing surfaces using vias with 005Lee. 005Lee teaches coils on opposing substrate surfaces and "a connection element" containing "conductive material" that "electrically interconnect[s]" them. Ex1008, 21:39-51. Seong teaches connecting coils on different surfaces using vias. Ground 1 Limitations [1d]/[1e]. Cho also teaches "wireless charging coil 111 on one surface 11 of the substrate may be connected through via holes to the wireless charging coil 112 formed on the other surface 12 of the substrate." Ex1010 ¶¶66-67, Cls. 2, 10. Seong's and Cho's teachings of connecting coils on two opposite substrate surfaces using a plurality of vias was a common and effective way to connect 005Lee's opposing-surface antenna patterns, and vias would have been obvious to try as one of a finite number of predictable solutions for this purpose.

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293. In my opinion, a POSA would have reasonably expected success. Vias were commonly used for this purpose, would have been straightforward to implement, and 005Lee already teaches electrically interconnecting various components.

2. [1]

a. [1pre]

Reference Number	Claim Limitation
[1pre]	A smartphone antenna module comprising:

294. In my opinion, to the extent the preamble is limiting, 005Lee teaches it.

295. 005Lee teaches a "smartphone" including a "flexible printed circuit board" comprising "a plurality of loop antennas" and "conductive patterns" for "NFT," "MST," and "wireless charg[ing]" as shown in the annotated figure below:

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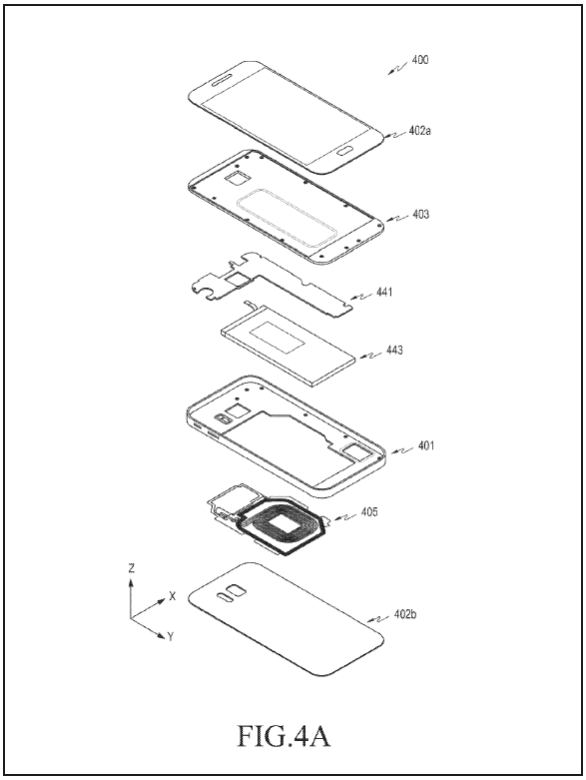


FIG.4A

Ex1008, 1:65-67, 6:23, 17:24-31, 19:5-12, Fig. 4A.

296. In my opinion, a POSA would have understood that this is a smartphone antenna module including because it comprises multiple antennas.

b. [1a]

Reference Number	Claim Limitation
[1a]	a substrate having a first major surface and a second major surface facing away from the first major surface;

297. In my opinion, 005Lee teaches this limitation.

298. 005Lee teaches "**base member 551**" (substrate) can be "in the form of a multi-layer circuit board" with "loop antennas for **NFT**, **MST**" and "wireless charge" and "[e]ach of the conductive patterns … can be formed

on **one surface** of the base member 551 or the **other surface**" of the "**base member 551**" as shown in the annotated figure below:

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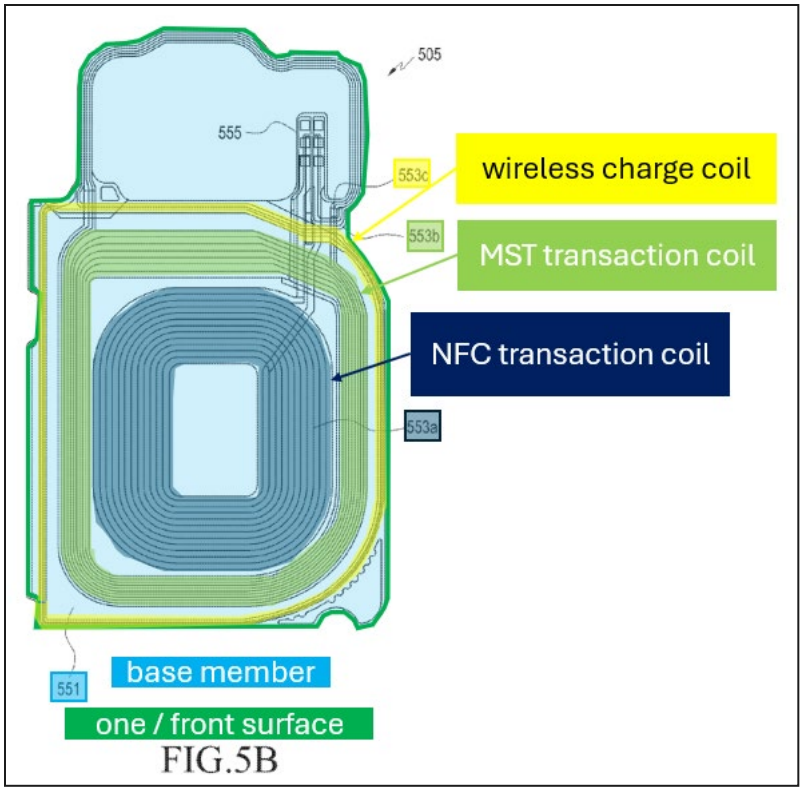


FIG.5B

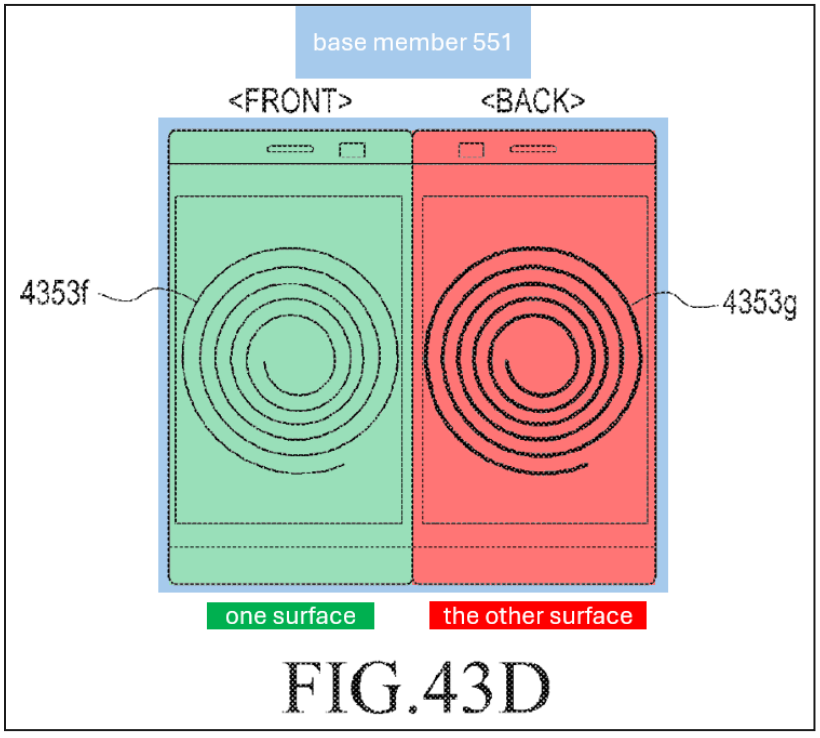
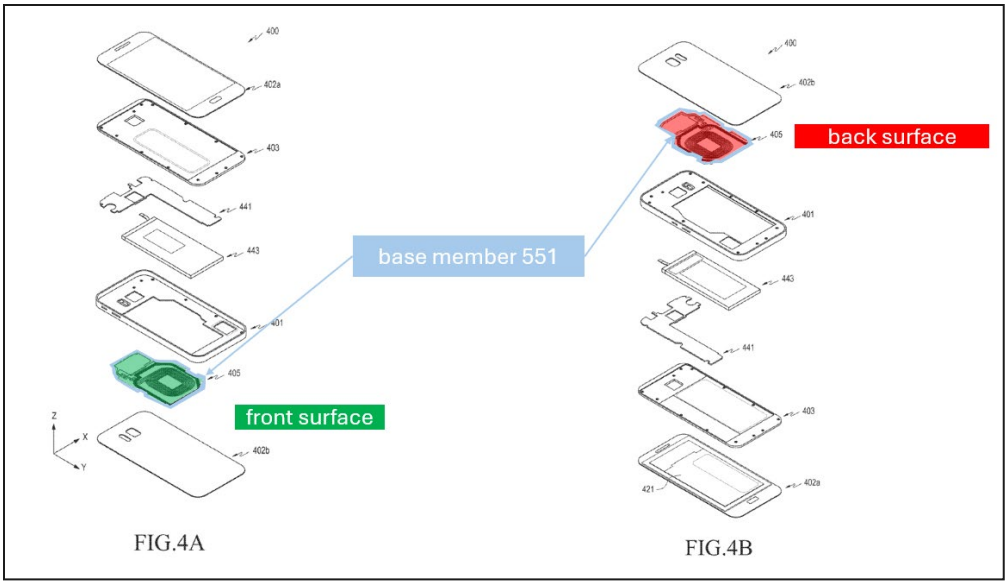


FIG.43D

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Ex1008, 17:4-19, 18:36-40, 19:5-12, 49:59-62, Figs. 4A (depicting "**one surface**" from a top view), 4B (depicting "**other surface**" from a bottom view), 5B (depicting "**one [front] surface**"), 43D (depicting coil antennas "separated from each other" on the "**front**" and "**back**" surfaces), 27:58-67 ("the first and second coils … can be formed in … different layers (or surfaces) of the **flexible printed circuit board**").

299. The "**other surface**" / "**back**" surface of 005Lee's "**base member 551**" is the claimed first major surface, and the "**one surface**" / "**front**" surface (depicted in Figure 5B) is the claimed second major surface facing away from the first major surface.

c. [1b]

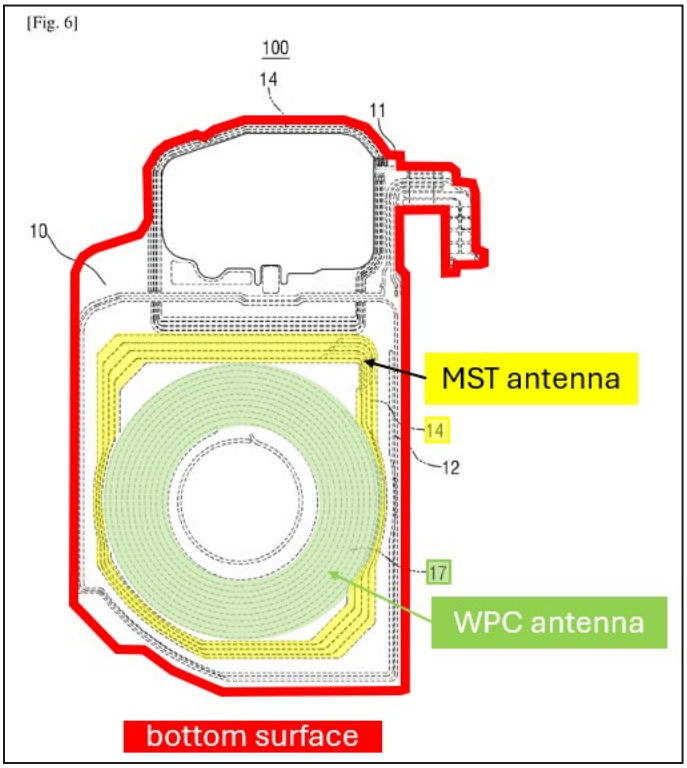
Reference Number	Claim Limitation
[1b]	a first antenna pattern formed on the first major surface and comprising an inner coil and an outer coil surrounding the inner coil;

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300. In my opinion, 005Lee in view of Seong renders this limitation obvious.

301. As explained in Ground 3 Limitation [1a], 005Lee teaches forming antenna patterns on the "**other surface**" / "**back**" surface. Ex1008, Figs. 4B, 43D; Section X.C.1. However, 005Lee does not explicitly disclose the details of the antenna patterns for this surface. Thus, in my opinion, a POSA would have been motivated to look for teachings of complementary coil layouts for the "**other surface**" / "**back**" surface.

302. Seong teaches a first antenna pattern on the "**bottom surface**" comprises "**WPC antenna**" and "**MST antenna**" surrounding "**WPC antenna**" as shown in the annotated figure below:



Ex1006 ¶64, Fig. 6; Ground 1 Limitation [1b].

303. It would have been obvious to incorporate Seong's "bottom surface" coil pattern teachings with 005Lee. Section X.C.1.

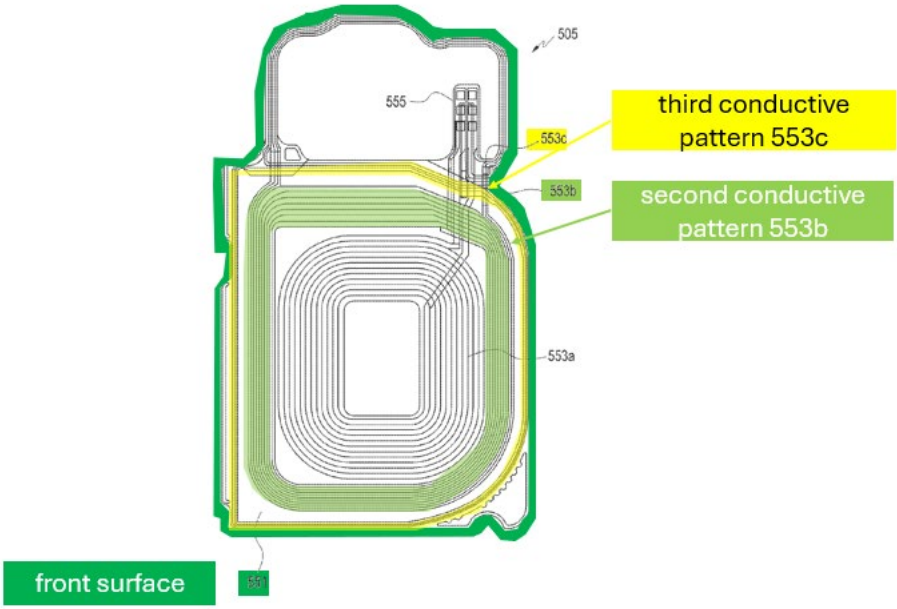
d. [1c]

Reference Number	Claim Limitation
[1c]	a second antenna pattern formed on the second major surface and comprising an inner antenna pattern, and an outer antenna pattern;

304. In my opinion, 005Lee teaches this limitation.

305. 005Lee teaches a second antenna pattern formed on the "**front surface**" (second major surface), comprising a "**second conductive pattern 553b**" (an inner pattern) and "**a third conductive pattern 553c**" (an outer pattern) surrounding the "**second conductive pattern 553b**" as shown in the annotated figure below:

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Ex1008, 17:14-16, 19:28-34, Fig. 5B.

e. [1d]

Reference Number	Claim Limitation
[1d]	the inner antenna pattern comprising a plurality of concentric circular lines and defining a radially-extending inner gap into which the plurality of concentric circular lines of the inner antenna pattern does not extend, wherein at least part of the concentric circular lines of the inner antenna pattern overlaps the inner coil formed on the first major surface and is connected to the inner coil through vias; and

306. In my opinion, 005Lee teaches this limitation and renders it obvious in view of Seong and Cho.

307. 005Lee teaches a "**second conductive pattern 553b**" or **MST transaction coil** comprising a plurality of **concentric circular lines** defining a

radially-extending inner gap into which the plurality of **concentric circular lines** of **MST transaction coil** does not extend (especially when using 005Lee's concentrically circular coils) as shown in the annotated figure below:

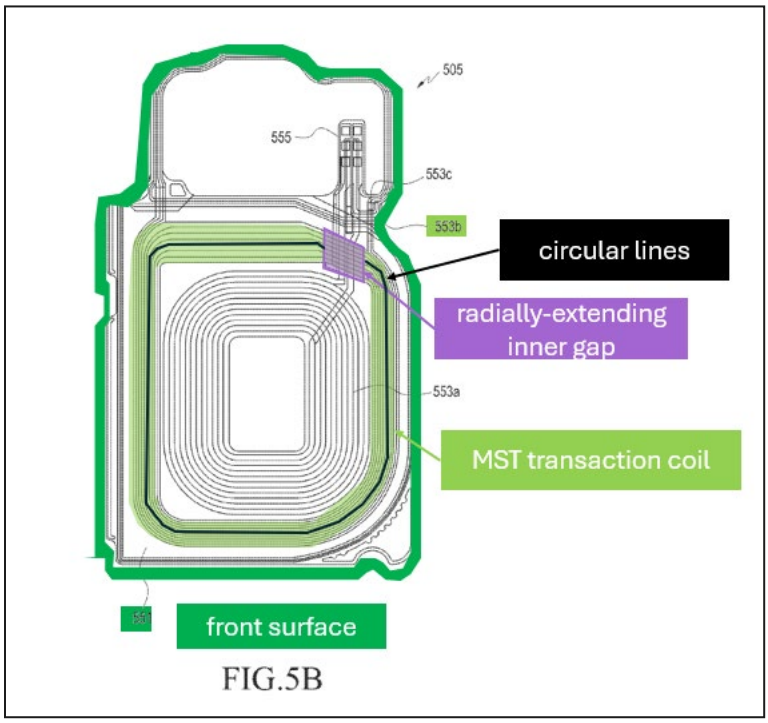
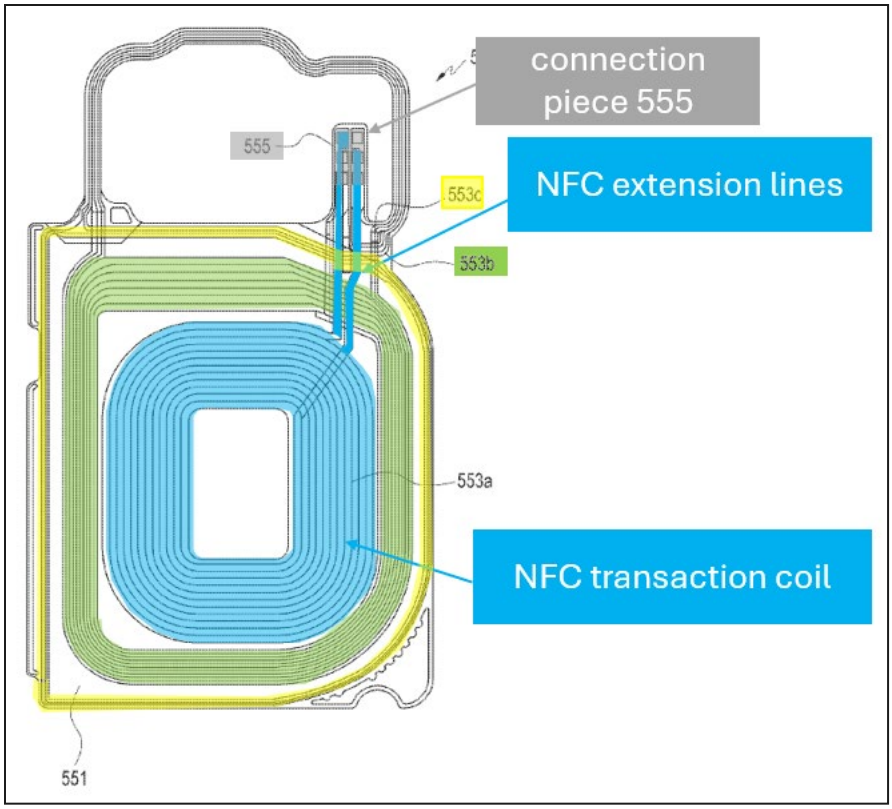


FIG.5B

Ex1008, 19:28-34, Fig. 5 (modified to illustrate **radially-extending inner gap**).

308. In my opinion, a POSA would have understood that 005Lee's Figure 5B shows a **radially-extending inner gap**. 005Lee teaches "**connection piece 555**" "connect[s] the **conductive patterns 553a**, 553b, and 553c to the control circuit" and depicts **NFC extension lines** performing this connection as shown in the annotated figure below:

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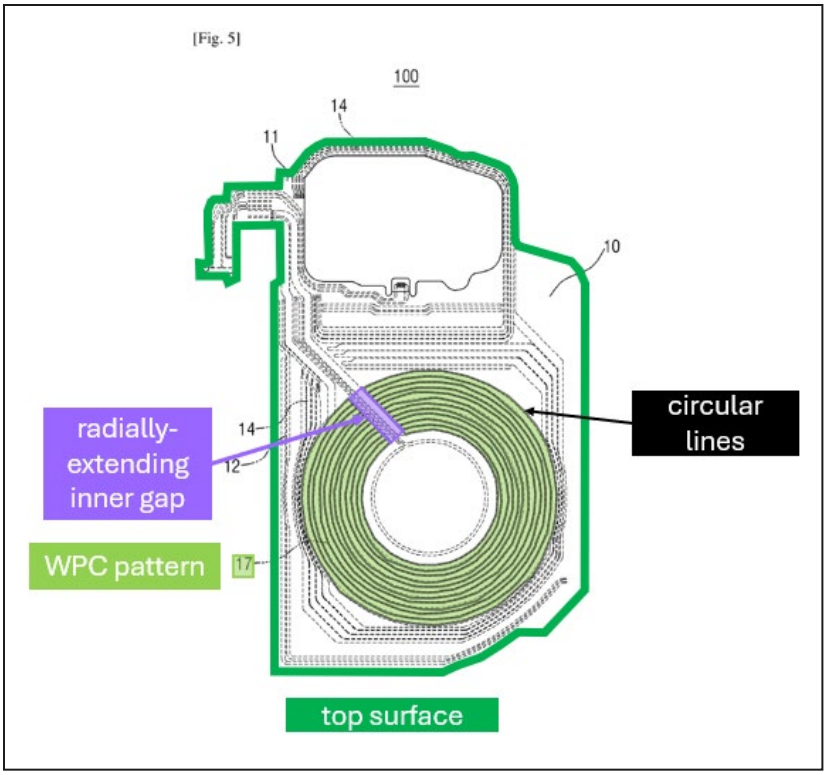
Ex1008, 17:52-57, Fig. 5B.

309. For the depicted **NFC extension lines** to function without interfering with conductive patterns **553b** and **553c**, extension lines and conductive patterns cannot touch, as such contact would cause short circuiting. Thus, in my opinion, a POSA would have understood a **radially-extending inner gap** exists through which **NFC extension lines** run.

310. Further, it would have been obvious to use a **radially-extending inner gap** in view of Seong. Section X.C.1.

311. Seong teaches a **radially-extending inner gap** as shown in the annotated figure below:

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Ex1006, Fig. 5; Ground 1 Limitation [1d].

312. Further, the 005Lee-Seong-Cho combination renders obvious at least part of the concentric circular lines of the "**second conductive pattern**" on the "**front**" surface overlaps Seong's "**WPC antenna**" on the opposing surface, which would improve compactness and reduce unused substrate space, and it would have been obvious in view of Seong and Cho to connect them through vias. Ground 1 Limitation [1d]; Section X.C.1.

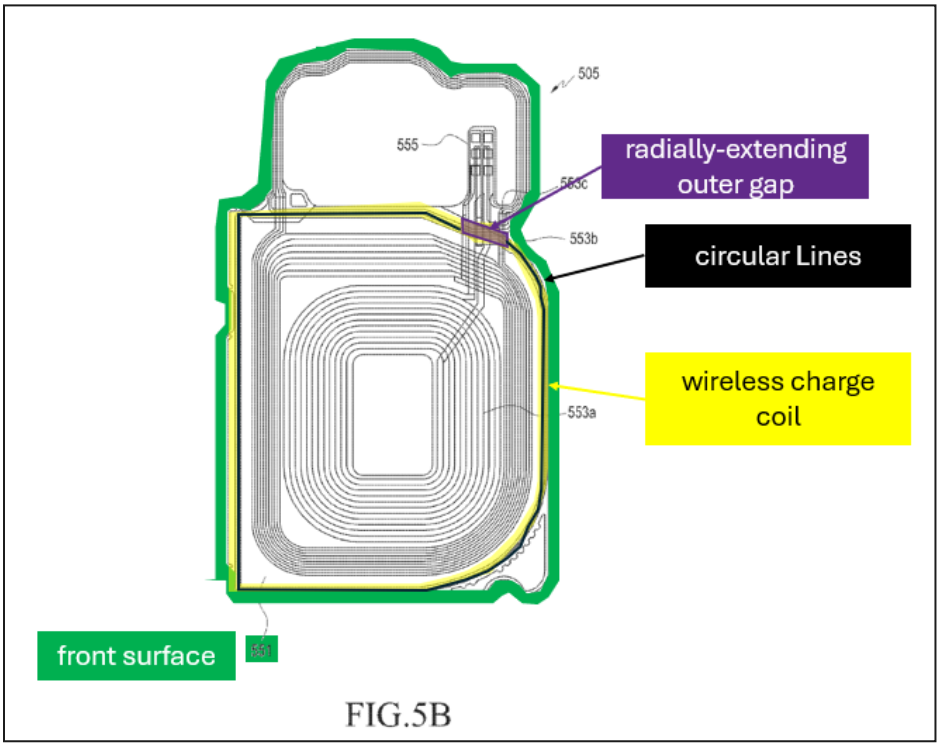
f. [1e]

Reference Number	Claim Limitation
[1e]	the outer antenna pattern comprising a plurality of concentric circular lines and defining a radially-extending outer gap into which the plurality of concentric circular lines of the outer antenna pattern

	does not extend, wherein at least part of the concentric circular lines of the outer antenna pattern overlaps the outer coil formed on the first major surface and is connected to the outer coil through vias,

313. In my opinion, 005Lee teaches this limitation and renders it obvious in view of Seong and Cho.

314. 005Lee teaches the "**third conductive pattern 553c**" or **wireless charging coil** comprises a plurality of concentric circular lines defining a **radially-extending outer gap** into which the plurality of **concentric circular lines** of the "**wireless charging coil**" does not extend as shown in the annotated figure below:



Ex1008, 19:28-34, Fig. 5 (modified to illustrate the **radially-extending outer gap**); Ground 3 Limitation [1d].

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315. Further, this limitation would have been obvious in view of Seong's teachings on gaps and circular lines (Ground 1 Limitation [1e]) for similar reasons as Ground 3 Limitation [1d].; Section X.C.1.

316. Further, the 005-Lee-Seong-Cho combination renders obvious at least part of the concentric circular lines of the "**third conductive pattern 553c**" on the "**front**" surface overlaps Seong's "**MST antenna**" on the opposing surface, which would improve compactness and reduce unused substrate space, and it would have been obvious in view of Seong and Cho to connect them through vias. Ground 1 Limitation [1e]; Section X.C.1.

g. [1f]

Reference Number	Claim Limitation
[1f]	wherein at least part of the concentric circular lines of the outer antenna pattern generally surround at least part of the concentric circular lines of the inner antenna pattern,

317. In my opinion, 005Lee teaches this limitation or alternatively renders it obvious in view of Seong.

318. In 005Lee, at least part of the concentric **circular lines** of "**third conductive pattern 553c**" generally surround at least part of the concentric **circular lines** of "**second conductive pattern 553b**" as shown in the annotated figure below:

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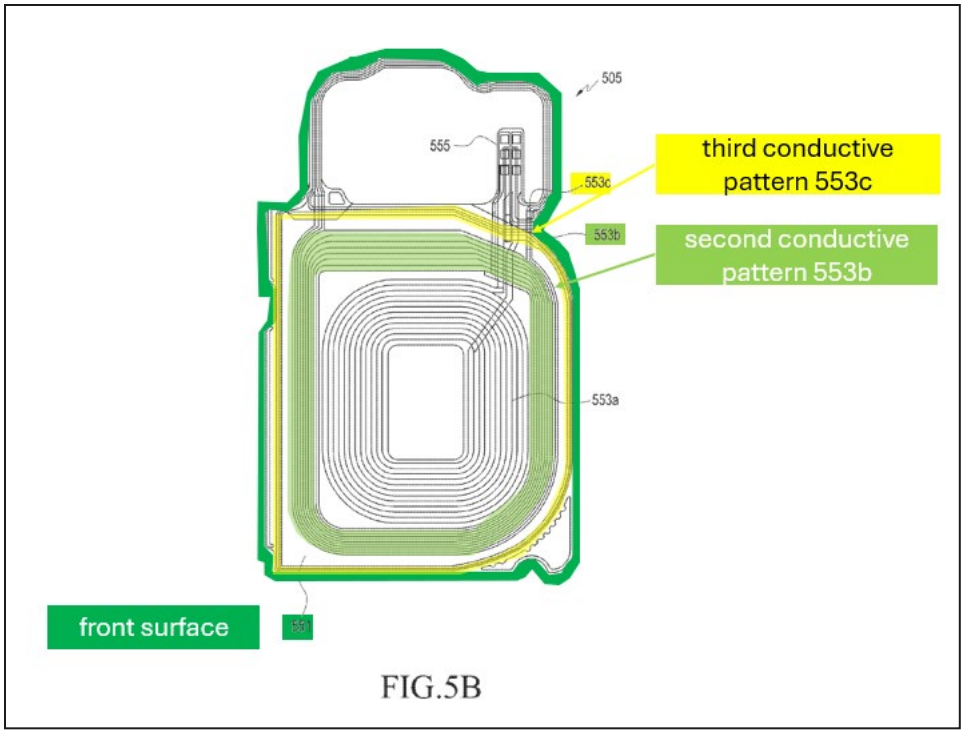


FIG.5B

Ex1008, 17:14-16, 19:28-34, Fig. 5B.

319. It would have been obvious to incorporate Seong's circular-line teachings with 005Lee, (Section X.C.1; Ground 1 Limitations [1d]/[1e]; Ex1006, Fig. 5), such that the combination taught a "**third conductive pattern 553c**" and a "**second conductive pattern 553b**" comprise a plurality of **concentric circular lines**.

h. [1g]

Reference Number	Claim Limitation
[1g]	wherein the radially-extending outer gap and the radially-extending inner gap are connected and aligned in a direction.

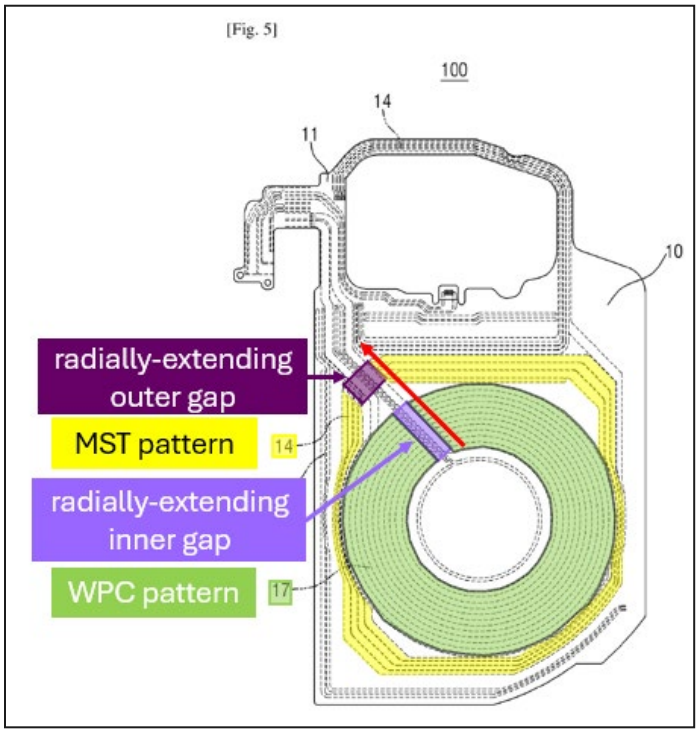
320. In my opinion, 005Lee in view of Seong renders this limitation obvious.

321. 005Lee in view of Seong renders obvious using radially-extending inner

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and outer gaps. Ground 3 Limitations [1d]/[1e].

322. Seong teaches this limitation as shown in the annotated figure below:



Ex1006, Fig. 5; Ground 1 Limitation [1g].

323. In my opinion, it would have been obvious to incorporate Seong's coil-gaps and C-shaped lines teachings with 005Lee. Section X.C.1. The combination satisfies this limitation as shown in the annotated figure below:

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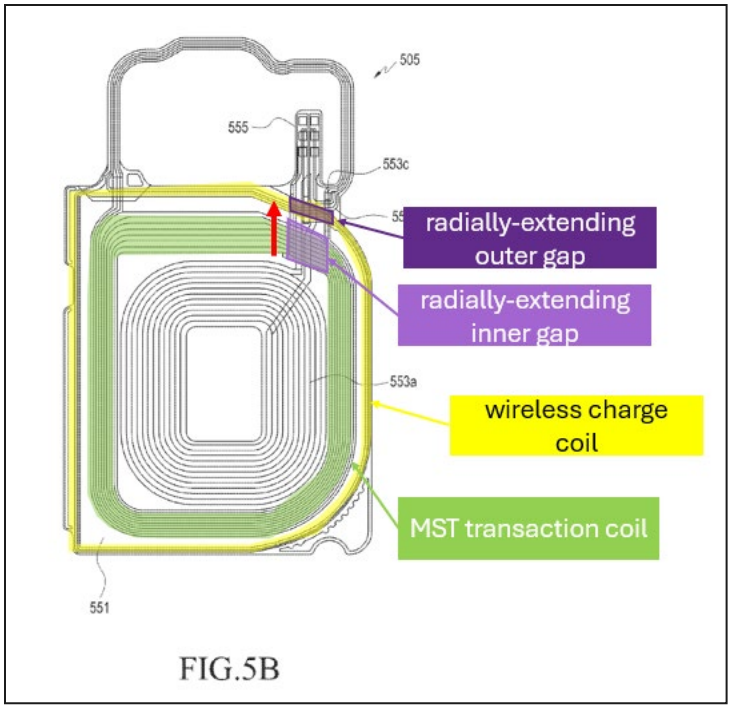


FIG.5B

Ex1008, 19:28-34, Fig. 5.

324. This limitation is also satisfied when 005Lee's coils are concentric circles (Ground 3 Limitations [1d]/[1e]/[1f]). Ex1006, 19:28-34.

3. [2]

a. [2pre]

Reference Number	Claim Limitation
[2pre]	The smartphone antenna module of claim 1, further comprising an inner extension line formed on the second major surface and extending through the radially-extending outer gap and further through at least part of the radially-extending inner gap; and

325. In my opinion, the 005Lee-Seong-Cho combination renders claim 1 obvious, and further renders obvious the remaining limitations of this claim.

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326. 005Lee teaches and in view of Seong renders obvious radially-extending inner and outer gaps through which extension lines run. Ground 3 Limitations [1d]/[1e]/[1f].

327. 005Lee further teaches an **inner extension line** formed on the "**front**" surface (second major surface), and teaches and renders obvious in view of Seong the **inner extension line** extending through both the **radially-extending inner gap** and at least part of the **radially-extending outer gap** as shown in the annotated figure below:

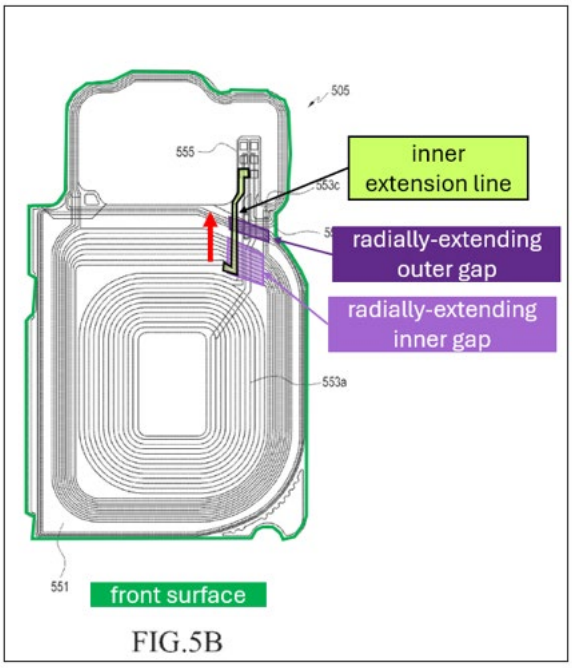


FIG.5B

Ex1008, 17:53-63, Fig. 5B; Section X.C.1.

b. [2a]

Reference Number	Claim Limitation
[2a]	an outer extension line formed on the second major surface and extending through at least part of the radially-extending outer gap.

328. In my opinion, 005Lee in view of Seong renders this limitation obvious.

329. 005Lee teaches and in view of Seong renders obvious a radially-extending outer gap through which extension lines run. Ground 3 Limitations [1e]/[1f].

330. 005Lee further teaches an **outer extension line** formed on the "**front**" surface (second major surface), and renders obvious in view of Seong **outer extension line** extending through at least part of the **radially-extending outer gap** as shown in the annotated figure below:

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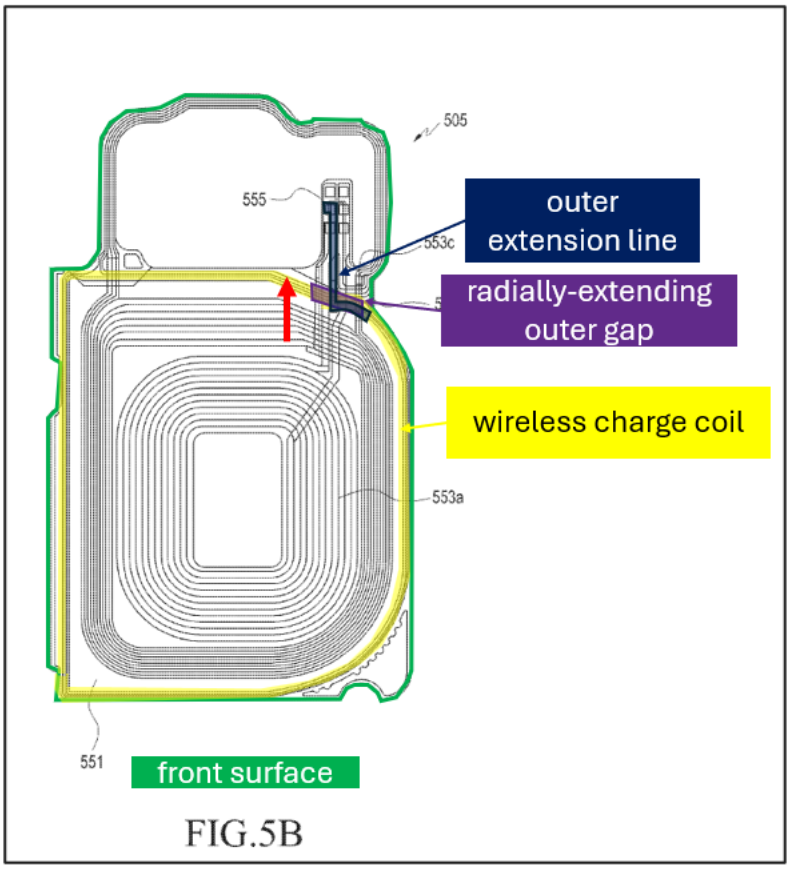


FIG.5B

Ex1008, 17:53-63, Fig. 5B; Section X.C.1.

4. [3]

Reference Number	Claim Limitation
[3]	The smartphone antenna module of claim 2, wherein the inner extension line and the outer extension line extend generally in parallel, and wherein each of the inner extension line and the outer extension line formed on the second major surface comprises a portion that overlaps the outer coil formed on the first major surface.

331. In my opinion, the 005Lee-Seong-Cho combination renders claim 2 obvious, and further renders obvious the remaining limitations of this claim.

332. 005Lee's **inner extension line** and **outer extension line** are extending generally in parallel as shown in the annotated figure below:

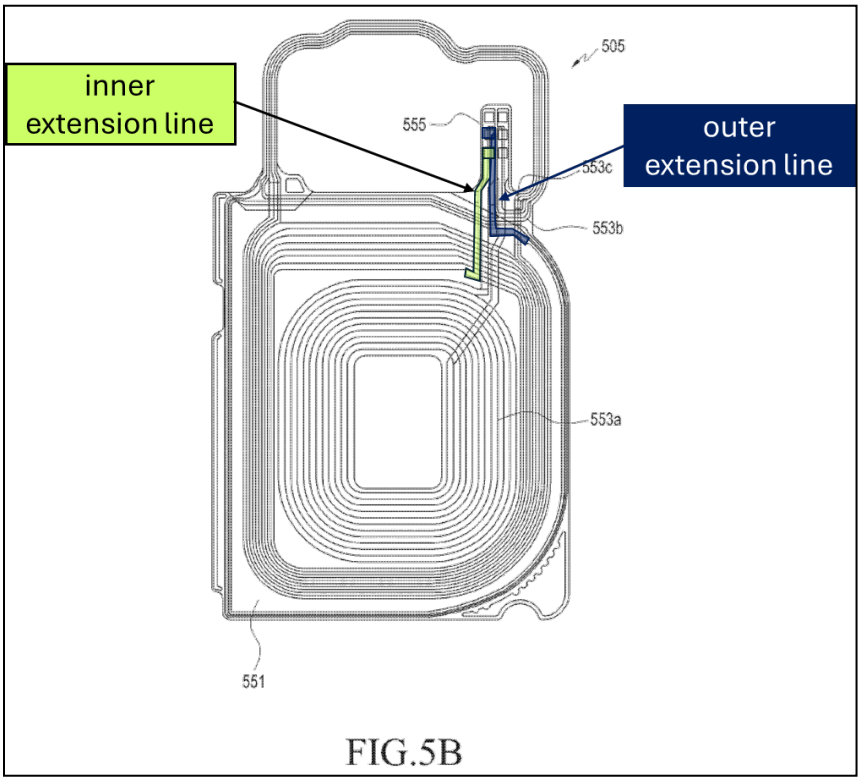


FIG.5B

Ex1008, 17:53-63, Fig. 5B.

333. Further, 005Lee teaches forming "conductive patterns 553a, 553b, and 553c" on both its "**front**" and "**back**" surfaces. Ground 3 Limitations [1a]/[1b]/[1c]. It would have been obvious to incorporate Seong's "bottom surface" coil antenna pattern teachings with 005Lee. Section X.C.1. In the combination, each of the **inner extension line** and **outer extension line** on the "**front**" surface (second major surface) overlaps the outer coil on 005Lee's "**back**" surface (first major surface) as shown in the annotated figure below:

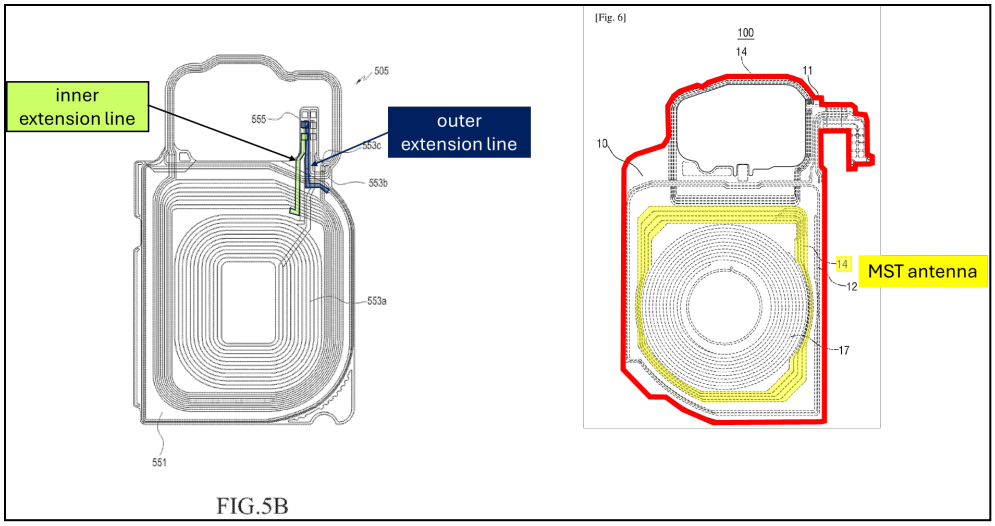


FIG.5B

Ex1008, Fig. 5B; *id.*, Figs. 4A-4B, 43D, Ground 3 Limitation [1a].

334. Further, in my opinion, a POSA would have found an arrangement with an overlap portion to be obvious. 005Lee teaches shaping its coils in concentric circles. Ex1008, 19:28-34. In my opinion, a POSA would have found it obvious to shape 005Lee's coils on both surfaces in tight, concentric circles to maximize space efficiency, and when so shaped, the combination satisfies this limitation.

5. [4]/[14]

Reference Number	Claim Limitation
[4]	The smartphone antenna module of claim 2, wherein the inner extension line is electrically connected to a terminal of the inner coil, wherein at least part of the concentric circular lines of the inner antenna pattern is in a C shape.
[14]	The smartphone of claim 13, wherein the inner extension line is electrically connected to a terminal of the inner coil, wherein at least part of the concentric circular lines of the inner antenna pattern is in a C shape.

335. In my opinion, the 005Lee-Seong-Cho combination renders claims 1 and 11 obvious, and further renders obvious the remaining limitations of these claims.

336. 005Lee teaches an inner extension line (Ground 3 Limitation [2pre]) and the 005Lee-Seong-Cho combination renders obvious electrically connecting 005Lee's Figure 5B coils with Seong's Figure 6 coils using vias (Ground 3 Limitations [1d]/[1e]; Section X.C.1). This electrical connection occurs at a terminal of the inner coil because that is where the via is located.

337. At least part of the concentric circular lines of 005Lee's "**second conductive pattern 553b**" on the "**front**" surface (inner antenna pattern) is in a C-shape (especially when 005Lee's coils are concentric circles) as shown in the annotated figure below:

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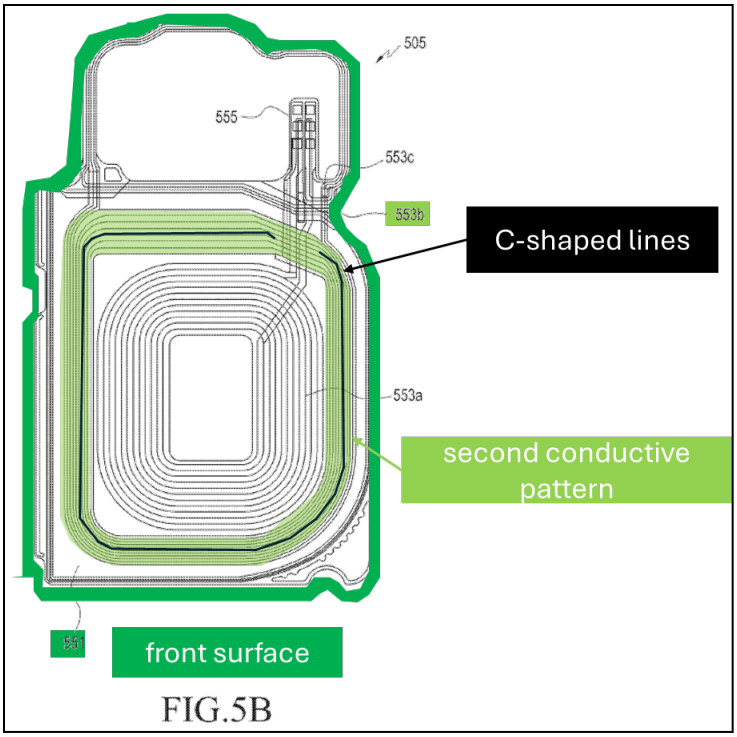


FIG.5B

Ex1008 Fig. 5B; Ground 3 Limitation [1d].

6. [5]/[15]

Reference Number	Claim Limitation
[5]	The smartphone antenna module of claim 2, wherein the outer extension line is electrically connected to a terminal of the outer coil, wherein at least part of the concentric circular lines of the outer antenna pattern is in a C shape.
[15]	The smartphone of claim 13, wherein the outer extension line is electrically connected to a terminal of the outer coil, wherein at least part of the concentric circular lines of the outer antenna pattern is in a C shape.

338. In my opinion, the 005Lee-Seong-Cho combination renders claims 1 and 11 obvious and further renders obvious the remaining limitations of these claims.

339. 005Lee teaches an outer extension line (Ground 3 Limitation [2a]) and the

005Lee-Seong-Cho combination renders obvious electrically connecting 005Lee's Figure 5B coils with Seong's Figure 6 coils using vias (Ground 3 Limitations [1d]/[1e]; Section X.C.1). This electrical connection occurs at a terminal of the outer coil because that is where the via is located.

340. At least part of the concentric circular lines of 005Lee's "**third conductive pattern**" (outer antenna pattern) is in a C-shape (especially when 005Lee's coils are concentric circles) as shown in the annotated figure below:

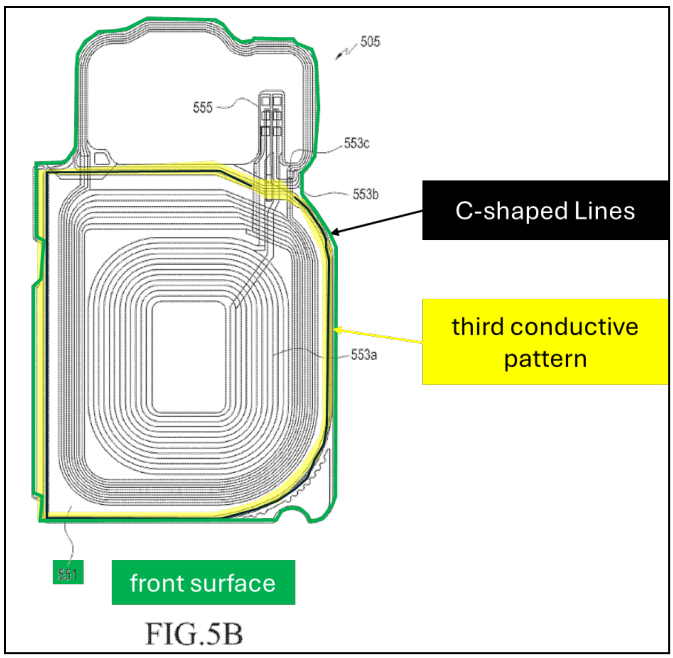


FIG.5B

Ex1008 Fig. 5B; Ground 3 Limitation [1e].

7. [6]/[17]

Reference Number	Claim Limitation
[6]	The smartphone antenna module of claim 2, wherein at least one of the inner extension line and the outer extension line is electrically connected to the first antenna pattern formed on the first major surface through at least one via.

[17]	The smartphone of claim 13, wherein at least one of the inner extension line and the outer extension line is electrically connected to the first antenna pattern formed on the first major surface through at least one via.

341. In my opinion, the 005Lee-Seong-Cho combination renders claims 2 and 13 obvious and further renders obvious the remaining limitations of these claims.

342. 005Lee teaches, and the 005Lee-Seong-Cho combination renders obvious, at least one of the **inner extension line** and **outer extension line** is electrically connected to the first antenna pattern formed on the "**back**" through at least one via. 005Lee teaches, and the 005Lee-Seong-Cho combination renders obvious, the **inner extension line** and **outer extension line** are electrically connected to the "**WPC antenna**" and "**MST antenna**" on the "**bottom**" surface, respectively, through vias. Ground 3 Limitations [1d]/[1e]/[2pre]/[2a]. And, Seong's "**WPC antenna**" and "**MST antenna**" comprise the first antenna pattern on "**back**" surface (first major surface). Ground 3 Limitations [1b].

8. [7]/[18]

Reference Number	Claim Limitation
[7]	The smartphone antenna module of claim 2, wherein the inner extension line is referred to as a first inner extension line and is electrically connected to a first terminal of the inner coil, wherein the smartphone antenna module further comprises a second inner extension line formed on the second major surface, wherein the

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	second inner extension line is electrically connected to a second terminal of the inner coil and extends through at least part of the radially extending outer gap.
[18]	The smartphone of claim 13, wherein the inner extension line is referred to as a first inner extension line and is electrically connected to a first terminal of the inner coil, wherein the smartphone antenna module further comprises a second inner extension line formed on the second major surface, wherein the second inner extension line is electrically connected to a second terminal of the inner coil and extends through at least part of the radially-extending outer gap.

343. In my opinion, the 005Lee-Seong-Cho combination renders claims 1 and 11 obvious and further renders obvious the remaining limitations of these claims.

344. The 005Lee-Seong-Cho combination renders obvious a **first inner extension line** electrically connected to a **first terminal** of "**second conductive pattern**" on the "**bottom**" surface though via. Ground 3 Claims [4]/[14].

345. For the same reasons discussed with Ground 3 Claims [4]/[14], the 005Lee-Seong-Cho combination renders obvious 005Lee's smartphone antenna module comprises a **second inner extension line** formed on the "**front**" surface (second major surface) that electrically connects to a **second terminal** of "**WPC antenna**" on the "**bottom**" surface though vias, and the **second inner extension line** extends through at least part of the **radially-extending outer gap** as shown in the annotated figure below:

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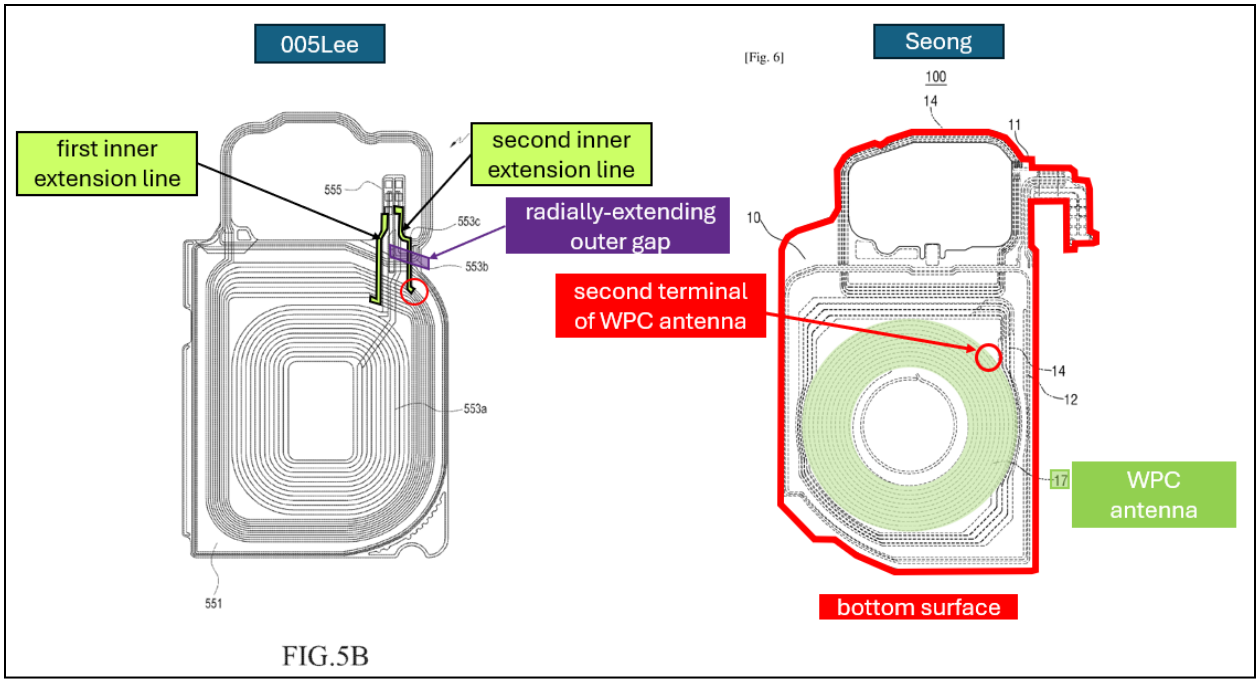


FIG.5B

Ex1008, 17:53-63, Fig. 5B; Section X.C.1.

9. [8]/[16]

Reference Number	Claim Limitation
[8]	The smartphone antenna module of claim 1, wherein the inner coil and the outer coil are electrically connected in parallel.
[16]	The smartphone of claim 13, wherein the inner coil and the outer coil are electrically connected in parallel.

346. In my opinion, the 005Lee-Seong-Cho combination renders claims 1 and 13 obvious and further renders obvious the remaining limitations of these claims.

347. Cho teaches electrically connecting inner and outer coils in parallel. Cho's "wireless communication coil" comprises a "first coil portion" and a "second coil portion[,]" which "may be connected in series or in

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parallel." Ex1010 ¶¶90, 91.

348. It would have been obvious to incorporate Cho's parallel-electrical-connection teachings with the combined 005Lee-Seong teachings to electrically connect 005Lee's MST and wireless charge coils (inner and outer coils) in parallel. Section X.C.1.

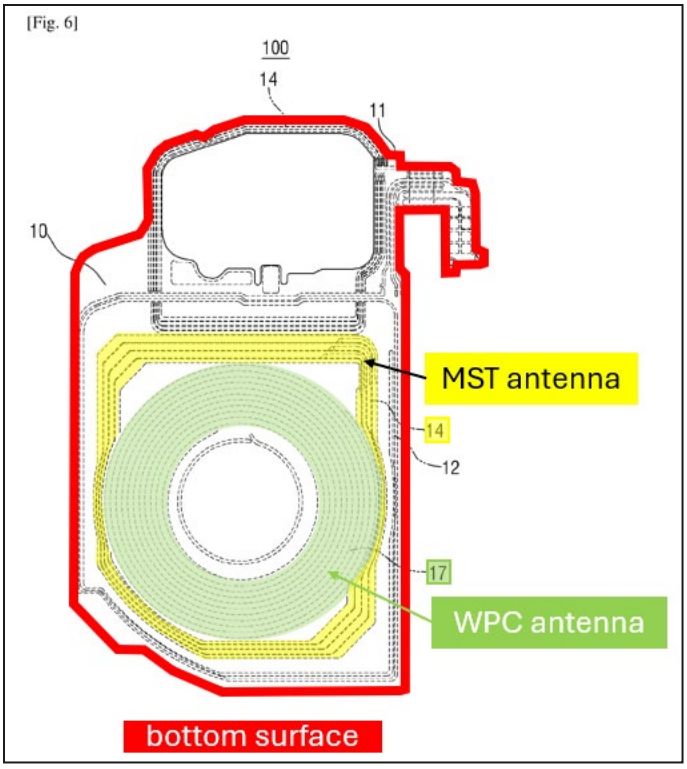
10. [9]/[19]

Reference Number	Claim Limitation
[9]	The smartphone antenna module of claim 1, wherein the inner coil includes a wire line having a width different from that of a wire line of the outer coil, wherein the inner coil has a first number of turns, and the outer coil has a second number of turns, wherein the first number of turns is greater than the second number of turns.
[19]	The smartphone of claim 13, wherein the inner coil includes a wire line having a width different from that of a wire line of the outer coil, wherein the inner coil has a first number of turns, and the outer coil has a second number of turns, wherein the first number of turns is greater than the second number of turns.

349. In my opinion, the 005Lee-Seong-Cho combination renders claims 1 and 13 obvious and further renders obvious the remaining limitations of these claims.

350. Seong's "**WPC antenna**" on the "**bottom**" surface (inner coil) includes a wire line having a width different from that of a wire line of "**MST antenna**" on the "**bottom**" surface (outer coil) as shown in the annotated figure below:

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Ex1006 ¶64, Fig. 6; Ground 1 Limitation [1b]. Seong's coil's wire lines' widths may vary, as Seong Figure 6 depicts. Ex1006 ¶63.

351. And, Seong's "**WPC antenna**" on the "**bottom**" surface (inner coil) has a first number of turns, "**MST antenna**" on the "**bottom**" surface (outer coil) has a second number of turns, wherein the first number of turns is greater than the second number of turns. Ex1006 ¶64, Fig. 6; Ground 1 Limitation [1b]. As shown above, Seong depicts "**WPC antenna**" having approximately 11 turns, and "**MST antenna**" having approximately 4 turns. Seong teaches antenna pattern "shape" and "arrangement" "may be varied," including the number of coil turns. Ex1006 ¶63.

352. It would have been obvious to incorporate Seong's bottom-surface coil-

pattern teachings with 005Lee. Section X.C.1.

11. [10]/[20]

Reference Number	Claim Limitation
[10]	The smartphone antenna module of claim 1, further comprising two additional extension lines formed on the second major surface and extending through both the radially-extending inner gap and the radially-extending outer gap.
[20]	The smartphone claim 13, further comprising two additional extension lines formed on the second major surface and extending through both the radially-extending inner gap and the radially-extending outer gap.

353. In my opinion, the 005Lee-Seong-Cho combination renders claims 1 and 13 obvious and 005Lee further teaches the remaining limitations of these claims.

354. 005Lee in view of Seong renders obvious radially-extending inner and outer gaps through which extension lines extend. Ground 3 Limitations [1d]/[1e]/[1f].

355. 005Lee further teaches a "**NFC transaction coil**" and depicts, and renders obvious in view of Seong, two "**NFC transaction coil**" extension lines (two additional extension lines) formed on the "**front**" surface (second major surface) extending through both the **radially-extending inner gap** and the **radially-extending outer gap** as shown in the annotated figure below:

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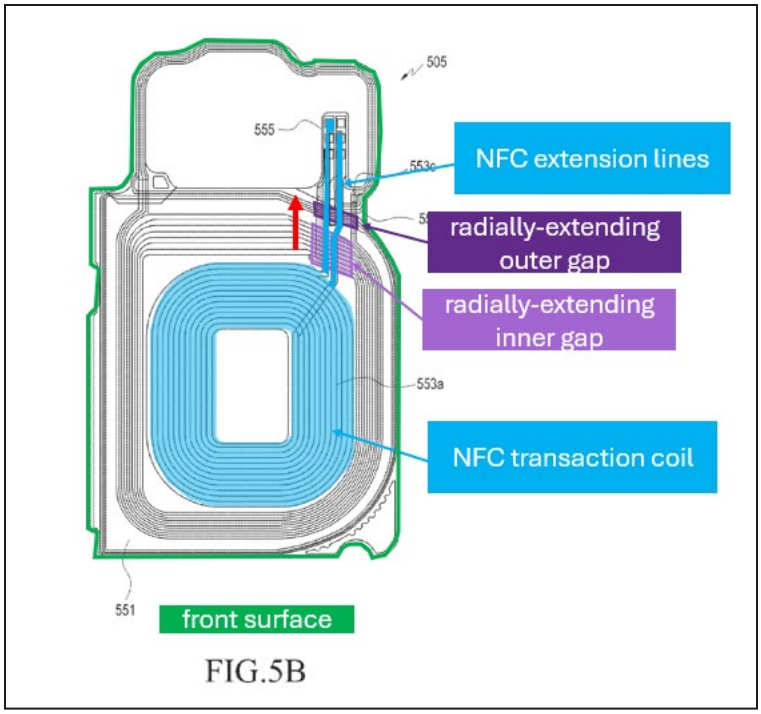


FIG.5B

Ex1008, 17:53-63, 19:28-30, Fig. 5B; Section X.C.1.

12. [11]/[21]

Reference Number	Claim Limitation
[11]	The smartphone antenna module of claim 10**,** wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein each of the two additional extension lines is electrically connected to a terminal of the third antenna pattern.
[21]	The smartphone of claim 20, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein each of the two additional extension lines is electrically connected to a terminal of the third antenna pattern.

356. In my opinion, the 005Lee-Seong-Cho combination renders claims 10 and 20 obvious and 005Lee further teaches the remaining limitations of these

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claims.

357. 005Lee teaches its second antenna pattern formed on the "**front**" (second major surface) comprises "**NFC transaction coil**" (third antenna pattern) generally surrounded by "**second conductive pattern 553b**" (inner antenna pattern) as shown in the annotated figure below:

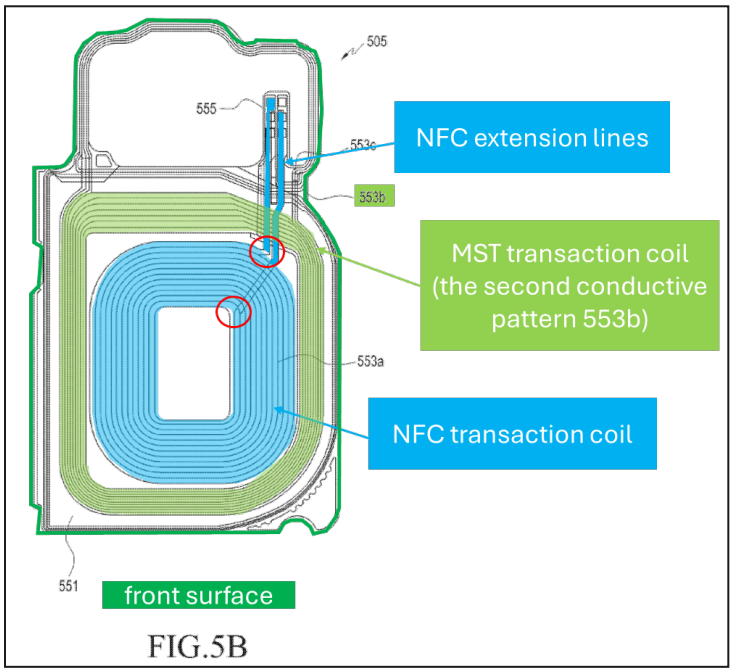


FIG.5B

Ex1008, 19:28-30, Fig. 5B; Ground 3 Limitation [10]/[20].

358. As Figure 5B depicts, 005Lee illustrates each of the two "**NFC transaction coil**" extension lines is electrically connected to a terminal of "**NFC transaction coil**." *Id.*, Fig. 5b; 17:53-63.

13. [12]/[22]

Reference Number	Claim Limitation

[12]	The smartphone antenna module of claim 10, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein at least one of the two additional extension lines contacts the third antenna pattern on the second major surface.
[22]	The smartphone of claim 20, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein at least one of the two additional extension lines contacts the third antenna pattern on the second major surface.

359. In my opinion, the 005Lee-Seong-Cho combination renders claims 10 and 20 obvious and further renders obvious the remaining limitations of these claims.

360. Seong teaches a second antenna pattern formed on the "**front**" (second major surface) comprises "**NFC transaction coil**" (third antenna pattern) generally surrounded by "**second conductive pattern 553b**" (inner antenna pattern), wherein at least one of the two "**NFC transaction coil**" extension lines (two additional extension lines) contacts "**NFC transaction coil**" on the "**front**" surface (second major surface). Ground 1 Limitations [10]/[20]/[11]/[21]; Ex1008, 17:53-63, 19:28-30, Fig. 5B.

14. [13pre]/[13a]/[13b]/[13c]/[13d]

Reference Number	Claim Limitation
[13pre]	A smartphone comprising a display module comprising a display surface;
[13a]	a rear cover comprising a rear surface facing away from the display surface;
[13b]	a battery placed between the display module and the rear cover; and

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[13c]	the smartphone antenna module of claim 2 placed between the battery and the rear cover,
[13d]	wherein at least one of the inner coil and the outer coil are configured for wireless battery charging.

361. In my opinion, the 005Lee-Seong-Cho combination renders claim 2 obvious and 005Lee further teaches the remaining limitations of this claim.

362. 005Lee teaches a smartphone comprising "**a front cover 402*a***" (display module) comprising a "**display device 421**" (display surface), "**a rear surface 402*b***" facing away from the "**display device**," "**battery 443**," placed between the "**front cover**" and the "**rear surface**," and "**a conductive pattern unit**" placed between the "**battery**" and the "**rear surface**" as shown in the annotated figure below:

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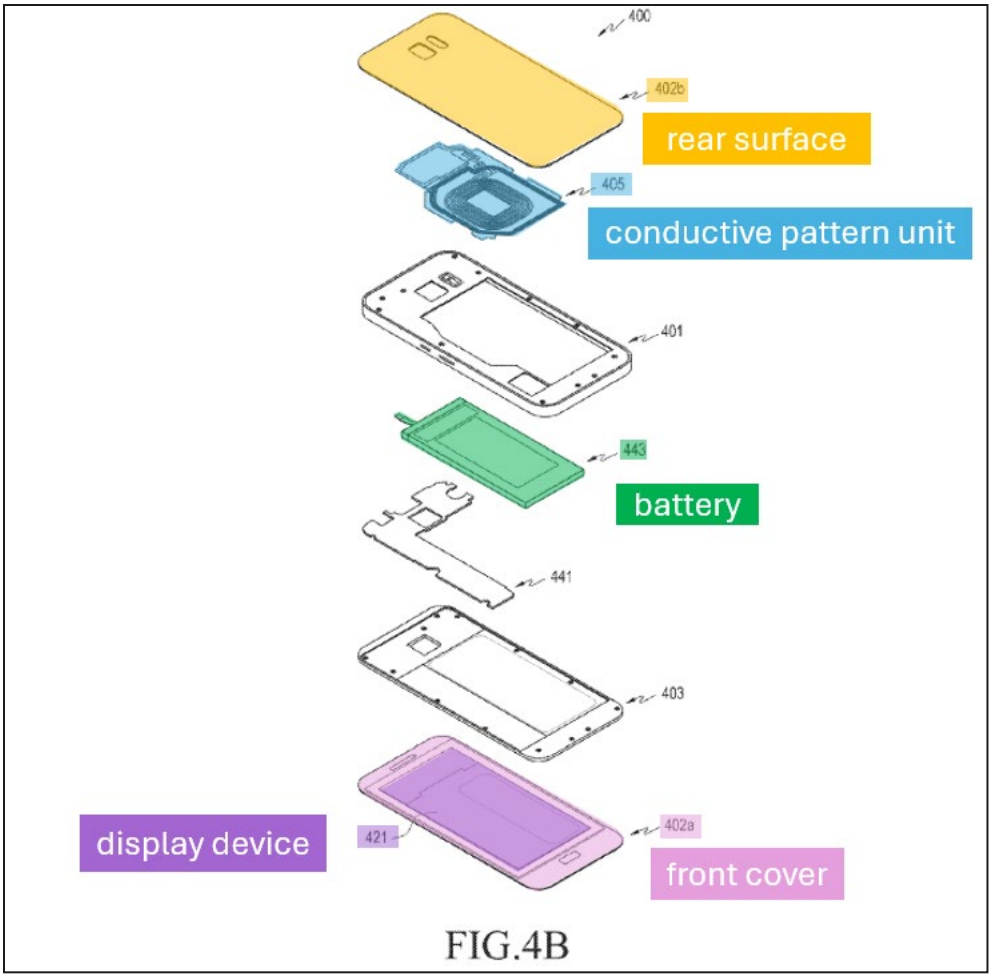


FIG.4B

Ex1008, 6:23, 15:18-31, 15:41-63, Figs. 4A, 4B.

363. Seong teaches an inner and outer coil configured for wireless charging. Ground 1 Claim [13]. It would have been obvious to incorporate Seong's bottom-surface coil-pattern teachings with 005Lee. Section X.C.1.

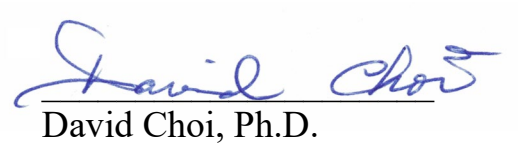
XI. SECONDARY CONSIDERATIONS OF NON-OBVIOUSNESS

364. I am unaware of any secondary considerations of non-obviousness that provide evidence the claims of the above patents are not obvious. To the contrary, as I explained in detail above, the claims are based on an obvious

combination of well-known antenna module components and configurations. To the extent Patent Owner attempts to argue there are secondary considerations of non-obviousness, I reserve the right to evaluate Patent Owner's arguments and purported evidence at that time.

I 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; and further that these statements were 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 the Title 18 of the United States Code.

Dated: January 26, 2026



David Choi, Ph.D.

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