

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.
Petitioner

v.

Neodron, Ltd.
Patent Owner

Case No. TBD
U.S. Patent No. 9,411,472

DECLARATION OF DR. KHALIL NAJAFI

I, Dr. Khalil Najafi, hereby declare the following:

I. INTRODUCTION

1. I, Dr. Khalil Najafi, have been retained by counsel for Petitioner as a technical expert in the above-captioned case. Specifically, I have been asked to render certain opinions in regard to the IPR petition with respect to U.S. Patent No. 9,411,472 (the “’472 Patent”). I understand that the Challenged Claims are claims 1, 5-7, 11-13, and 17-23. My opinions are limited to the Challenged Claims.

2. My compensation in this matter is not based on the substance of my opinions or the outcome of this matter. I have no financial interest in Petitioner. I am being compensated at an hourly rate of \$600 for my analysis and testimony in this case.

3. In reaching my opinions in this matter, I have reviewed the following materials:

- Ex. 1001 – U.S. Patent No. 9,411,472 to Simmons et al. (“’472 Patent”);
- Ex. 1002 – File History of ’472 Patent (“’472 Patent File History”);
- Ex. 1007 – U.S. Patent Publication No. 2011/0001708 to Sleeman (“*Sleeman*”);
- Ex. 1008 – U.S. Patent Publication No. 2009/0160787 to Westerman et al. (“*Westerman* ’787”);
- Ex. 1009 – U.S. Patent Publication No. 2011/0248948 to Griffin et al. (“*Griffin*”);

- Ex. 1010 – U.S. Patent Publication No. 2011/0012840 to Hotelling et al. (“*Hotelling*”);
- Ex. 1011– *QT60161 16 Key QMatrix™ KeyPanel Sensor IC*, Quantum Research Group Ltd (2001) (“*QT60161 Datasheet*”);
- Ex. 1013 – Raphael Wimmer, *Capacitive Sensors for Whole Body Interaction*, in Whole Body Interaction, 121-133 (D. England ed., April 2011) (“*Wimmer*”);
- Ex. 1014 – Larry K. Baxter, *Capacitive Sensors Designs and Applications*, IEEE Press (1997) (“*Baxter*”);
- Ex. 1015 – Steve Kolokowsky and Trevor Davis, *Touchscreens 101: Understanding Touchscreen Technology and Design*, Cypress Semiconductor Corp. (June 2009) (“*Kolokowsky*”);
- Ex. 1016 – U.S. Patent No. 3,482,241 to Johnson (“*Johnson*”);
- Ex. 1017 – B. Stumpe, *A New Principle for X-Y Touch System*, CERN (1977) (“*Stumpe*”);
- Ex. 1018 – Jeremy White, *Multi-Touch Interfaces and Map Navigation*, University of Wisconsin-Madison (2009) (“*White*”);
- Ex. 1019 – Philip I.S. Lei and Angus K.Y. Wong, *The Multiple-Touch User Interface Revolution*, IT Pro, IEEE Computer Society 42-49 (January/February 2009) (“*Lei*”);
- Ex. 1020 – Becca Hutchinson, *Six alumni awarded Presidential Citations for Outstanding Achievement*, UDaily, University of Delaware (Oct. 21, 2008, <http://www1.udel.edu/udaily/2009/oct/citations102108.html>, retrieved June 22, 2020) (“*Hutchinson*”);
- Ex. 1021 – Gary Barrett and Ryomei Omote, *Projected-Capacitive Touch Technology*, Information Display 26(3):16-21 (March 2010) (“*Barrett*”);

- Ex. 1022 – Kannan Srinivasagam and B. Vibheesh, *Differentiating Noise from Real Touch – The Key to Robust Capacitive Sensing*, Cypress Semiconductor Corp. (October 2010) (“Srinivasagam”);
- Ex. 1023 – Seunghoon Ko et al., *Low Noise Capacitive Sensor for Multi-touch Mobile handset’s applications*, Proceedings of IEEE Asian Solid-State Circuits Conference (November 8-10, 2010) (“Ko”);
- Ex. 1024 – *The Compact Oxford English Dictionary* (2nd ed. 1999) (“Oxford Dictionary”).

A. Background and Qualifications

4. I am currently the Schlumberger Professor of Engineering, which is an endowed professor position, and the Thurnau Professor in the department of Electrical Engineering and Computer Science, College of Engineering, University of Michigan, Ann Arbor. I served two five-year terms as the Chair of Electrical and Computer Engineering division and as the co-Chair of Electrical Engineering and Computer Science department at the University of Michigan, from September 2008 until September 2018. I am a Professor of Electrical Engineering and Computer Science and Professor of Biomedical Engineering at the University of Michigan. I have been on the faculty at the University of Michigan at Ann Arbor since 1990, and from 1988-1990, I was an assistant research scientist at the University of Michigan.

5. I received my undergraduate degree, a Bachelor of Science in Electrical Engineering, *summa cum laude*, in 1980, a Master of Science in Electrical Engineering in 1981, and a Ph.D. in Electrical Engineering in August 1986, all from

the University of Michigan. My doctoral research thesis was on implantable biomedical micromachined silicon microprobes for recording signals from individual neurons in the brain.

6. I have taught many courses while a professor at the University of Michigan. The subjects of these courses covered a wide variety of topics, including electronic integrated circuits and devices, microfabrication technologies, and microfabricated sensors, actuators and microsystems. I have been recognized for the quality of my teaching by the University through several awards, including being named the Thurnau Professor for Outstanding Contributions to Undergraduate Teaching, 1999-2002, a Teaching Excellence Award by the College of Engineering, and a Teaching Excellence Award, Department of Electrical Engineering and Computer Science. I was selected as the "Professor of the Year", by students in the Department of Electrical Engineering and Computer Science, and the Eta Kappa Nu Student Honor Society Chapter in 1993-1994.

7. My areas of expertise revolve around Micro Electro Mechanical Systems (MEMS) devices and microsystems design, structures, and technologies. MEMS and microsystems are microfabricated sensor and actuator devices, together with their interface electronic circuits and packaging, for measuring a number of physical, chemical, biological, and other non-electronic signals. They are used in many applications, including implantable biomedical devices and microsystems,

automotive, aerospace and defense, health care, environmental monitoring, and other emerging consumer areas such as Internet of Things (IoT) and autonomous systems. Through my many research projects, I have also conducted research on integrated circuits and electronics for interfacing to different kinds of sensors, especially capacitive devices. I have authored or co-authored over five hundred forty (540) published articles related to these topics.

8. I have been a principal investigator on research projects totaling approximately \$32 million since 1989, funded by US government agencies, including The National Institutes of Health (NIH), The National Science Foundation (NSF), The Defense Advanced Research Projects Agency (DARPA), Army Research Lab (ARL), The Air Force Office of Scientific Research (AFOSR), NASA, The Defense Treat Reduction Agency (DTRA), and several industrial companies. I have conducted research on many different transduction mechanisms for sensors and actuators, including capacitive, piezoresistive, piezoelectric, electromagnetic, tunneling, thermal, fluidic, and radiative techniques. I have developed many different capacitive sensors and actuators, including micromachined capacitive accelerometers, gyroscopes, pressure sensors, force sensors, tactile/touch sensors, and micropumps. I have worked on the development of multi-element capacitive tactile sensor arrays used for touch/force distribution sensing (K. Suzuki, K. Najafi, K.D. Wise, "A 1024-Element High-Performance Silicon Tactile Imager," IEEE

Transactions on Electron Devices, Vol. ED-37, No. 8, pp. 1852-1860, August 1990
(This paper received the Paul Rappaport Award for the best paper published in an
Electron Device Society publication in 1990)). I have also conducted research on a
variety of energy harvesting devices for miniature sensors and Internet of Things
(IoT) devices.

9. I have been a co-founder and member of the Board of Directors of
Integrated Sensing Systems (ISS), Inc., a company devoted to the manufacture of
integrated microsystems and micro electro mechanical systems (MEMS) for
biomedical and industrial applications, a co-founder and member of the Board of
Directors of ePack Corp., a company devoted to environment-resistant packaging of
MEMS and microsystems, and a co-founder and Scientific Advisor and Member of
the Board of Enertia Microsystems, Inc., a company devoted to the development and
commercialization of high-performance inertial sensors such as gyroscopes.

10. During my professional tenure, I have served as an Editor, Associate
Editor, or member of the Editorial Board for the following scientific journal
publications:

- IEEE Proceedings, 2011-2016
- IEEE/ASME Journal of Micro Electro Mechanical Systems (JMEMS),
2003-2010
- IOP Journal of Micromechanics & Microengineering, 1991-2013

- Sensors and Materials Journal, Published in Japan, since 1997-2017
- Journal of Biomedical Microdevices, 1998-2009
- IEEE Transactions on Electron Devices, March 1996-Oct. 2006
- IEEE Transactions on Biomedical Engineering, Sept. 1999-December 2000
- IEEE Journal of Solid-State Circuits, May 2000-February 2004

11. I have been a member of the Institute of Electrical and Electronics Engineers (“IEEE”) since 1986, a Fellow of the IEEE since 2000, and a Fellow of the American Institute for Medical and Biological (AIMBE) since 2005. In 2015 I received the IEEE Daniel E. Noble Technical Field Award for “For leadership in microsystem technologies and seminal contributions to inertial sensors and hermetic wafer-level packaging.” In 2013 I received the IEEE Sensors Council Technical Achievement Award “For leadership in microsystem technologies and seminal contributions to inertial sensors and hermetic wafer-level packaging.” In 2005 I received the University of Michigan’s Distinguished Faculty Achievement Award, for exceptional contributions in scholarship, teaching mentorship and service. I have received the Research Excellence Award from of College of Engineering at the University of Michigan for the 1998-99 Academic Year. From 1992-1997, I was one of the National Science Foundation's National Young Investigator Awardees, which included a research grant for the five-year period.

12. I have been involved either as a chair, co-chair, or member of various organizing and technical program committees of all the most prominent national and international conferences dealing with solid-state sensors and actuators and MEMS. Most recently I was the General Chair of the 2009 IEEE International Conference on Solid-State Sensors, Actuators, and Microsystems, held in Denver, Colorado. This is the largest and most prestigious conference dealing with microfabricated sensors, actuators, and microsystems and related fabrication technologies. I served as the President of the Electrical and Computer Engineering Department Heads Association (ECEDHA) in 2016-2017.

13. I am co-inventor on 42 issued US patents, as listed in my CV (Ex. 1004), including the following patents related to topics in this proceeding:

- Navid Yazdi, and K. Najafi, "Microelectromechanical Capacitive Accelerometer and Method of Making Same," US Patent No. 6,035,714, issued on March 14, 2000
- N. Yazdi, K. Najafi, "Single-Side Microelectromechanical Capacitive Accelerometer and Method of Making Same", US Patent No. 6,167,757, Issued January 2, 2001.
- N. Yazdi, K. Najafi, and A. Salian, "Single-side Microelectromechanical Capacitive Accelerometer and Method of Making Same," US Patent No. 6,286,369, Issued September 11, 2001
- N. Yazdi, K. Najafi, "Single-Side Microelectromechanical Capacitive Accelerometer and Method of Making Same", US Patent No. 6,402,968 B1, June 11, 2002

- N. Yazdi, K. Najafi, and A. Salián, “Single-side Microelectromechanical Capacitive Accelerometer and Method of Making Same,” US Patent No. 6,718,605, Issued April 13, 2004
- Khalil Najafi, and Junseok Chae, “Micromachined Capacitive Lateral Accelerometer Device and Monolithic, Three-Axis Accelerometer Having Same,” US Patent # 6,938,484 B2, Issued Sept. 6, 2005
- Maysam Ghovanloo, and K. Najafi, “Demodulator, chip and method for digitally demodulating an FSK signal,” USPTO number, 7,881,409, Issued Feb. 1, 2011
- K. Najafi, and Y. Tang, “High aspect-ratio low noise multi-axis accelerometers,” US Patent No. 10,495,663, Issued December 3, 2019
- K. Najafi, Yemin Tang, “Capacitive-based Transducer with High-Aspect Ratio,” US Patent 10,524,059, Issued December 31, 2019

II. LEGAL FRAMEWORK

14. I am a technical expert and do not offer any legal opinions. However, counsel has informed me as to certain legal principles regarding patentability and related matters under United States patent law, which I have applied in performing my analysis and arriving at my technical opinions in this matter.

15. I have been informed that the Patent Trial and Appeal Board (“PTAB”) now applies the claim construction standard applied by Article III courts (i.e., the *Phillips* standard) regardless of whether a patent has expired. I have been informed that under the *Phillips* standard, claim terms are to be given the meaning they would have to a person having ordinary skill in the art at the time of the invention, taking

into consideration the patent, its file history, and, secondarily, any applicable extrinsic evidence (e.g., dictionary definitions).

16. I have also been informed that the implicit or inherent disclosures of a prior art reference may anticipate the claimed invention. Specifically, if a person having ordinary skill in the art at the time of the invention would have known that the claimed subject matter is necessarily present in a prior art reference, then the prior art reference may “anticipate” the claim. Therefore, a claim is “anticipated” by the prior art if each and every limitation of the claim is found, either expressly or inherently, in a single item of prior art.

17. I have also been informed that a person cannot obtain a patent on an invention if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art. I have been informed that a conclusion of obviousness may be founded upon more than a single item of prior art. I have been further informed that obviousness is determined by evaluating the following factors: (1) the scope and content of the prior art, (2) the differences between the prior art and the claim at issue, (3) the level of ordinary skill in the pertinent art, and (4) secondary considerations of non-obviousness. In addition, the obviousness inquiry should not be done in hindsight. Instead, the obviousness

inquiry should be done through the eyes of a person having ordinary skill in the relevant art at the time the patent was filed.

18. In considering whether certain prior art renders a particular patent claim obvious, counsel has informed me that I can consider the scope and content of the prior art, including the fact that one of skill in the art would regularly look to the disclosures in patents, trade publications, journal articles, industry standards, product literature and documentation, texts describing competitive technologies, requests for comment published by standard setting organizations, and materials from industry conferences, as examples. I have been informed that for a prior art reference to be proper for use in an obviousness analysis, the reference must be “analogous art” to the claimed invention. I have been informed that a reference is analogous art to the claimed invention if: (1) the reference is from the same field of endeavor as the claimed invention (even if it addresses a different problem); or (2) the reference is reasonably pertinent to the problem faced by the inventor (even if it is not in the same field of endeavor as the claimed invention). In order for a reference to be “reasonably pertinent” to the problem, it must logically have commended itself to an inventor's attention in considering his problem. In determining whether a reference is reasonably pertinent, one should consider the problem faced by the inventor, as reflected either explicitly or implicitly, in the specification. I believe that all of the references that my opinions in this IPR are based upon are well within

the range of references a person having ordinary skill in the art would consult to address the type of problems described in the Challenged Claims.

19. I have been informed that, in order to establish that a claimed invention was obvious based on a combination of prior art elements, a clear articulation of the reason(s) why a claimed invention would have been obvious must be provided. Specifically, I am informed that a combination of multiple items of prior art renders a patent claim obvious when there was an apparent reason for one of ordinary skill in the art, at the time of the invention, to combine the prior art, which can include, but is not limited to, any of the following rationales: (A) combining prior art methods according to known methods to yield predictable results; (B) substituting one known element for another to obtain predictable results; (C) using a known technique to improve a similar device in the same way; (D) applying a known technique to a known device ready for improvement to yield predictable results; (E) trying a finite number of identified, predictable potential solutions, with a reasonable expectation of success; (F) identifying that known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art; or (G) identifying an explicit teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine the prior art references to arrive at the claimed invention.

20. I am informed that the existence of an explicit teaching, suggestion, or motivation to combine known elements of the prior art is a sufficient, but not a necessary, condition to a finding of obviousness. This so-called “teaching suggestion-motivation” test is not the exclusive test and is not to be applied rigidly in an obviousness analysis. In determining whether the subject matter of a patent claim is obvious, neither the particular motivation nor the avowed purpose of the patentee controls. Instead, the important consideration is the objective reach of the claim. In other words, if the claim extends to what is obvious, then the claim is invalid. I am further informed that the obviousness analysis often necessitates consideration of the interrelated teachings of multiple patents, the effects of demands known to the technological community or present in the marketplace, and the background knowledge possessed by a person having ordinary skill in the art. All of these issues may be considered to determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent.

21. I also am informed that in conducting an obviousness analysis, a precise teaching directed to the specific subject matter of the challenged claim need not be sought out because it is appropriate to take account of the inferences and creative steps that a person of ordinary skill in the art would employ. The prior art considered can be directed to any need or problem known in the field of endeavor at the time of invention and can provide a reason for combining the elements of the prior art in the

manner claimed. In other words, the prior art need not be directed towards solving the same specific problem as the problem addressed by the patent. Further, the individual prior art references themselves need not all be directed towards solving the same problem. I am informed that common sense is important and should be considered. Common sense teaches that familiar items may have obvious uses beyond their primary purposes.

22. I also am informed that the fact that a particular combination of prior art elements was “obvious to try” may indicate that the combination was obvious even if no one attempted the combination. If the combination was obvious to try (regardless of whether it was actually tried) or leads to anticipated success, then it is likely the result of ordinary skill and common sense rather than innovation. I am further informed that in many fields it may be that there is little discussion of obvious techniques or combinations, and it often may be the case that market demand, rather than scientific literature or knowledge, will drive the design of an invention. I am informed that an invention that is a combination of prior art must do more than yield predictable results to be non-obvious.

23. I am informed that for a patent claim to be obvious, the claim must be obvious to a person of ordinary skill in the art at the time of the invention. I am informed that the factors to consider in determining the level of ordinary skill in the art include (1) the educational level and experience of people working in the field at

the time the invention was made, (2) the types of problems faced in the art and the solutions found to those problems, and (3) the sophistication of the technology in the field.

24. I am informed that it is improper to combine references where the references teach away from their combination. I am informed that a reference may be said to teach away when a person of ordinary skill in the relevant art, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the patent applicant. In general, a reference will teach away if it suggests that the line of development flowing from the reference's disclosure is unlikely to be productive of the result sought by the patentee. I am informed that a reference teaches away, for example, if (1) the combination would produce a seemingly inoperative device, or (2) the references leave the impression that the product would not have the property sought by the patentee. I also am informed, however, that a reference does not teach away if it merely expresses a general preference for an alternative invention but does not criticize, discredit, or otherwise discourage investigation into the invention claimed.

25. I am informed that the final determination of obviousness must also consider "secondary considerations" if presented. In most instances, the patentee raises these secondary considerations of non-obviousness. In that context, the

patentee argues an invention would not have been obvious in view of these considerations, which include: (a) commercial success of a product due to the merits of the claimed invention; (b) a long-felt, but unsatisfied need for the invention; (c) failure of others to find the solution provided by the claimed invention; (d) deliberate copying of the invention by others; (e) unexpected results achieved by the invention; (f) praise of the invention by others skilled in the art; (g) lack of independent simultaneous invention within a comparatively short space of time; (h) teaching away from the invention in the prior art.

26. I am further informed that secondary considerations evidence is only relevant if the offering party establishes a connection, or nexus, between the evidence and the claimed invention. The nexus cannot be based on prior art features. The establishment of a nexus is a question of fact. While I understand that the Patent Owner here has not offered any secondary considerations at this time, I will supplement my opinions in the event that the Patent Owner raises secondary considerations during the course of this proceeding.

III. OPINION

A. Level of a Person of Ordinary Skill in the Art

27. I was asked to provide my opinion as to the level of skill of a person having ordinary skill in the art of the '472 Patent at the time of the claimed invention, which counsel has told me to assume is December 8, 2011. In determining the characteristics of a hypothetical person of ordinary skill in the art of the '472 Patent, I considered several factors, including the type of problems encountered in the art, the solutions to those problems, the rapidity with which innovations are made in the field, the sophistication of the technology, and the education level of active workers in the field. I also placed myself back in the time frame of the claimed invention and considered the colleagues with whom I had worked at that time.

28. In my opinion, a person having ordinary skill in the art at the time of the claimed invention of the '472 Patent would be a person having at least a bachelor's degree in electrical engineering, computer engineering, computer science, or a related field, and at least two years of experience in the research, design, development, and/or testing of human-machine interfaces such as touch sensors or other capacitive sensors and the firmware or system software that govern said interfaces, or the equivalent, with additional education substituting for experience and vice versa. Such a person would have been capable of understanding the '472 patent and the prior art references discussed below.

29. Based on my education, training, and professional experience in the field of the claimed invention, I am familiar with the level and abilities of a person of ordinary skill in the art at the time of the claimed invention. Additionally, I met at least these minimum qualifications to be a person having ordinary skill in the art as of the time of the claimed invention of the '472 Patent.

B. Background of the Technology

i. Basic Principles of Capacitive Sensing

30. “The term capacitance describes how much electrical charge can be stored between two non-connected conductive objects” and “Capacitive Sensing is a term for a number of different sensing techniques that measure changes in capacitance between a sensor antenna and its surrounding.” *Wimmer* at p. 122. The figure below depicts a basic example of a capacitive sensor including an antenna (or electrodes) and a nearby, grounded, conductive object, such as a human hand:

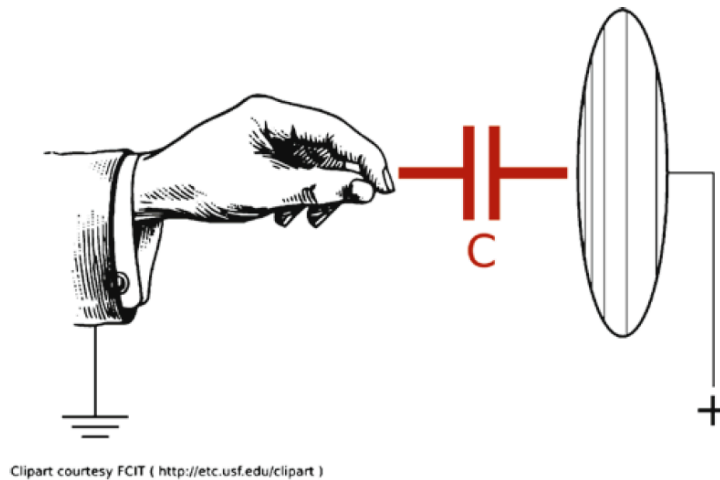


Fig. 10.1 Basic principle of capacitive sensing. An antenna and a nearby conductive, grounded object form a capacitor. The capacitance of this capacitor is determined by antenna size, object size, distance between both, and material properties. By measuring the capacitance, movement near the antenna can be detected. This can be used for tracking hand or body movement

Wimmer at p. 123.

31. In the example above, the hand and electrode form a capacitor, which stores electrical charge. The sensor detects changes in the amount of stored charge (i.e., capacitance) between the electrode and the hand. This means that as the hand moves closer or further away from the electrode, the capacitance changes. This enables the sensor to measure the proximity and movement of the hand.

32. Capacitive sensors have many different applications. For example, capacitive sensors have been used to detect the material properties, motion or position, or proximity of an object that is either conductive or has a dielectric constant (i.e., ability to store electrical energy) different from the environment. *Baxter* at p. 1 (“Capacitive sensors electronically measure the capacitance between two or more conductors in a dielectric environment, usually air or a liquid.”); p. 37

(“Three different uses of capacitive sensors are to detect material properties, to sense motion or position, and to detect the proximity of conductive or dielectric objects.”). However, my analysis focuses on capacitive touch sensors, which sense external conductive objects, such as fingers, in close proximity to or in contact with the sensor.

ii. Brief History of Capacitive Touch Sensing

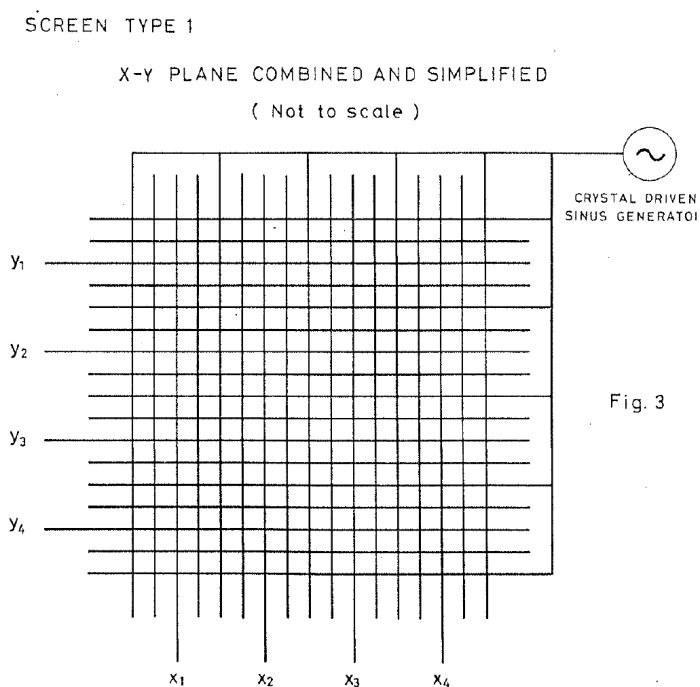
33. One of the first recorded uses of a capacitive sensor was in 1907 by Dr. Max Cremer, a German physician, who observed a living frog’s heartbeat by measuring capacitance between two plates. *Wimmer* at p. 123 (“Probably the first use of capacitive sensors for primitive Whole Body Interaction was in 1907. German physician Max Cremer put a living frog between two capacitor plates. By measuring capacitance changes he could observe the frog’s heartbeat.”)

34. In 1919, a gesture controlled capacitive sensor was used for a musical instrument known as a Theremin which used two capacitive sensing antennas to control volume and pitch of a tone. *Id.* (“In 1919 Leonid Termen presented the Theremin, a musical instrument using two capacitive sensing antennas for controlling pitch and volume of a tone. The Theremin is played by hand movement near each antenna.”).

35. The first capacitive touchscreen was invented in 1967 by Eric Johnson for use in air traffic control consoles. *Johnson* at Abstract (“A plurality of touch-

sensitive contacts, placed adjacent [to] the screen of a cathode ray tube, which may be selectively actuated for indicating which portion of the image on the cathode ray screen is to be examined [sic] in further detail. . . . Either resistance change or capacitance change across the actuated contact may be sensed.”); 6:15-17 (“An example will be given of the use of the touch display device in the amendment of flight plans in an Air Traffic Control System.”).

36. In 1977, CERN developed the first touchscreen utilizing an x-y electrode grid pattern, such as that illustrated in the figure below:



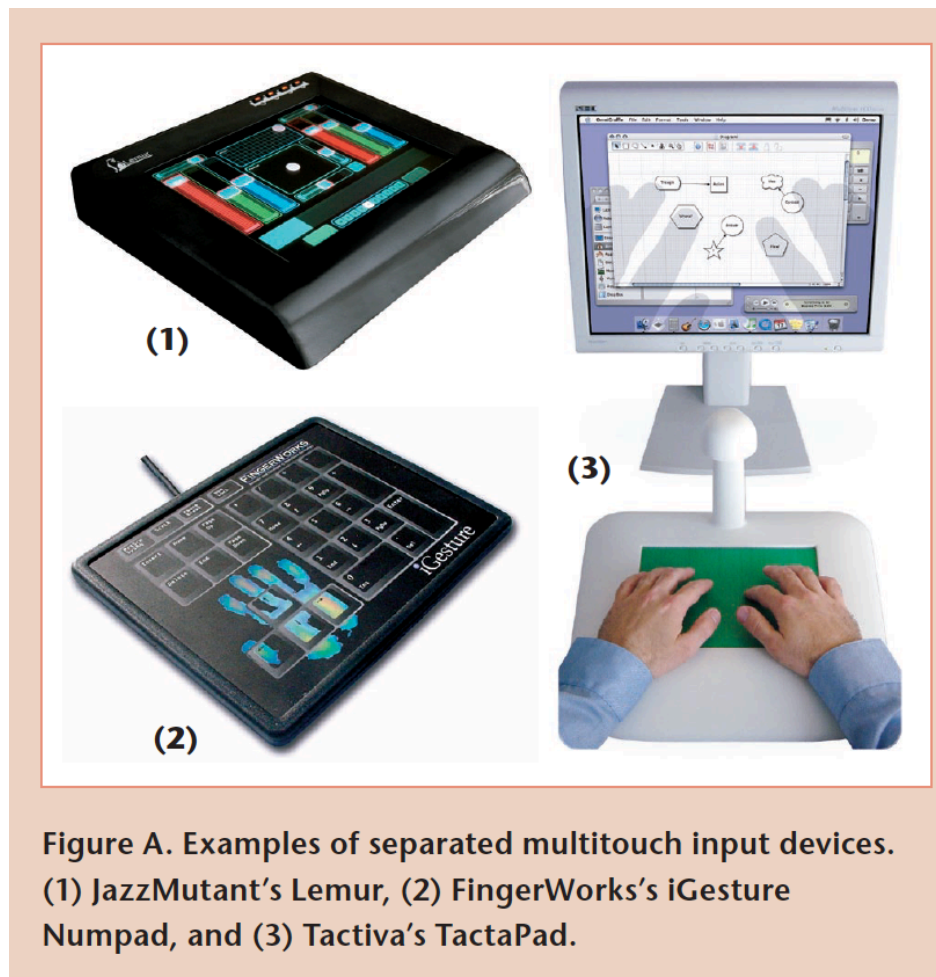
Stumpe at Fig. 3; *see also, id.* at p. 1 (“The new system is a complete x-y co-ordinate system where each co-ordinate represents a touch sensitive narrow line area going from one side of the screen to the other.”).

37. “When the screen is touched by a finger all the x-y capacitors under the finger will change capacity as the dielectric in front of these is modified by the presence of the finger.” *Id.* at p. 5. A microprocessor scanned the status of the x-y lines to “find out the gravity point for a touch.” *Id.* This x-y design allowed for “a more flexible use of the touch screen”, and the inventors even suggested incorporating it in “the first pocket sized mini-terminal for use with any computer system.” *Id.* at pp. 7-8.

38. In 1984, the first capacitive multi-touch tablet that could detect an arbitrary number of touch inputs was developed by William Buxton at the University of Toronto. *White* at pp. 6-7 (“The capacitive approach for detecting contact was further explored at University of Toronto in the form of a multi-touch tablet in 1984. William Buxton, along with the Computer Systems Research Institute, developed a thin tablet that was capable of detecting an arbitrary number of touch inputs by relaying the location and the force of each touch.”).

39. The development of multi-touch systems led to sensors that were capable of detecting gestures. *Lei* at p. 44 (“Capacitive multi-touch tables appeared as early as 1985, and the pinching gesture for scaling was first demonstrated in 1991.”). For example, Fingerworks developed several capacitive touch pads that could recognize numerous multi-touch hand gestures. *Id.* (“Fingerworks . . .

produced several touch-pads that can recognize a rich vocabulary of multitouch hand gestures.”).



Id.

40. Fingerworks, which was founded by Dr. Wayne Westerman¹ and Dr. John Elias, was acquired by Apple in 2005, and the Fingerworks multitouch technology was used for the touchscreen in first generation of the iPhone in 2007. *Hutchinson* at p. 2 (“We were working together from the start,” said Westerman,

¹ Dr. Westerman is the named inventor of many capacitive sensing patents including *Westerman* '787, which I discuss in more detail below.

who teamed with Elias to develop the computer ‘touchstream’ keyboard technology, which is operated by gesturing or moving fingers across a touch- and motion-sensitive surface. ‘It has been a great and shaping relationship.’”); (“In 2005, Apple Inc. purchased Fingerworks”); *White* at p. 9 (“The largest distribution of multi-touch interfaces has occurred within the last two years by Apple, with more than 30 million iPhone and iTouch devices sold worldwide from 2007 to 2009. . . . both devices can accept multi-point interactions on a limited basis by using techniques developed by Wayne Westerman.”) (internal citations omitted).

iii. Projected Capacitive Touch Sensors

41. Since the release of the iPhone in 2007, projected capacitive touch sensors have been commonly used for touchscreens because they are durable, support unlimited multitouch, and are highly transmissive allowing for excellent optical clarity of the display screen below. *Barrett* at p. 16 (“The advent of the iPhone has ushered in a seismic change in the touch-screen business. Projected capacitive (pro-cap), the touch technology used in the iPhone touch screen, has become the first choice for many small-to-medium (<10 in.) touch-equipped products now in development. . . . The three most important advantages of pro-cap technology are as follows: •High durability (long life) • Excellent optical performance (high transmissivity) • unlimited multi-touch”).

42. Projected capacitive sensors include a surface layer of a non-conductive material, such as glass or plastic, covering one or two layers of thin-film conductors, which are themselves separated by an insulator:

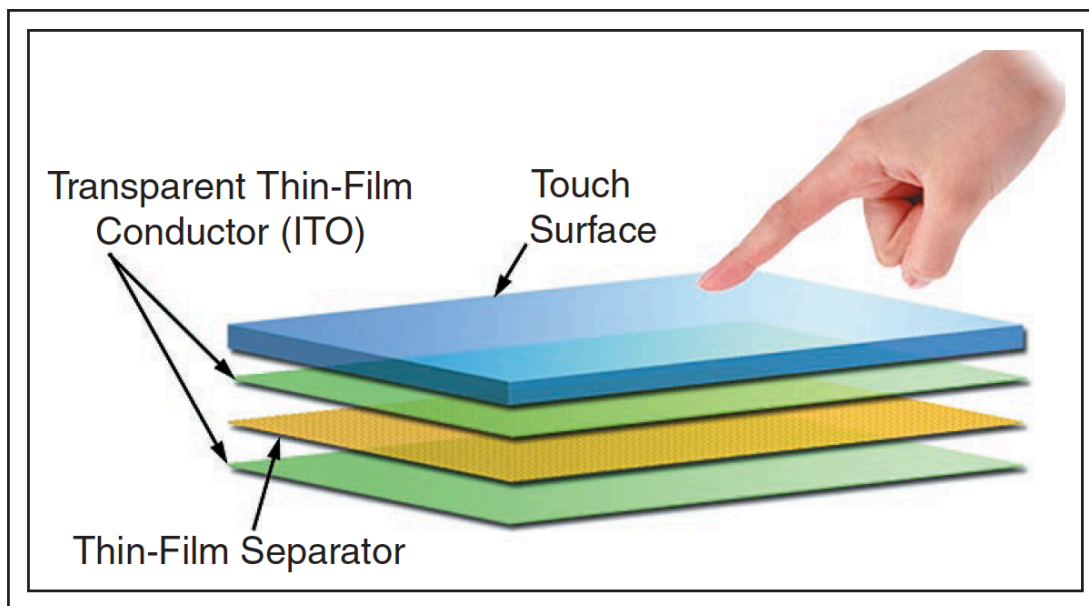


Fig. 4: The pro-cap design concept shows two transparent conductor layers separated by an insulator, all under the touch surface. (Note that the transparent conductors are shown as solid sheets when in fact they are actually patterned.) In some cases, an additional unpatterned ITO layer is added at the bottom of the stack as a shield for LCD noise. Source: Barrett and Omote.

Id. at p. 19; *see also, id.* at p. 16 (“Pro-cap touch screens can be made entirely of plain glass, allowing them to be immune to most chemicals, operated in extreme temperatures, and sealed to meet the requirements for most wash-down and explosive environments. Pro-cap touch screens can also be made entirely of plastic, allowing them to be virtually unbreakable and have the flexibility to be contoured or bent.”).

43. The conductive layers include electrodes, which can be etched in different patterns including, for example, an interlocking diamond pattern including “one layer of horizontal diamond rows and one layer of vertical diamond columns” such as shown in the figure below:

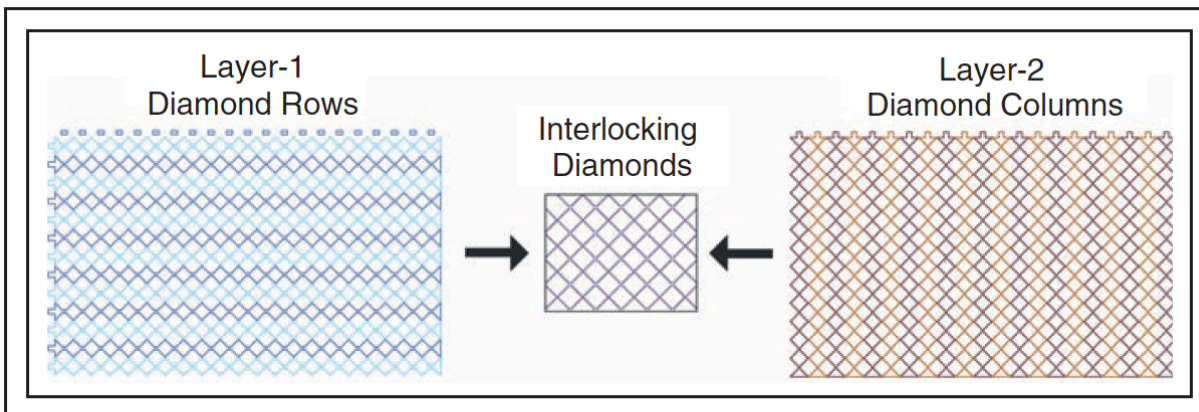


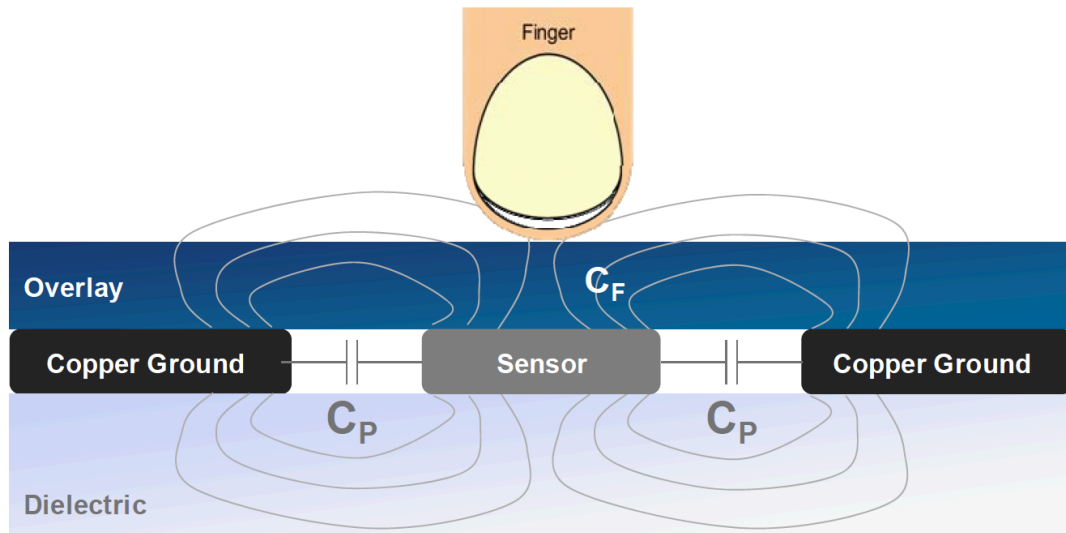
Fig. 5: The diamond pro-cap sensor pattern is formed by two interlocking diamond-shaped layers. Source: Barrett and Omote.

Id. at p. 19.

44. Projected capacitance sensors can be categorized as either self-capacitive or mutual capacitive. *Id.* at pp. 16-17. Self-capacitive sensors measure the capacitance of each individual electrode with respect to ground. *Id.* at p. 16 (“[Self-capacitance] is based on measuring the capacitance of a single electrode with respect to ground.”). When a finger is near or touches the sensor, “the human-body capacitance changes the self-capacitance of the electrode.” *Id.* at p. 16. More particularly, “[p]lacing a finger near fringing electric fields adds capacitance to the system” as shown in the figure below:

Sensor Capacitance = C_X

$$C_X = C_P + C_F$$



* Diagram not to scale

Srinivasagam at p. 1.

45. Self-capacitive sensors include one or two layers of sensing electrodes that are scanned by the controller in a serial sequence. *Barrett* at p. 16 (“In a self-capacitance touch screen, transparent conductors are patterned into spatially separated electrodes in either a single layer or two layers.”), p. 17 (“Self-capacitance touch screens are scanned using a straightforward serial method because every electrode is connected individually to the controller.”).

46. In the two-layer design, the sensing electrodes are “usually arranged in a layer of rows and a layer of columns; the intersections of each row and column represent unique touch coordinate pairs.” *Id.* at p. 16. Because each electrode is scanned individually, the controller cannot unambiguously detect more than one

touch. *Id.* at p. 17 (“Measuring individual electrodes rather than electrode intersections is the source of one of the major disadvantages of two-layer self-capacitance touch screens – the inability to unambiguously detect more than one touch.”). As shown in the figure below, two fingers simultaneously touching the screen results in “ghost points” because the controller is only able to detect that two rows and two columns have been touched:

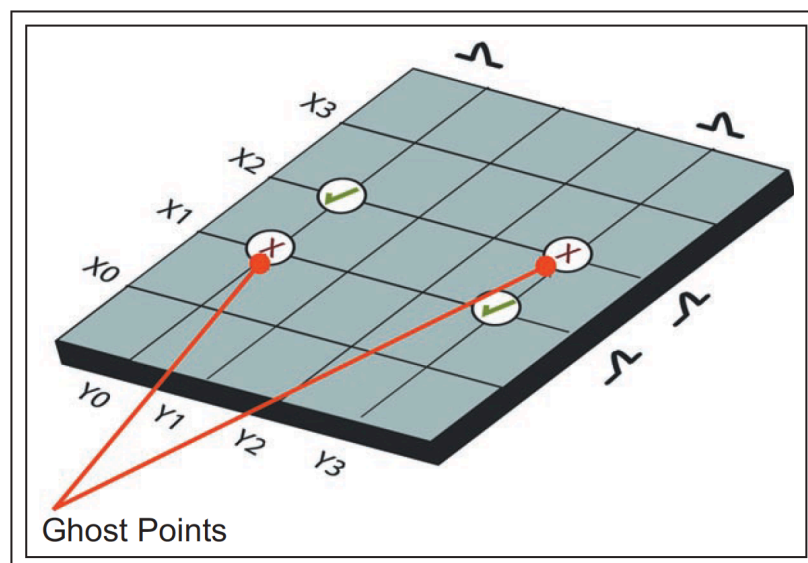


Fig. 2: When a self-capacitance touch screen is touched with two fingers that are diagonally separated, a pair of “ghost points” are created because the controller only knows that two columns and two rows have been touched; it cannot tell which coordinate pairs belong together because it is only scanning individual electrodes, not electrode intersections. Source: Barrett and Omote.

Id. at p. 17.

47. Mutual capacitive touch sensors also include “spatially separated electrodes in two layers usually arranged as rows and columns.” *Id.* at p. 17. However, mutual capacitive sensors include one layer of electrodes (e.g., the X layer) connected to a voltage source (a drive circuit), which are commonly referred

to as the drive lines. *See e.g., Westerman '787* at Figs. 1a-b, [0028] (“Drive lines (e.g., rows) 100 can be driven by stimulation signals from drive circuit 102.”).

48. When the drive lines are charged by the voltage source, they capacitively couple with the electrodes in the other layer (e.g., the Y layer), which are commonly referred to as the sense lines, forming mutual capacitance at the intersecting points (i.e., pixels/nodes):

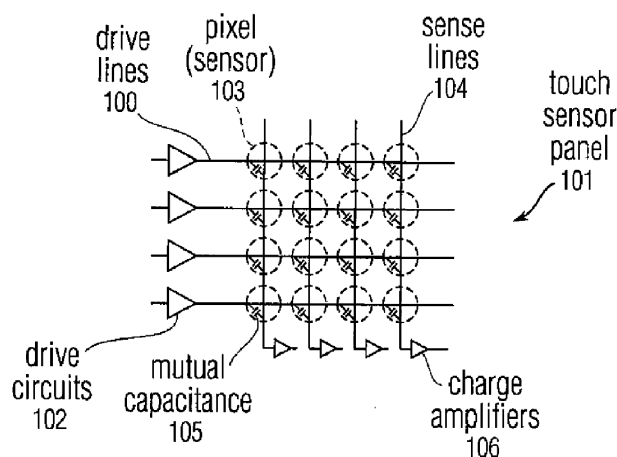


Fig. 1a

Westerman '787 at Fig. 1a, [0028] (“Because a mutual capacitance 105 can be formed when drive lines 100 and sense lines 104 (e.g., columns) at their crossing points (separated from each other by a dielectric), charge from the drive lines can be coupled onto the sense lines . . .”).²

49. As depicted in the figure below, when a conductive object such as a finger comes into close contact with the sensor, it interrupts the capacitive coupling

² My example arbitrarily denotes the X layer electrodes as including the drive lines and the Y layer electrodes as including the sense lines; however, this could also be reversed.

between the X (drive) and Y (sense) electrodes diverting some of the charge field from the coupled electrodes to the finger thereby decreasing the overall coupled capacitance:

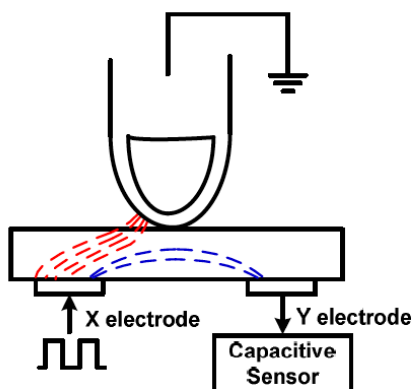


Fig.1 Behavioral model of capacitive sensing

Ko at p. 1, (“A behavioral model of capacitive sensing is shown in Fig. 1. When a conductive object like a finger approaches to the separated X, Y ITO electrodes, fringing fields between two electrodes are directed to the finger, causing the decrease in capacitance. The exact touch point record can be achieved by detecting the largest capacitive change and then conducting interpolation scheme.”); *see also*, Barrett at p. 17 (“Mutual capacitance makes use of the fact that most conductive objects are able to hold a charge if they are very close together. If another conductive object, such as a finger, comes close to two conductive objects, the change field (capacitance) between the two objects changes because the human-body capacitance ‘steals’ some of the charge.”).

50. In order to scan the electrodes in a mutual capacitive sensor, the controller charges a single drive line and then measures the capacitance of each sense line that intersects with the charged drive line. *Barrett* at p. 17 (“In this type of scan, . . . the controller drives a single column (Y) and then scans every row (X) that intersects with that column, measuring the capacitance value at each X-Y intersection.”). This process is repeated for every drive line until the cycle starts over. *Id.* (“This process is repeated for every column and then the entire cycle starts over.”). Thus, rather than measuring each sense electrode individually, mutual capacitance sensors measure the intersections of the X and Y electrode layers³, which allows the controller to unambiguously detect multiple touch points:

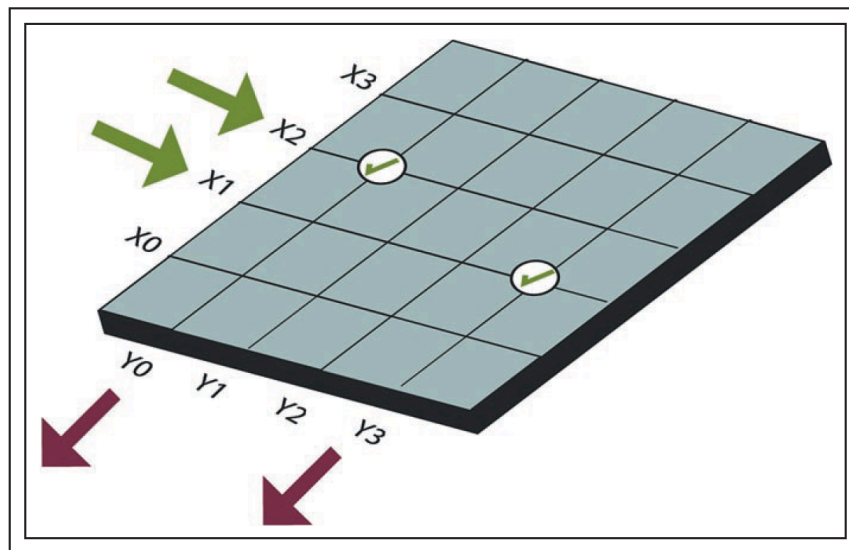


Fig. 3: In a mutual-capacitance touch screen, every electrode intersection can be unambiguously identified as a touch point. Source: Barrett and Omote.

Id. at p. 18.

³ These intersections of the drive and sense electrode layers are also known as “nodes” or “pixels”.

51. The following table provides a useful summary of the similarities and differences between self-capacitive and mutual capacitive touch sensors:

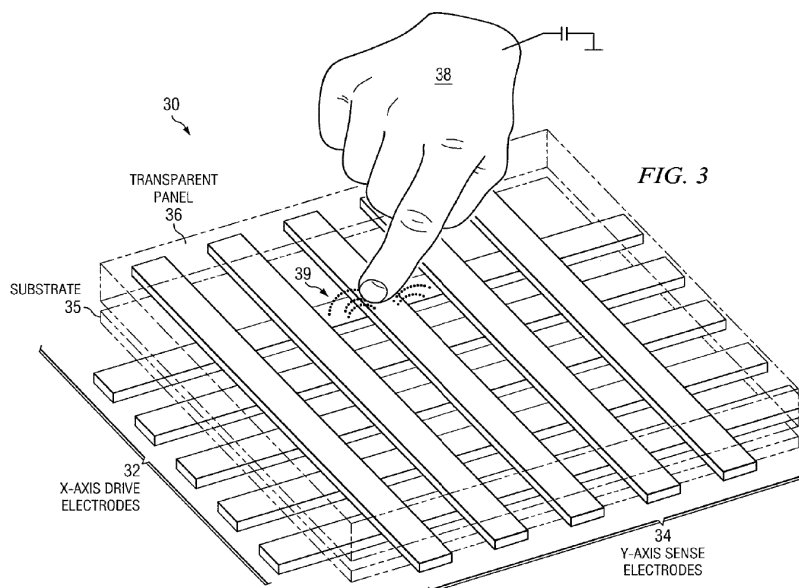
Table 1: A comparison of the key characteristics of self-capacitance and mutual-capacitance as applied in touch screens.		
Characteristic	Self-Capacitance	Mutual Capacitance
Electrode types	Sensing only	Driving & sensing
Number of layers	1 or 2	2
Sensor design	Multi-pad or row & column	Any design with unique electrode intersections; usually row & column
Scanning method	Each electrode individually	Each electrode intersection
Measurement	Capacitance of electrode to ground	Capacitance between electrodes
Ghost points	No in multi-pad; Yes in row & column	No

Id. at p. 18.

C. Claimed Invention in the '472 Patent

52. The '472 Patent describes a “touch sensor that has a touch detection threshold that automatically adapts to various grounding scenarios.” *'472 Patent* at 2:28-31. In one embodiment, the touch sensor is a conventional mutual-capacitance sensor including “an array of drive and sense electrodes forming an array of capacitive nodes.” *Id.* at 2:67-3:2. A controller applies a pulsed or alternating voltage on the drive electrode which “induces a charge on the sense electrode, and the amount of charge induced is susceptible to external influence (such as a touch or the proximity of an object).” *Id.* at 3:8-12. The controller measures the change in

capacitance for each node in the array to determine the touch position(s). *Id.* at 3:12-18.



Id. at Fig. 3.

53. The '472 Patent recognizes that the touch sensor may be utilized under various grounding conditions. *Id.* at 5:58-60. For example, the device housing the touch sensor may be ungrounded or “floating” when there is no or a weak path to ground. *Id.* at 5:62-63. As shown below, Fig. 4a depicts a grounded scenario where the device 20 has a path to ground 44 and Figure 4b depicts a floating scenario where the device 20 does not have a path to ground:

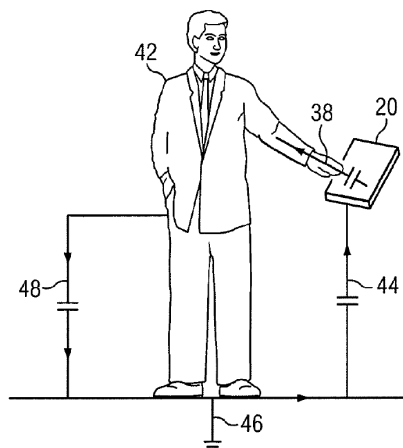


FIG. 4a

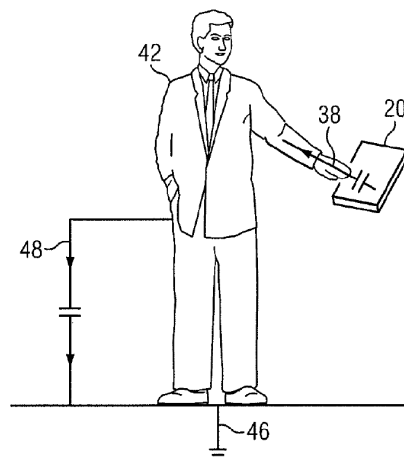


FIG. 4b

Id. at Figs. 4a-b.

54. When the device is floating, the “capacitance changes detected by touch sensor 30 of device 20 due to touch object 38 interacting with device 20 may be smaller in magnitude than in scenarios where device 20 is grounded.” *Id.* at 6:25-28. In particular, “a touch of touchscreen display 22 when device 20 is floating may result in maximum magnitude 54b being less than touch detection threshold 52c.” *Id.* at 7:22-25; *see also, id.* at Fig. 5b. This erroneously results in an undetected touch. To solve this problem, the ’472 Patent proposes “dynamically adjust[ing] touch threshold 52 to account for various grounding scenarios device 20 may encounter in order to correctly detect touches in floating scenarios.” *Id.* at 7:25-28.

55. The ’472 Patent describes several ways of determining the sensor’s grounding status. Including, for example, by communicating with software to determine if the device is physically coupled to a power source or another device via

a cable (*id.* at 7:66-8:15), by correlating the touch location with the locations of where the drive and sense electrodes intersect (*id.* at 8:21-26), or by analyzing the geometry of the shape of one or more capacitance graphs (*id.* at 9:39-55).

56. “[I]f touch sensor 30 determines that device 20 is floating, the stored threshold value is adjusted to a value that is a certain percentage of a maximum capacitance magnitude for known floating touches.” *Id.* at 10:11-14. In other words, the sensor lowers the threshold value if poor grounding conditions are detected to account for touches inducing capacitance changes that are smaller in magnitude than they would otherwise be if the device were grounded. The sensor changes the adjusted threshold value back to its initial value after touches are not detected for a predetermined time. *Id.* at 10:31-36.

D. Claim Construction

57. Claims 1 and 13 of the ’472 Patent include the limitation, “determine a grounding status of the touch sensor based on a strength of a charge return path between the touch sensor [/touch-sensitive device] and a ground.” Claim 7 similarly recites, “determining . . . a grounding status of the touch sensor based on a strength of a charge return path between the touch sensor and a ground.”

58. I have been asked to offer opinions regarding the meaning a person having ordinary skill in the art at the time of the invention would give to these

limitations taking into consideration the patent, its file history, and, secondarily, any applicable extrinsic evidence (e.g., dictionary definitions).

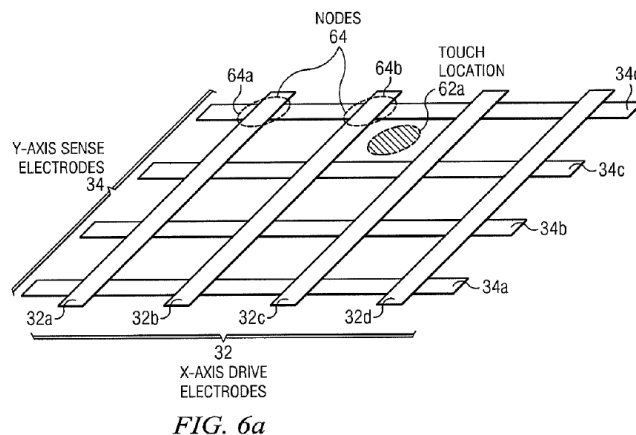
59. I first found it instructive to analyze how this concept is described in context of the '472 Patent specification. Per the '472 Patent specification, “touch sensor 30 determines the strength of the charge return path between touch sensor 30 and ground 46 in order to determine whether device 20 is grounded or floating and consequently whether the stored threshold value should be adjusted.” *'472 Patent* at 7:66-8:3. As I discussed above, the specification describes several ways to accomplish this. For example, the touch sensor may communicate with software on the device to determine whether the device is physically connected to a power source or some other device via a cable:

For example, some embodiments of touch sensor 30 determine whether device 20 is currently connected to another device or system via a cable. In certain embodiments, touch sensor 30 communicates with software running on device 20 (i.e., an operating system of device 20) to determine whether device 20 is currently charging (and is therefore connected via a power cable to a power source) and/or if device 20 is currently connected to another computer system for synchronization (i.e., device 20 is connected to a computer via a cable such as a Universal Serial Bus (USB) cable). In certain embodiments, touch sensor 30 determines that device 20 is grounded if it is determined that device 20 is connected to another device or system via a cable.

Id. at 8:3-15.

60. In another proposed method, “touch sensor 30 determines the strength of the charge return path between touch sensor 30 and ground 46 by determining the

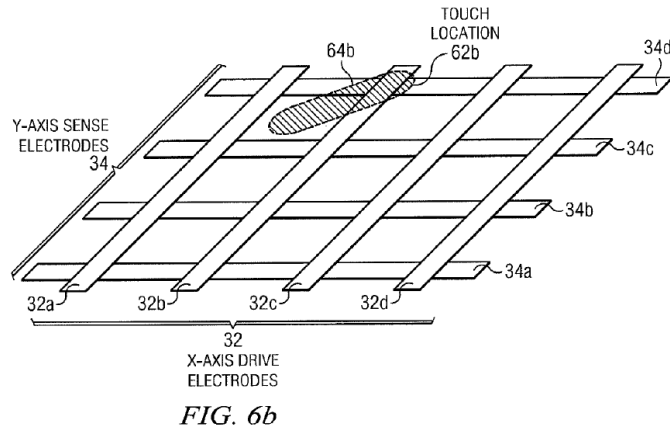
location in which touch object 38 touched touchscreen display 22 and correlating the location with locations in which sense electrodes 34 and drive electrodes 32 intersect.” *Id.* at 8:21-26. When the sensor determines the touch does not cover an intersection of drive and sense electrodes (i.e., a node), as shown in the figure below, then the capacitance measurements are not used to adjust the threshold value. *Id.* at 9:15-20.



Id. at Fig. 6a.

61. When a touch does intersect with a node as depicted in the figure below, then the sensor will use the capacitance measurements to adjust the threshold value.

Id. at 9:20-26.



Id. at Fig. 6b.

62. This is because a touch directly over a node produces a larger change in capacitance than a touch located in between nodes. Thus, in a situation where a touch is deemed to be located on a node, but still produces a lower than expected capacitance value, then the strength of the charge return path is low.

63. Alternatively, the touch sensor may “determine[] the strength of the charge return path between touch sensor 30 and ground 46 by analyzing the geometry of the shape of one or more capacitance graphs.” *Id.* at 9:39-42. As shown in the figures below, “a touch of device 20 when it is grounded (e.g. FIG. 5A) results in a spike in measured capacitance that is larger and more concentrated than a touch of device 20 when it is floating.” *Id.* at 9:48-52.

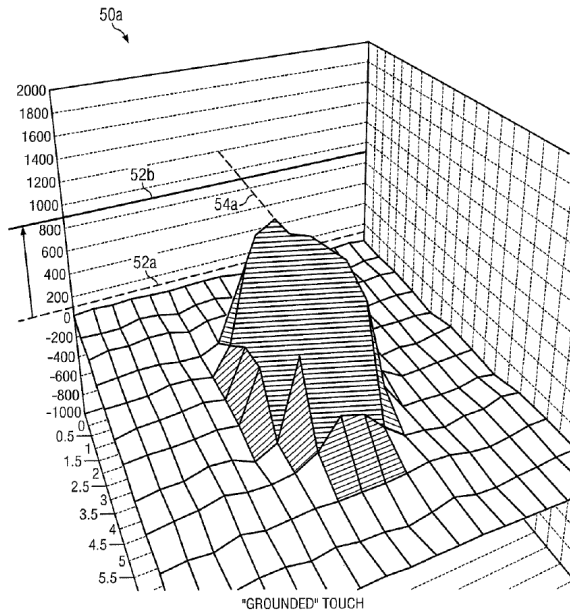


FIG. 5a

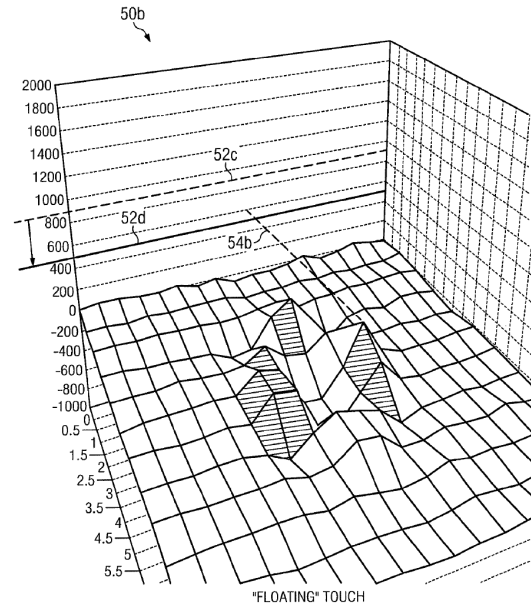


FIG. 5b

Id. at Figs. 5a-b.

64. Thus, a person having ordinary skill in the art would understand the '472 Patent specification contemplates analyzing different types of data in order to determine a grounding status of the touch sensor based on a strength of a charge return path between the touch sensor and a ground.

65. This is also confirmed by the language of the '472 Patent claims. Independent claims 1, 7, and 13 require determining the strength of the return path between the touch sensor and the ground, but do not specify how this should be accomplished. However, the '472 Patent also includes several dependent claims directed to some of the different embodiments of determining the strength of the charge return path described in the specification. Claim 15, for example, depends from Claim 13 and determines the strength of the charge return path using the second

method described the specification – “determining that the external object has touched the touch sensor at a location that at least partially covers a particular one of the nodes.” Claim 19 also depends from Claim 13 and instead uses the third method described in the specification – “analyzing shapes of one or more capacitance graphs.”

66. I have been informed that an independent claim must be broad enough to encompass the subject matter of its dependent claims. Thus, a person having ordinary skill in the art would understand that claims 1, 7, and 13 must be broad enough to capture analyzing different types of data in order to assess the strength of the charge return path between the sensor and ground.

67. This is also consistent with the examiner’s interpretation of this limitation during prosecution of the ’472 Patent. Specifically, the examiner construed “‘strength of a charge return path’ as the results of an analysis of data to determine a grounding status.” ’472 Patent File History at p. 212.

68. Based on the ’472 Patent specification, claims, and file history, it is my opinion that a person having ordinary skill in the art at the time of the ’472 Patent would understand “determine[ing . . .] a grounding status of the touch sensor based on a strength of a charge return path between the touch sensor and a ground” must at least include “analyze [/analyzing] data indicative of the touch sensor’s grounding

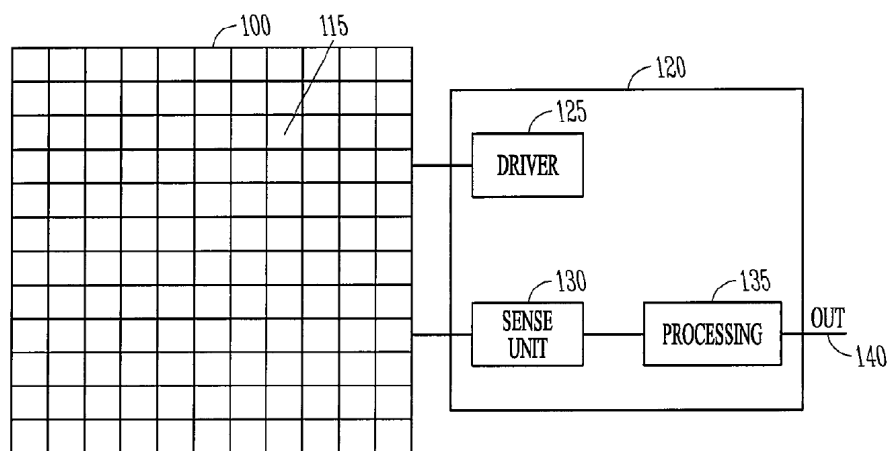
state.” Given the clarity provided by the ’472 Patent and its file history, I did not find it necessary to consult any dictionary definitions or other extrinsic evidence.

E. Obviousness over *Sleeman* and *Westerman* ’787

i. *Overview of the prior art*

a) *Sleeman*

69. *Sleeman* describes a touchscreen “having a plurality of sensor nodes 115 to provide signals . . . about a first touch” and a “controller 120 [] communicatively coupled to the touchscreen sensor nodes 115 to receive the signals and determine whether the received signals are representative of a finger touch or a stylus touch.” *Sleeman* at [0015]. As shown in the figure below, the controller 120 includes a driver 125 and a sense unit 130 coupled to processing circuitry 135:



Id. at Fig. 1.

70. The driver 125 “drives the touchscreen with electrical pulses.” *Id.* at [0016]. “When a finger or stylus or other device is touching the screen, the transfer

of charge responsive to the touch may be received from one or more nodes, such as at a sense unit 130 that may **measure the transferred charge at each node** to determine whether or not a touch has occurred **at each node.**” *Id.* (emphasis added); *see also, id.* at [0023] (“In one embodiment, the **nodes are pulsed with electrical signals in order to access the capacitance of each node,** and the signature is comprised of change of capacitance for each node.”) (emphasis added). As I explained above, only mutual-capacitance sensors include drivers with electrical pulses (i.e., drive electrodes). *See*, ¶¶47-48 above.

71. Additionally, self-capacitive sensors are only capable of measuring the capacitance of each sense electrode – not each intersection of X-Y electrodes (i.e., nodes). *See*, ¶¶45-46, ¶¶50-51 above. Since *Sleeman* expressly discloses measuring the capacitance of each node instead of each sense electrode or sense line, this further confirms *Sleeman* is describing a mutual-capacitance touchscreen.

72. For each node, the sense unit 130 may, for example, “measure a change in capacitance caused by a touch, and convert the measured change into a digital signal” which is then passed to processing circuitry 135. *Id.* at [0016]-[0017]. The processing circuitry analyzes the digital signals to determine a “signature . . . comprised of change of capacitance for each node.” *Id.* at [0023]. The touch signature is analyzed in order to determine whether the received signals are

representative of a finger touch or a stylus touch, and to enter a detection mode as a function of the type of touch determined.” *Id.* at [0015].

73. As explained by *Sleeman*, different objects produce different touch signatures having different shapes and capacitance signal intensities. *Id.* at [0019] (“FIGS. 2, 3 and 4 are block diagram representations of nodes on a touchscreen and the signals corresponding to touch signatures generated at each node responsive to different types of touches.”). The signature’s shape “includes both the center peak and the halo of a set of signals from nodes of the touchscreen.” *Id.* at [0029]. For example, a touch from a small finger generates “a strong signal . . . at such nodes as indicated at 210, forming a strong center peak signal,” which is surrounded by “a halo region 215, which generally have a weaker signal, as the finger starts to lose contact with nodes in the halo region due to the domed nature of fingers.” *Id.* at [0019]

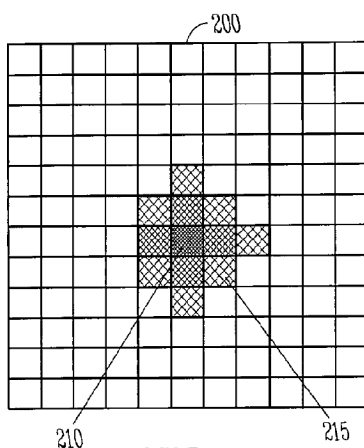


FIG. 2

Id. at Fig. 2.

74. Similarly, a touch from a stylus “generates a signature that corresponds to a sharply defined” including a center peak 410, which “is small, such as one node, or perhaps two adjacent nodes with one-half signal intensity.” *Id.* at [0021].

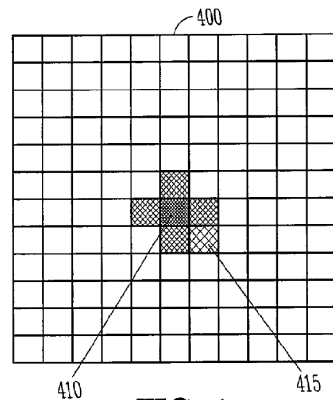


FIG. 4

Id. at Fig. 4.

75. In contrast, a touch from a large finger produces “a center peak 310 that may include more nodes as illustrated” and a larger halo region 315. *Id.* at [0020].

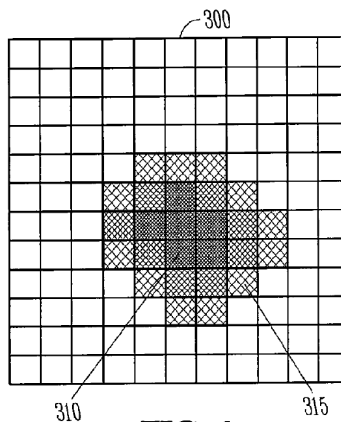


FIG. 3

Id. at Fig. 3.

76. Thus, *Sleeman*'s signature shape analysis takes both the size (i.e., the number of nodes affected by the touch) as well as the signal intensity (i.e., strong signals versus weak signals). *Id.* at [0025] ("If the received signals have a strong center peak surrounded by a halo region, the shape is representative of a finger touch. A small finger touch corresponds to received signals having a slightly smaller center peak and halo region than a large finger touch. In one embodiment, received signals having a shape with a slightly weaker center peak as compared to a finger touch, and small halo are representative of a stylus touch.").

77. "Once the shape of the signature is determined, controller 120 may either enter a detect mode of operation if the touching object is a finger, or based on the type of signature, modify an internal detection threshold for entering the detect mode." *Id.* at [0022]. Specifically, *Sleeman* proposes lowering the detection threshold when signatures having smaller and less intense peak signals are detected. *Id.* ("If a stylus shape is detected, the internal detection threshold may be lowered. If a very small finger, such as a child's finger is detected, the internal detection threshold may also be lowered."). The detection threshold is set based on "the strongest signals present across all nodes measured." *Id.* at [0023]. This enables the controller to better detect touches from objects that generate smaller and weaker capacitance signals.

78. *Sleeman* also discusses accommodating multi-touch situations by localizing sets of nodes corresponding to individual touches and defining unique thresholds for each localized set of nodes. *Id.* at [0026].

79. As I mentioned above, I understand that for a prior art reference to be proper for use in an obviousness analysis, the reference must be “analogous art” to the claimed invention. I have been informed that a reference is analogous art to the claimed invention if: (1) the reference is from the same field of endeavor as the claimed invention (even if it addresses a different problem); or (2) the reference is reasonably pertinent to the problem faced by the inventor (even if it is not in the same field of endeavor as the claimed invention).

80. In my opinion, *Sleeman* is both in the same field of endeavor and reasonably pertinent to the problem faced by the inventor of the '472 Patent. The '472 Patent “generally relates to touch sensors” where “a touch sensor encompasses a touch screen.” '472 *Patent* at 1:6, 1:26-28. Likewise, the Challenged Claims are directed generally toward touch sensors or touch-sensitive devices. *Id.* at 12:28 (claim 1 reciting “a touch sensor”), 13:38 (claim 7 reciting a method relating to touch sensor operation), 14:44 (claim 13 reciting a “touch-sensitive device”). *Sleeman* is similarly directed to “a touchscreen 110 having a plurality of sensor nodes 115.” *Sleeman* at [0015]. For this reason, *Sleeman* is in the same field of endeavor as the claimed invention of the '472 Patent.

81. I also consider *Sleeman* to be reasonably pertinent to the problem faced by the inventors of the '472 Patent. This is because both the '472 Patent and *Sleeman* are directed to adjusting detection thresholds in order to ensure the touch sensor is sensitive enough to identify real touches in spite of factors that lower the amount of capacitance signal received by the controller.

b) Westerman '787

82. *Westerman '787* describes a mutual capacitance touch sensor including “an array of sensors 103 that can be formed from a plurality of drive lines 100 and a plurality of sense lines 104.” *Westerman '787* at [0028]. The drive lines 100 are “driven by stimulation signals from drive circuits 102,” which form “a mutual capacitance 105 . . . between drive lines 100 and sense lines 104 (e.g. columns) at their crossing point” and “charge from the drive lines can be coupled onto the sense lines, where charge amplifiers 106 detect the charge and generate touch output values indicative of the amount of touch detected at a particular pixel.” *Id.*

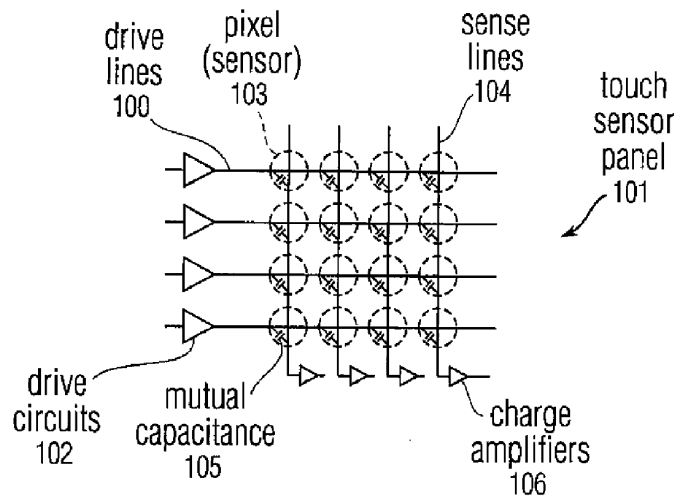


Fig. 1a

Id. at Fig. 1a.

83. The disclosure of *Westerman* '787 focuses on negating the effects of poor grounding on the performance of the mutual capacitance sensor. When a finger or other object touching the sensor is grounded, the amount of charge coupled onto the sense line is reduced because some of the charge is shunted to ground through the grounded finger. *Id.* at [0030] (“Grounded plate 214 can block some of the electric field lines 210 flowing from the left plate to the right plate. Because blocked electric field lines 210 can be shunted to ground through the grounded finger, virtually no charge is coupled through to the sense column (see 216) for the blocked electric field lines 210.”). This is shown in the figure below where the user’s finger (represented by a grounded plate 214) blocks some of the charge C_{sig} from being coupled onto the sense line, which causes a decrease in the amount of charge detected by the charge amplifier 206:

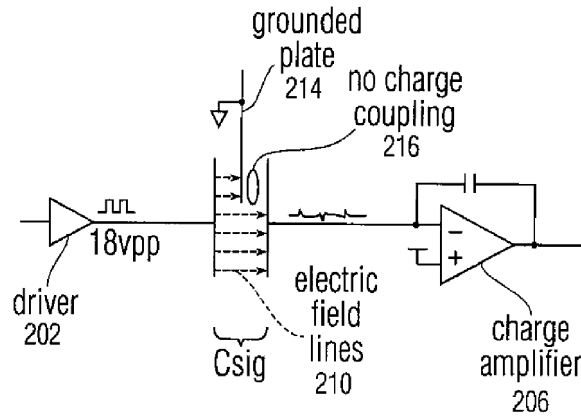


Fig. 2a

Id. at Fig. 2a.

84. When a finger is poorly grounded, the finger (depicted as plate 214 in the figure below) “forms a capacitance $C1$ with respect to the sense line and blocks some of the field lines 210, but instead of shunting the charge to ground, a capacitance $C2$ to the sense line is also formed.” *Id.* at [0031]. This means “[t]he [ungrounded] finger attenuates the amount of charge coupled onto the sense line, but some charge is still coupled through.” *Id.*

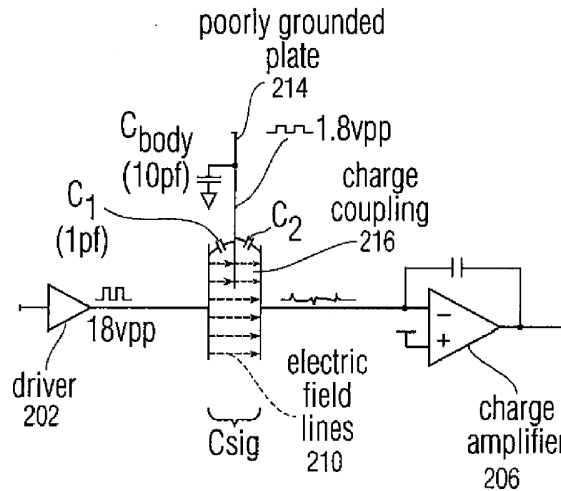
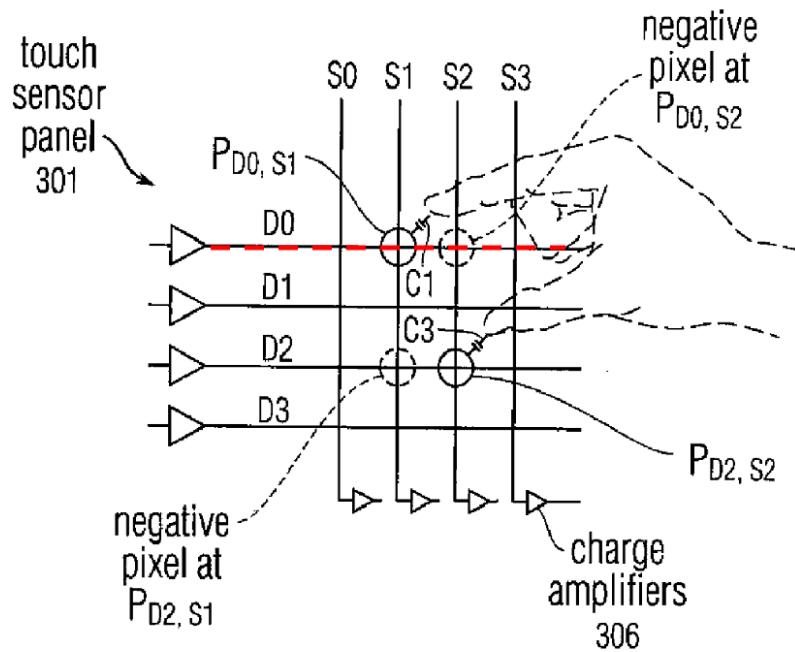


Fig. 2b

Id. at Fig. 2b.

85. Thus, poor grounding reduces the effect of the touch causing a less of a change in the capacitance measured by charge amplifier 206. *Id.* at [0031] (“The result of this charge coupling through the finger and onto the sense line is that the effect of a finger touch is reduced.”).

86. The issues created by poor grounding conditions are further exacerbated during multi-touch events. As shown in the example below, the drive line D0 is being stimulated (denoted in red below) and “charge from P_{D0,S1} is coupled onto the finger touching down over P_{D0,S1}, but rather than being shunted to ground an attenuated waveform appears on the finger” and this “attenuated signal (and therefore some charge) is coupled back onto sense line S1, and is also coupled through the user’s other finger onto sense line S2.” *Id.* at [0034].



Id. at Fig. 3a (annotated).

87. This causes an “increase the charge coupling onto S2 as compared to the case when the user is grounded” and “the effect of charge coupling back onto S1 and S2 will reduce the apparent touch detected at touch locations $P_{D0,S1}$ and $P_{D2,S2}$, based on the measured touch output values at those locations. In addition, this effect will increase the charge coupling and reduce the output indicative of a touch for pixels outside the touch locations, such as pixel $P_{D0,S2}$. *Id.* at [0034]-[0035]. “This amount of charge coupling, when detected by charge amplifier 306, gives the appearance of a so-called ‘negative pixel’ or a negative amount of touch at $P_{D0,S2}$. Pixel $P_{D2,S1}$ can also experience the same negative pixel effect.” *Id.* at [0035].

88. Thus, poor grounding conditions “can weaken not only the pixels being touched, but can also weaken adjacent pixels not being touched and located in the drive line being stimulated, to the point where they produce output readings indicative of a negative touch” and “this problem is made worse if there are multiple pixels being touched along the drive line being stimulated, because now even more charge can be coupled onto other sense lines being simultaneously touched.” *Id.* at [0037]; *see also, id.* at Fig. 3b.

89. *Westerman* '787 proposes correcting this problem using a compensation algorithm performed after determining the grounding status by calculating a ratio of pixels with positive touch output values to pixels having negative touch output values. *Id.* at [0053] (“Note that this compensation can be applied, or at least evaluated, for all pixels in the touch sensor panel, whether or not the palm, finger or other object is grounded or not. The gain factor α can be set to be small (e.g. 0.1) to limit excessive results if the palm is in fact grounded. One way to determine if the palms are grounded is to compute the ratio of pixels with positive touch output values to pixels having negative touch output values.”). The smaller the ratio of positive to negative pixels, the more negative pixels exist, which is indicative of an ungrounded touch. *Id.* (“The smaller the value, the more negative pixels exist, which is likely to mean an ungrounded palm.”).

90. In my opinion, *Westerman* '787 is both in the same field of endeavor and reasonably pertinent to the problem faced by the inventor of the '472 Patent. The '472 Patent “generally relates to touch sensors” where “a touch sensor encompasses a touch screen.” *'472 Patent* at 1:6, 1:26-28. Likewise, the Challenged Claims are directed generally toward touch sensors or touch-sensitive devices. *Id.* at 12:28 (claim 1 reciting “a touch sensor”), 13:38 (claim 7 reciting a method relating to touch sensor operation), 14:44 (claim 13 reciting a “touch-sensitive device”). *Westerman* '787 is similarly directed to “multi-touch sensor panels that utilize an array of capacitive sensors (pixels) to detect and localize touch events.” *Westerman* '787 at [0001]. For this reason, *Westerman* '787 is in the same field of endeavor as the claimed invention of the '472 Patent.

91. I also consider *Westerman* '787 to be reasonably pertinent to the problem faced by the inventors of the '472 Patent. This is because both the '472 Patent and *Westerman* '787 are directed to solving problems related to ensuring the touch sensor is sensitive enough to identify real touches in spite of poor grounding conditions.

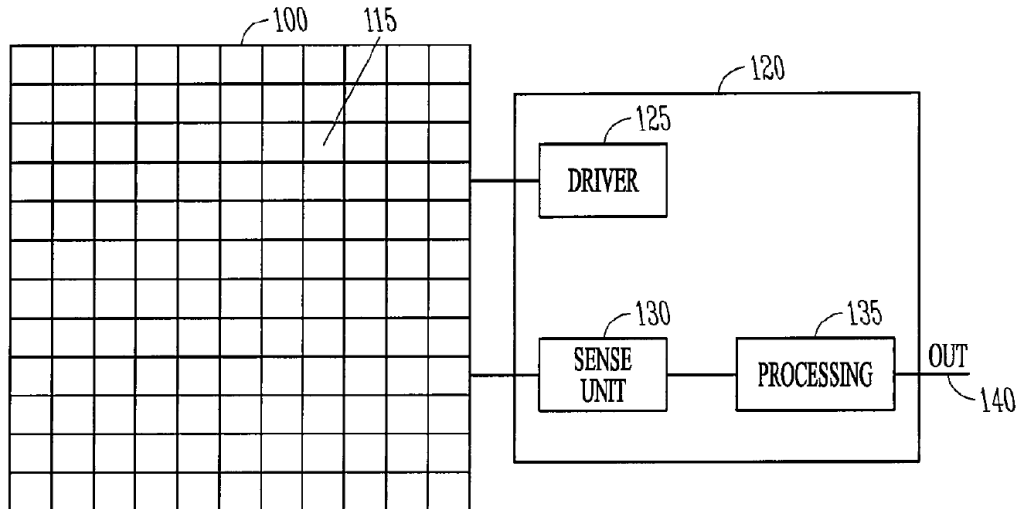
ii. Opinions regarding Claims 1, 7, and 13

a) a plurality of sense electrodes

92. Claims 1, 7, and 13 all require “a plurality of sense electrodes.” *Sleeman* does not use the word “electrode” in his disclosure, but a person having ordinary

skill in the art would understand *Sleeman* nevertheless expressly discloses a touchscreen including a plurality of sense electrodes. For the reasons explained above, a person having ordinary skill in the art would understand that *Sleeman* is describing a mutual capacitance touchscreen. See, ¶¶69-71 above. As I explained in the Background of the Technology, mutual capacitance touch sensors always include one layer of drive electrodes and one layer of sense electrodes. See, ¶¶47-49 above.

93. Based on this, a person having ordinary skill in the art would understand *Sleeman*'s plurality of sense electrodes are coupled to sense unit 130 and are depicted as either the horizontal or vertical lines in Figure 1:



Id. at Fig. 1.

94. Alternatively, a person having ordinary skill in the art would also recognize that *Sleeman*'s touch sensor necessarily includes a plurality of sense

electrodes that enable sense unit 130 to measure the transferred charge at each node. A person having ordinary skill in the art would understand that when *Sleeman's* drive electrodes are pulsed by driver 125, they capacitively couple with the sense electrodes coupled to sense unit 130 forming mutual capacitance at the intersecting points (i.e., nodes 115). *See*, ¶48 above. The sense unit 130 must be coupled to these sense electrodes in order to take the capacitance measurements. For this reason, a person having ordinary skill in the art would understand *Sleeman* inherently discloses a plurality of sense electrodes.

b) access a stored threshold value

95. Claims 1, 7, and 13 all require a controller to “access a stored threshold value.” *Sleeman's* controller 120 “is communicatively coupled to the touchscreen sensor nodes 115 to receive the signals and determine whether the received signals are representative of a finger touch or a stylus touch, and to enter a detection mode as a function of the type of touch determined.” *Sleeman* at [0015], Fig. 1. “Once the shape of the signature is determined, controller 120 may either enter a detect mode of operation if the touching object is a finger, or based on the type of signature, modify an **internal detection threshold** for entering the detect mode. . . . If a stylus shape is detected, **the internal detection threshold** may be lowered. If a very small finger, such as a child's finger is detected, **the internal detection threshold** may also be lowered.” *Id.* at [0022] (emphasis added); *see also, id.* at [0025] (“In one

embodiment, an internal detection threshold is set to be more sensitive when a stylus touch signature shape is encountered such that the touchscreen enters a detect mode wherein a lowered detection threshold is used to detect further touches consistent with the first touch.”).

96. A person having ordinary skill in the art would understand that the internal detection threshold must necessarily be stored and accessed by the controller in order for the controller to modify it. Indeed, if the “internal detection threshold” were not stored and accessed by the controller, then there would be nothing to modify. Therefore, a person having ordinary skill in the art would understand that *Sleeman*’s disclosure of the controller modifying an “internal detection threshold” is also an implicit disclosure of the controller accessing a stored threshold.

c) determine a grounding status of the touch sensor based on a strength of a charge return path between the touch sensor and a ground

97. As I discussed above, *Sleeman* describes a mutual capacitance sensor that adjusts a touch detection threshold to accommodate touches from different types of external objects including small fingers and styluses. *See*, ¶¶72-78 above. Specifically, *Sleeman*’s controller analyzes the size and intensity/strength of a detected touch signature (or multiple touch signatures in a multi-touch embodiment) to determine if a threshold adjustment is necessary. *Id.*

98. *Westerman* '787 also describes a mutual capacitance sensor and further recognizes that poor grounding conditions result in less of a change in capacitance than would otherwise be measured if there were a strong path to ground. *See*, ¶¶82-88 above. Specifically, *Westerman* '787 teaches poor grounding conditions “can weaken not only the pixels being touched, but can also weaken adjacent pixels not being touched and located in the drive line being stimulated, to the point where they produce output readings indicative of a negative touch” and “this problem is made worse if there are multiple pixels being touched along the drive line being stimulated, because now even more charge can be coupled onto other sense lines being simultaneously touched.” *Westerman* '787 at [0037].

99. To solve this problem, *Westerman* '787 first determines the sensor's grounding status by calculating a ratio of pixels/nodes with positive touch output values to pixels/nodes having negative touch output values where smaller ratio values are indicative of poor grounding conditions and then applies compensation based on the calculated ratio value. *Id.* at [0053]. For the reasons discussed above, “determine[ing . . .] a grounding status of the touch sensor based on a strength of a charge return path between the touch sensor and a ground” must at least include “analyze [/analyzing] data indicative of the touch sensor's grounding state.” *See*, ¶68 above.

100. As discussed above, the '472 Patent describes analyzing different types of data to determine the grounding status of the touch sensor including analyzing the capacitance changes resulting from a touch. *See*, ¶¶60-63 above. Since *Westerman* '787 similarly analyzes the capacitance change resulting from a touch to determine the touch sensor's grounding status, its positive to negative pixel ratio is data indicative of the sensor's grounding state thereby satisfying this claim limitation. Thus, although *Westerman* '787 makes reference to the grounding status of the user's finger, it is in fact describing "the grounding status of the touch sensor" as that phrase is used in the '472 Patent.

101. A person having ordinary skill in the art at the time of the '472 Patent would understand that *Sleeman*'s mutual capacitance sensor would have suffered from the same grounding problems identified by *Westerman* '787. Both *Sleeman* and *Westerman* '787 describe mutual capacitance sensors that measure a change of capacitance signal for each node/pixel. Based on the teachings of *Westerman* '787, a person of ordinary skill would understand that the change in capacitance readings measured by *Sleeman*'s touchscreen would have similarly been weaker/less intense under poor grounding conditions resulting in distorted capacitance measurements and touch signatures. In an ungrounded touch scenario involving two fingers, for example, the negative pixel effect described in *Westerman* '787 would cause their respective changes in capacitance to be lower than expected due to distortions caused

by poor grounding. In such a scenario, a person having ordinary skill in the art would understand that these distortions would make identification of the touch signatures less reliable resulting in legitimate touches going undetected by the controller.

102. *Sleeman* teaches adjusting the touch detection threshold to account for less intense change in capacitance signals caused by touches from different types of external objects including small fingers and styluses. *See*, ¶77 above. And, based on the teachings of *Westerman* '787, a person having ordinary skill would have been motivated to determine the grounding status of *Sleeman*'s touch sensor in the manner suggested by *Westerman* '787 so that it could determine when poor grounding conditions are present and lower the detection threshold accordingly.

103. A person having ordinary skill in art would have appreciated that this change would have only required minor changes to the controller's firmware and would have predictably resulted in *Sleeman*'s touch sensor recognizing poor grounding conditions so that it could lower the detection threshold to more reliably detect legitimate, albeit poorly grounded, touches.

104. Moreover, *Westerman* '787's grounding status ratio is a simple calculation that would not have significantly contributed to the computational load of the controller. The determination of *Westerman* '787's grounding status ratio would have further enhanced *Sleeman*'s ability to reduce the touch detection threshold in situations resulting in weaker capacitance signals. Therefore, there

would have been a reasonable expectation of success when modifying *Sleeman*'s controller to determine the sensor's grounding status as taught by *Westerman* '787.

d) adjust the stored threshold value based on the determined grounding status of the touch sensor

105. As I discussed above, *Sleeman* teaches analyzing the size and intensity of touch signatures. *See*, ¶¶73-77 above. "Once the shape of the signature is determined, controller 120 may either enter a detect mode of operation if the touching object is a finger, or based on the type of signature, modify an internal detection threshold for entering the detect mode." *Sleeman* at [0022]. Specifically, *Sleeman* proposes lowering the detection threshold when signatures having smaller and less intense peak signals are detected. *Id.* ("If a stylus shape is detected, the internal detection threshold may be lowered. If a very small finger, such as a child's finger is detected, the internal detection threshold may also be lowered."). Thus, *Sleeman* teaches lowering the internal detection threshold in order to increase the sensor's sensitivity to account for weaker signals being received by the controller.

106. As discussed above, *Westerman* '787 teaches poor grounding conditions similarly result in weaker capacitance signals, and for all of the reasons discussed above, it would have been obvious to a person having ordinary skill in the art at the time of the '472 Patent to enable *Sleeman*'s controller to also adjust (i.e., reduce) the threshold based on the determined grounding status ratio taught by *Westerman* '787. *See*, ¶¶101-104 above. Like *Sleeman*'s teaching that a threshold is lowered to

account for weaker signals due to a stylus or small finger, a person having ordinary skill in the art would have understood that similarly lowering the threshold in response to determining a poor grounding status would have predictably enabled *Sleeman*'s sensor to more reliably detect touches of poorly grounded external objects.

e) after adjusting the stored threshold value based on the determined grounding status of the touch sensor: determine that the external object has not touched the touch sensor within a predetermined amount of time; and change the stored threshold value back to an original value, the original value comprising a value of the stored threshold value before it was adjusted based on the determined grounding status of the touch sensor

107. *Sleeman* teaches analyzing a touch signature and entering a detect mode “as a function of the type of touch determined.” *Sleeman* at [0024], Fig. 5 (step 530). For example, the “internal detection threshold is set to be more sensitive when a stylus touch signature shape is encountered such that the touchscreen enters a detect mode wherein a lowered detection threshold is used to detect further touches consistent with the first touch.” *Id.* at [0025]. *Sleeman* teaches using the lowered threshold “for a predetermined amount of time following the first touch.” *Id.* at [0025].

108. *Sleeman* also discusses a prior touch sensor that entered a detect state with a reduced threshold, maintained the reduced threshold as long as touches were

detected, and restored the threshold to its original value after exiting the detect state to due to removal of touch:

In one prior device, the threshold is a function of the measured capacitance at each node which changes in response to a touch by a finger or stylus. The capacitive measurement is compared to the threshold, and if exceeding the threshold, a detect state is entered. The detect state is maintained as long as the measured capacitive changes on the nodes exceed the threshold. Commonly, the threshold is slightly reduced on entering the detect state to ensure that the detection state is maintained even if the capacitive change drops slightly due to measurement uncertainty or noise for example. The original threshold is restored once the detect state is exited due to removal of the touch.

Id. at [0003].

109. A person having ordinary skill would understand that exiting a detect state due to removal of touch necessarily involves determining that the external object has not touched the touch sensor within a predetermined amount of time. A person having ordinary skill in the art would have known that mutual capacitance sensors were scanned at predetermined frequencies ranging from ~20-200 Hz. *See e.g., Barrett* at p. 18 (“Scanning rates in current pro-cap controllers range from approximately 20 to 200 Hz . . .”). Assuming the touch sensor has a scan frequency of 100 Hz, for example, the sensor would be scanned 100 times per second with each scan lasting 10 milliseconds. One scan resulting in no capacitance measurements above the detected threshold would mean that the external object has not touched the sensor for at least 10 milliseconds. Thus, a determination that no capacitance

readings exceeded the adjusted threshold for one scan of the touch sensor means the external object has not touched the touch sensor within the predetermined amount of time it takes to complete one scan of the touchscreen.

110. For this reason, a person having ordinary skill in the art would understand that *Sleeman's* description of the prior device inherently teaches determining that the external object has not touched the touch sensor within a predetermined amount of time and changing the stored threshold value back to an original value.

111. For the reasons discussed above, it would have been obvious to a person having ordinary skill in the art at the time of the '472 Patent to enable *Sleeman's* controller to also adjust the threshold based on the determined grounding status. *See*, ¶¶101-104 above. Based on the teachings of *Sleeman*, it would have also been obvious to a person having ordinary skill to change the threshold back to its original value once the detect state is exited to due removal of touch per *Sleeman's* prior art embodiment. This is because a person having ordinary skill would understand that using the modified threshold for a predetermined amount of time following **the first touch** may result in the threshold being changed back to its original value while the external object is still touching the sensor. Such a reduction in sensor sensitivity while the external object is still interacting with the sensor would, under some circumstances, result in inadvertent non-detections of valid touches.

112. A person having ordinary skill would understand that adjusting the threshold after touch has been removed as taught by *Sleeman*'s prior art device would be a predicable way to avoid this problem and increase the sensor's performance. For this reason, a person of ordinary skill would have been motivated to modify *Sleeman*'s controller to restore the threshold back to its original value after removal of touch – i.e., after determining the external object has not touched the touch sensor within the predetermined amount of time it takes to complete at least one scan of the touchscreen.

113. A person having ordinary skill in the art would have understood this modification would only require a simple modification to the controller's firmware. Given this and the fact that *Sleeman* himself acknowledges this arrangement was well known in the art, there would have been a reasonable expectation of success when modifying *Sleeman*'s controller to change the threshold back to its original value after determining the external object has not touched the touchscreen for the predetermined amount of time it takes for the controller to complete at least one scan of the touchscreen.

iii. Opinions regarding Claim 22

- a) if the amount of capacitance is greater than the adjusted threshold value, the interaction with the touch sensor by the external object is processed as a touch by the external object; and if the amount of capacitance is less than the adjusted threshold value, the interaction with the touch sensor by the external object is not processed as a touch by the external*

object

114. As I discussed above, *Sleeman*'s controller enters a detect mode where "the controller interprets additional touches with a reduced threshold, as such touches are more likely to not correspond to noise, and be actual touches." *Sleeman* at [0022]; *see also id.* at [0026] ("The controller determines whether the received signals from the second touch are representative of a finger touch or a stylus touch, and enters a detect mode as a function of the type of the second touch determined such that multiple detect modes having lower detection thresholds are localized about the array of touch screen sensors.").

115. Based on *Sleeman*'s comparison of capacitance measurements to a threshold value to discern touches from non-touches, a person having ordinary skill in the art would understand that *Sleeman* processes interactions with an external object as a touch when the changed capacitance exceeds the threshold and concludes there has been no touch when the changed capacitance does not exceed the threshold. *Sleeman* at [0002] (explaining "thresholds may be used to determine whether the touchscreen is being initially touched"), [0003] (teaching "the threshold is a function of the measured capacitance at each node which changes in response to a touch by a finger or stylus" such that "[t]he capacitive measurement is compared to the threshold, and if exceeding the threshold, a detect state is entered").

F. Obviousness over *Sleeman* and *Hotelling*

i. Overview of Hotelling

116. *Hotelling* describes a touch sensitive device that can “detect its grounded state so that poor grounding can be selectively compensated for in touch signals outputted by the device.” *Hotelling* at Abstract. Per *Hotelling*, “The ability to detect how well grounded a touch sensitive device is can advantageously provide more accurate and faster touch sensing by not having to repeat measurements subject to poor device grounding.” *Id.* at [0019]. *Hotelling* also notes that the ability to determine the device’s grounding status enables power savings and allows the device to “more robustly adapt to various grounding conditions.” *Id.*

117. To accomplish this, the touch sensitive device “monitor[es] various touch sensitive device parameters indicative of the device’s grounding and determining the grounding based on the monitored parameters’ values.” *Id.* at [0023]. For example, the device may monitor charge and/or connection ports to determine if it is physically connected to another device or power source via a cable or other physical connection. *Id.* at [0024]-[0030]. In a mutual capacitive touch sensor embodiment, the device analyses touch signals “to determine the characteristics of the touch, including the location, orientation, shape, movement, and so on, of the touch image generated by the touch.” *Id.* at [0048]. Per *Hotelling*, the sensed touch image can be used to determine the device’s grounding status. *Id.* at [0050] (“Accordingly, sensing a touch image having this thumb configuration can

be an indication that the touch sensitive device is being held and therefore grounded.”).

118. In my opinion, *Hotelling* is in the same field of endeavor as the claimed invention of the ’472 Patent. The ’472 Patent “generally relates to touch sensors” where “a touch sensor encompasses a touch screen.” ’472 *Patent* at 1:6, 1:26-28. Likewise, the Challenged Claims are directed generally toward touch sensors or touch-sensitive devices. *Id.* at 12:28 (claim 1 reciting “a touch sensor”), 13:38 (claim 7 reciting a method relating to touch sensor operation), 14:44 (claim 13 reciting a “touch-sensitive device”). *Hotelling* is similarly directed to “to touch sensitive devices.” *Hotelling* at [0001]. For this reason, *Hotelling* is in the same field of endeavor as the claimed invention of the ’472 Patent.

119. *Hotelling* is also reasonably pertinent to the problem faced by the inventors of the ’472 Patent. This is because both the ’472 Patent and *Hotelling* are directed to solving problems related to ensuring the touch sensor is sensitive enough to identify real touches in spite of poor grounding conditions.

ii. ***Opinions regarding Claims 1, 7, and 13***

- a) *determine a grounding status of the touch sensor based on a strength of a charge return path between the touch sensor and a ground*

120. As I discussed above, *Sleeman* does not account for the fact that poor grounding conditions can distort capacitance measurements and touch signatures.

See, ¶¶97-101 above. However, *Hotelling* teaches “when a poorly grounded touch sensitive device receives a touch by an object, such as a user’s fingers, undesirable charge coupling called negative capacitance C_{neg} can be introduced into the device to cause the pixel touch output value to be in the opposite direction of the intended mutual capacitance change.” *Hotelling* at [0023]. As a result, “a pixel experiencing touch under poor grounding conditions can appear to **detect less of a touch** than is actually present.” *Id.* (emphasis added). To solve this problem, *Hotelling* “monitor[s] various touch sensitive device parameters indicative of the device’s grounding and determining the grounding based on the monitored parameters’ values.” *Id.*

121. Like the ’472 Patent, *Hotelling* teaches determining the touch sensor’s grounding state by detecting whether or not the device is physically connected to a power source or another device via a cable or dock. *Id.* at [0024]-[0030], Fig. 1. For example, “sensed power can indicate that the device 10 is plugged into a wall outlet, for example, thereby grounding the device through the wall ground. Therefore, sensing power via the connector port 10 a can indicate that the touch sensitive device 10 is grounded.” *Id.* at [0024].

122. *Hotelling* teaches several advantages to determining the grounding status of a touch sensor including improved accuracy, faster touch sensing, and power savings:

The ability to detect how well grounded a touch sensitive device is can advantageously provide more accurate and faster touch sensing by not having to repeat measurements subject to poor device grounding. Power savings can also be realized by not having to repeat measurements. Additionally, the device can more robustly adapt to various grounding conditions.

Id. at [0019].

123. A person having ordinary skill in the art would have understood that *Sleeman's* touch sensor would have suffered from the same distortions caused by poor grounding conditions, which would have hindered the controller's ability to analyze the touch signatures and determine the types of external objects in contact with the touch sensor. *Hotelling* teaches a similar "mutual capacitance sensor, in which a pair of conductive electrodes can be disposed in close proximity to each other . . . and in which one of the electrodes can be charged (e.g., stimulated with an AC voltage) to form fringing electric fields and a mutual capacitance therebetween." *Hotelling* at [0039].

124. Because poor grounding conditions would have made the sensed capacitance signals to appear lower than they should, *Sleeman's* system would not have properly accounted for this distortion using its disclosed technique that considers only the size and intensity of a touch signature to determine a proper detection threshold. For example, a touch scenario involving a large finger would normally be assigned a higher detection threshold, but the changes in capacitance encountered would be lower than expected due to distortions caused by poor

grounding. In such a scenario, legitimate touches may not exceed the detection threshold and may go undetected.

125. For this reason, a person having ordinary skill in the art would have been motivated to enable *Sleeman*'s controller to determine the sensor's grounding status as taught by Hotelling. This modification would have predictably enabled *Sleeman*'s controller to recognize the occurrence of a touch event despite poor grounding conditions, and, as explained in more detail below, properly adjust the detection threshold in order to more reliably detect legitimate touches. Moreover, a person having ordinary skill in the art would have been motivated to configure *Sleeman*'s controller to determine the grounding status as to achieve the same benefits taught by Hotelling including improved accuracy, faster touch sensing, and power savings.

126. A person of ordinary skill would have understood this change would have required minor changes to the touch sensitive device's hardware and the controller's firmware and would have predictably resulted in *Sleeman*'s touch sensor recognizing poor grounding conditions so that it could lower the detection threshold to more reliably detect valid touches. Therefore, a person having ordinary skill in the art would have understood there would have been a reasonable expectation of success when configuring *Sleeman*'s controller to determine the sensor's grounding status as taught by *Hotelling*.

b) adjust the stored threshold value based on the determined grounding status of the touch sensor

127. As I discussed above, *Sleeman* teaches analyzing the size and intensity of touch signatures. See, ¶¶73-77 above. “Once the shape of the signature is determined, controller 120 may either enter a detect mode of operation if the touching object is a finger, or based on the type of signature, modify an internal detection threshold for entering the detect mode.” *Sleeman* at [0022]. Specifically, *Sleeman* proposes lowering the detection threshold when signatures having smaller and less intense peak signals are detected. *Id.* (“If a stylus shape is detected, the internal detection threshold may be lowered. If a very small finger, such as a child’s finger is detected, the internal detection threshold may also be lowered.”). Thus, *Sleeman* teaches lowering the internal detection threshold in order to increase the sensor’s sensitivity to account for weaker signals being received by the controller.

128. As discussed above, *Hotelling* teaches poor grounding conditions similarly result in weaker capacitance signals, and for all of the reasons discussed above, it would have been obvious to a person having ordinary skill in the art at the time of the ’472 Patent to enable *Sleeman*’s controller to also adjust (i.e., reduce) the threshold based on the determined grounding status ratio taught by *Hotelling*. See, ¶¶123-126 above. A person having ordinary skill in the art would have understood that similarly lowering the threshold in response to determining a poor grounding status would have predictably enabled *Sleeman*’s sensor to more reliably detect touches of poorly grounded external objects.

G. Obviousness over *Sleeman, Westerman '787* or *Hotelling*, and *Griffin*

i. *Overview of Griffin*

129. *Griffin* describes a portable electronic device, such as a mobile phone, having a touch-sensitive display that “may be any suitable touch-sensitive display, such as a capacitive, resistive, infrared, surface acoustic wave (SAW) touch-sensitive display, strain gauge, optical imaging, dispersive signal technology, acoustic pulse recognition, and so forth, as known in the art.” *Griffin* at [0022], Fig. 6. *Griffin* teaches “identifying a value of at least one parameter of a portable electronic device” and modifying a touch threshold “based on the value of the at least one parameter, yielding a modified touch threshold.” *Id.* at Abstract.

130. “The parameters may include, for example, touch parameters, function parameters, ambient parameters, and user parameters.” *Id.* at [0040]. “Parameters or characteristics of the touch as well as other variables may be utilized to modify a touch threshold, and tables or simple equations or formulas may be applied in the modification process.” *Id.* at [0041]. Modified thresholds may only be utilized for predefined periods of time. For example, a modified threshold may only be utilized until touches “are not detected for a period of time.” *Id.* at [0043].

131. In my opinion, *Griffin* is in the same field of endeavor as the claimed invention of the '472 Patent. The '472 Patent “generally relates to touch sensors” where “a touch sensor encompasses a touch screen.” '472 Patent at 1:6, 1:26-28.

Likewise, the Challenged Claims are directed generally toward touch sensors or touch-sensitive devices. *Id.* at 12:28 (claim 1 reciting “a touch sensor”), 13:38 (claim 7 reciting a method relating to touch sensor operation), 14:44 (claim 13 reciting a “touch-sensitive device”). *Griffin* is similarly directed to “portable electronic devices having touch-sensitive devices and their control.” *Id.* at [0001]. The touch-sensitive device may be a “touch-sensitive display 118 may be any suitable touch-sensitive display, such as a capacitive. . . . [which] includes a capacitive touch-sensitive overlay 114.” *Id.* at [0022].

ii. *Opinions regarding Claims 5, 11 and 17*

a) wherein changing the stored threshold value back to the original value comprises periodically drifting, at a predetermined rate, the stored threshold value back to the original value

132. As discussed above, *Sleeman* teaches changing the stored threshold back to the original value after no touch is detected for a predetermined amount of time. *See*, ¶¶107-113 above. However, *Sleeman* does not disclose accomplishing this by periodically drifting the value back at a predetermined rate.

133. *Griffin* teaches a touch-sensitive display including touch thresholds that are “modifiable and may be based on the values of any number of parameters.” *Griffin* at [0033]. For example, *Griffin*’s “touch threshold information may be stored in a table, map, or **equation**.” *Id.* at [0045] (emphasis added). As shown below,

Griffin demonstrates that touch thresholds may be modified by changing the value linearly over time:

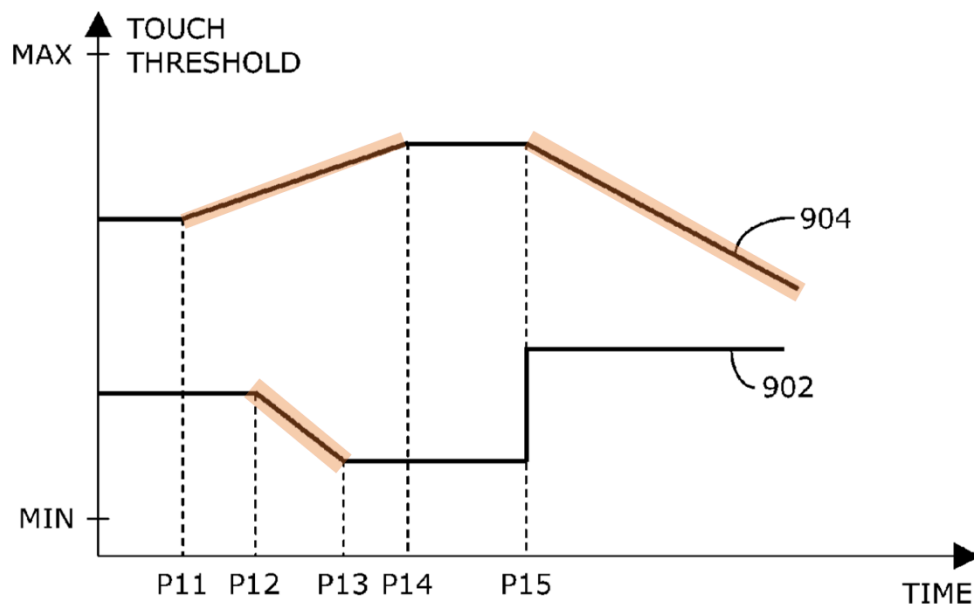


FIG. 9

Id. at Fig. 9 (emphasis added).

When a change in parameter P11 is identified, the **upper touch threshold 904 is modified by linearly increasing the upper touch threshold 904 over time**, although the lower touch threshold remains unchanged. For example, the parameter P11 may be a combination of ambient parameters changing over time. Parameter P12 causes the lower touch threshold 902 to be modified by linearly decreasing the lower touch threshold 902 over time until detection of change in parameter P13. Neither of the parameters P12 and P13 affects the upper touch threshold 904.

Id. at [0058] (emphasis added).

134. Of course, the equation of a line is $y = mx + b$. A person having ordinary skill in the art would understand that when expressing a threshold value as a linear equation, the variable x is time, the variable y is the value of the threshold,

and the constant m is the rate at which the value of the threshold changes over time (i.e., the slope of the line). A person having ordinary skill in the art would also understand that storing threshold information as a linear equation as taught by *Griffin* would encompass storing a predetermined rate of change (i.e., the constant m) for the threshold value.

135. The '472 Patent discloses an embodiment where periodically drifting a threshold value back to its original value at a predetermined rate encompasses “periodically adjust[ing] back to initial touch detection threshold 52c of 900 at a predetermined rate. For example, in one embodiment, touch detection threshold 52 is adjusted to 600 after one second, to 700 after two seconds, to 800 after three seconds, and finally back to 900 after four seconds if no interactions with touch sensor 30 are detected.” ’472 Patent at 10:28-50. The '472 Patent also clarifies it is not limited to this rate of adjustment, but rather “anticipates any appropriate rate of adjustment.” *Id.* at 10:54-57.

136. As demonstrated in the highlighted portions of Figure 9, *Griffin* also teaches a periodic adjustment of the threshold value. Particularly, the threshold value y is adjusted once for every timestep x . The exemplary timestep discussed in the '472 Patent is one second, but a person having ordinary skill in the art would understand that timestep is not limited to this and could be smaller. For these reasons, a person having ordinary skill in the art would understand *Griffin*’s teaching

of adjusting the threshold value in accordance with a linear equation is consistent with the '472 Patent's description of periodically drifting a threshold value back to its original value at a predetermined rate.

137. It would have been obvious to a person having ordinary skill in the art to change *Sleeman*'s stored threshold value back to its original value by periodically drifting it at predetermined rate as taught by *Griffin*. As I discussed previously, a controller of a mutual capacitance sensor performs scans at a frequency of 20-200 Hz, which is much faster than human user is able to interact with it. *See*, ¶109 above. Thus, a person having ordinary skill in the art would have understood that even if the user's finger or other object has not been in contact with the touch sensor in the amount of time it takes for the controller to complete multiple scans of the nodes, the user may still be interacting with the sensor. For example, the user's finger may lose contact with the sensor for a second or two while the user is interacting with the sensor. Assuming the grounding conditions have not changed and the threshold is raised back to its original value, this may result in a valid touch going undetected.

138. Therefore, a person having ordinary skill in the art would understand that it would be advantageous to gradually change the threshold back to its original value at a predetermine rate per *Griffin*'s teachings to account for the fact that a user may still be interacting with the sensor. This would predictably result in making the sensor more robust and less likely to inadvertently miss valid touches. For these

reasons, a person having ordinary skill in the art would have been motivated to change *Sleeman*'s threshold back to its original value by periodically drifting it at a predetermined rate as taught by *Griffin* to achieve the predictable result of a more robust and reliable touch sensor.

139. A person of ordinary skill would understand this modification would only require a simple change to *Sleeman*'s controller firmware. Additionally, this modification would have enhanced *Sleeman*'s ability to reliably detect different types of touches and would have therefore not changed *Sleeman*'s principle of operation or rendered it inoperable for its intended purpose. For these reasons, there would have been a reasonable expectation of success when implementing this modification.

iii. Opinions regarding Claims 6, 12, and 18

a) adjusting the stored threshold value based on the determined grounding status of the touch sensor comprises replacing the stored threshold value with a new threshold value

140. *Sleeman* discloses that controller 120 “modif[ies] an internal detection threshold” based on the type of signature detected:

Once the shape of the signature is determined, controller 120 may either enter a detect mode of operation if the touching object is a finger, or based on the type of signature, **modify an internal detection threshold** for entering the detect mode. Once in the detect mode, the controller interprets additional touches with a reduced threshold, as such touches are more likely to not correspond to noise, and be actual touches. If a stylus shape is detected, the **internal detection threshold may be lowered**. If a very small finger, such as

a child's finger is detected, **the internal detection threshold may also be lowered.**

Id. at [0022] (emphasis added).

141. It is understood that “to modify” something means to change or alter it in some way. *Oxford Dictionary* at p. 952 (defining “modify” as “to change (an object) in respect of some of its qualities”). This understanding coupled with *Sleeman’s* disclosure of lowering an internal threshold means a person having ordinary skill in the art would understand that “modif[ing]” the threshold value requires replacing the original threshold value with a new, lower threshold value in memory.

142. Therefore, a person having ordinary skill in the art would understand that modifying the internal detection threshold by lowering it means replacing the original internal threshold value with the new, lower value.

b) the stored threshold value is adjusted at a predetermined rate

143. As shown above, *Griffin* teaches adjusting a stored threshold value at a predetermined rate. *See*, ¶¶133-134 above. *Griffin* also generally teaches modifying thresholds in response to various parameters for a variety of reasons including “to reduce inadvertent input” and “reduce power consumption and prevent unintended voice calls and text messaging” *Griffin* at [0033], [0043].

144. It would have been obvious to a person having ordinary skill in the art to adjust *Sleeman’s* stored threshold value at a predetermined rate as taught by

Griffin. It was well known in the art that capacitance changes occur in mutual-capacitance touch sensors as a user's finger (or other conductive object) approaches the sensor. See e.g., *QT60161 Datasheet* at p. 7 ("Decreasing signals should not be compensated quickly, since an approaching finger could be compensated for partially or entirely before even touching the touch pad.").

145. A person having ordinary skill in the art would understand this would result in situations where the threshold would be adjusted prior to the finger making full contact with the touch sensor making the sensor more sensitive to noise. A person having ordinary skill in the art would have been motivated to enable *Sleeman*'s controller to change the threshold at a predetermined rate, such as taught by *Griffin*, in order to prevent the threshold to be lowered the full amount prior to the external object making full contact with the sensor. Combining these known elements in this way would have predictably resulted in making *Sleeman*'s touch sensor more resistant to noise and less susceptible to false touch detections.

146. A person of ordinary skill would understand this modification would only require a simple change to *Sleeman*'s controller firmware. Additionally, this modification would have enhanced *Sleeman*'s ability to reliably detect different types of touches and would have therefore not changed *Sleeman*'s principle of operation or rendered it inoperable for its intended purpose. For these reasons, there

would have been a reasonable expectation of success when implementing this modification.

iv. *Opinions regarding Claim 21*

a) wherein the stored threshold value is adjusted after a predetermined number of interactions with the touch sensor by the external object

147. As I discussed above, *Griffin* teaches a touch-sensitive display including a touch threshold that is “modifiable and may be based on the values of any number of parameters.” *Griffin* at [0033]. In one example, “[t]he touch threshold may be modified based on the rate of detected touches, also referred to herein as the touch rate, e.g., how often touches occur or the number of touches in a period of time.” *Id.* at [0044]. *Griffin* further explains, “when the touch rate is high, the touch threshold may be decreased, to reduce the user’s effort to trigger functions, such as when typing on a virtual keyboard 604. When the touch rate is low, the touch threshold may be increased, resulting in more deliberate touches to meet the threshold, such as when selecting the “DELETE” virtual button 602.” *Id.*

148. As explained by *Griffin*, the touch rate is “the number of touches in a period of time,” (*id.* at [0044]), and a person having ordinary skill in the art would understand that distinguishing a “high” touch rate or a “low” touch rate would be made by comparing the number of touch interactions in a period of time with a predetermined “high” or “low” number of interactions. For this reason, a person

having ordinary skill in the art would understand that *Griffin*'s teaching of modifying a touch threshold based on the number of touches in a period of time encompasses adjusting a threshold value "after a predetermined number of interactions with the touch sensor by the external object."

149. Additionally, it would have been obvious to a person having ordinary skill in the art to configure *Sleeman*'s touchscreen to also modify the threshold based on the touch rate as taught by *Griffin*. As demonstrated by *Griffin*, adjusting detection thresholds based on the number of touch interactions detected in a specified period of time was a well-known way to improve usability of touch sensors. For instance, *Griffin* teaches a high number of interactions may mean that the user is attempting to type on a virtual keyboard so the threshold may be advantageously reduced to make typing easier for the user. In contrast, if a small number of interactions are detected in a period of time, then the threshold may be advantageously increased to prevent unintended interactions from being processed as legitimate inputs by the user. For this reason, a person having ordinary skill would have been motivated to improve similar touch sensors in the same way in order to achieve the same improvements to usability.

150. In my opinion, there would have been a reasonable expectation of success when modifying *Sleeman*'s touch sensor in this way. Indeed, this modification would have required only the straightforward addition to the

controller's firmware to modify the threshold based on the touch rate as taught by *Griffin*, which would have been well within the abilities of a person having ordinary skill in the art at the time of the '472 Patent.

H. Obviousness over *Sleeman*, *Westerman* '787, and *Hotelling*

iii. *Opinions regarding Claim 19*

a) wherein determining the grounding status of the touch sensor based on the strength of the charge return path between the touch sensor and ground comprises analyzing shapes of one or more capacitance graphs.

151. As I discussed above, *Sleeman* teaches analyzing the shapes of different touch signatures to determine the type of touch. *See*, ¶¶73-76 above. Specifically, *Sleeman* teaches “[a]n array with signal weighting may be used in one embodiment and compared to known arrays to determine the type of touch corresponding to the signals received.” *Sleeman* at [0029]. As shown below, *Sleeman*'s arrays are two dimensional graphs that denote the size of the touch (i.e., how many nodes are in contact with the external object) and intensity/weighting (i.e., magnitude) of the capacitance signals where darker shading indicates a stronger capacitance signal:

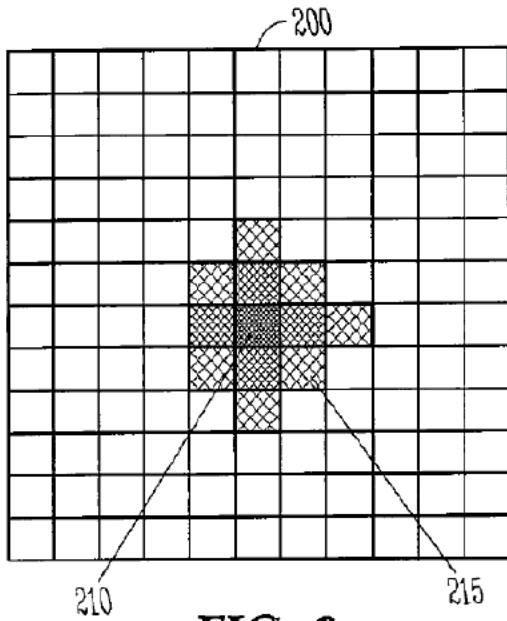


FIG. 2

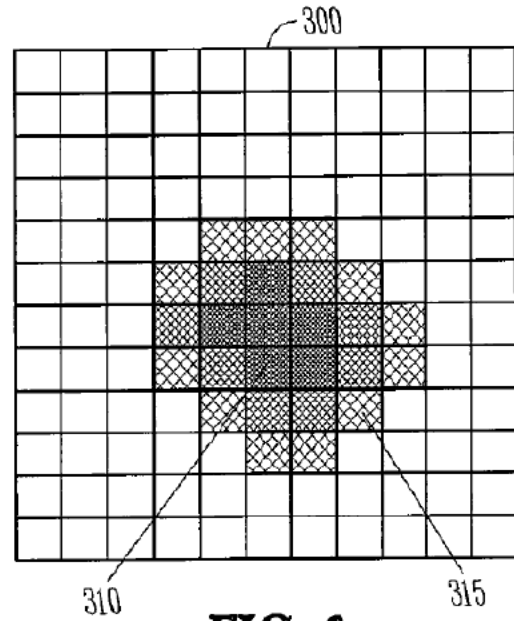


FIG. 3

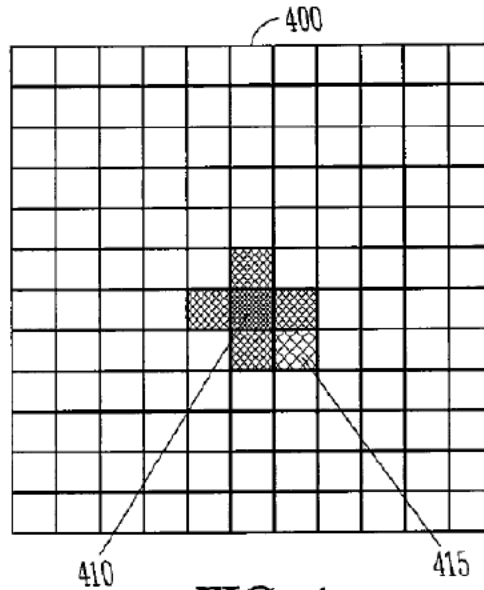


FIG. 4

Sleeman at Figs. 2-4; *see also, id.* at [0019] (“Surrounding the strong center peak 210, are nodes that form a halo region 215, which generally have **a weaker signal**, as the finger starts to lose contact with nodes in the halo region due to the domed

nature of fingers.”) (emphasis added), [0021] (“As shown at 400, a center peak 410 is small, such as one node, or perhaps two adjacent nodes with **one-half signal intensity. The center peak 410 may represent a weaker signal** due to the sharply defined touching object. This corresponds to a well defined tip that may be similar in size to the node size, or smaller than a node size. In further embodiments, the relative density of the nodes compared to the size of the touching object may result in more nodes being included in the center peak.”) (emphasis added).

152. *Sleeman*’s arrays are similar to the capacitance graphs described in the ’472 Patent, except that instead of using three-dimensional graphs, *Sleeman* denotes the magnitude of the capacitance signal by using darker shading for higher magnitude changes in capacitance. *Compare Sleeman* at Figs. 2-4 with ’472 Patent at Figs. 5a-b.

153. For the reasons discussed above, it would have been obvious to a person having ordinary skill in the art at the time of the ’472 Patent to enable *Sleeman*’s controller determine the touchscreen’s grounding status as by *Westerman* ’787. *See*, ¶¶97-104 above. As shown in the following figures, *Westerman* ’787 teaches differences in the capacitance graphs of grounded versus floating touches:

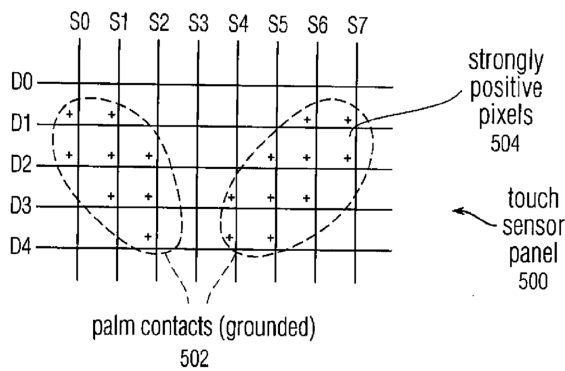


Fig. 5a

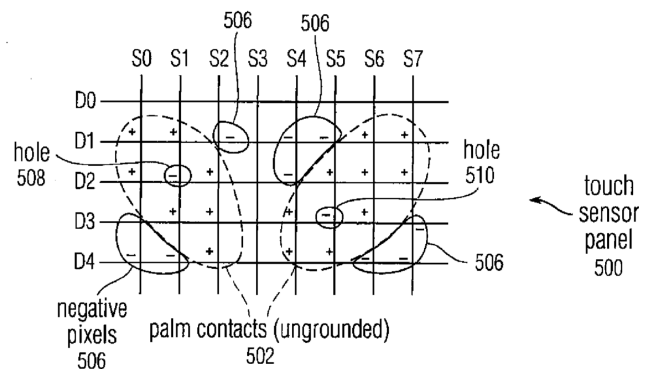


Fig. 5b

Westerman '787 at Figs. 5a-5b.

154. *Westerman '787* does not, however, teach analyzing these shapes to identify whether the sensor is grounded or floating.

155. As discussed above, *Hotelling* teaches many different parameters may be analyzed to determine the grounding status of a touch-sensitive device. *See*, ¶117 above. Included among these parameters are “the characteristics of the touch, including the location, orientation, **shape**, movement, and so on, of the **touch image** generated by the touch.” *Hotelling* at [0048] (emphasis added). Per *Hotelling*, the sensed touch image can be used to determine the device’s grounding status. *Id.* at [0050] (“Accordingly, sensing a touch image having this thumb configuration can be an indication that the touch sensitive device is being held and therefore grounded.”).

156. *Hotelling* also recognizes that “[t]he ability to detect how well grounded a touch sensitive device is can advantageously provide more accurate and faster

touch sensing” as well as provide power savings and enable the device to “more robustly adapt to various grounding conditions.” *Id.* at [0019].

157. Based on the teachings of Hotelling, a person having ordinary skill in the art would have been motivated to configure *Sleeman*’s controller to analyze the touch signature included in the capacitance graph in order to determine the touchscreen’s grounding status. *Sleeman* already analyzes the shapes of capacitance graphs to determine whether the internal detection threshold should be modified based on the type of touch. A person having ordinary skill in the art would have been motivated to extend this capability to also recognize grounding status as taught by *Hotelling*.

158. A person having ordinary skill in the art would have understood this modification would have predictably provided power savings benefits as well as enabled *Sleeman*’s touchscreen to provide more robust sensing performance as recognized by *Hotelling*. Therefore, a person having ordinary skill in the art would have been motivated to improve similar touch sensitive devices in the same way.

159. Additionally, a person having ordinary skill would understand this modification would have required minimal changes to the firmware on *Sleeman*’s controller since it is merely an extension of existing functionality. Therefore, there would have been a reasonable expectation of success when configuring *Sleeman*’s touchscreen in this manner.

iv. Opinions regarding Claim 20

a) wherein analyzing shapes of one or more capacitance graphs comprises: comparing a capacitance graph derived from plurality of signals indicative of an amount of capacitance between the touch-sensitive device and an external object with a plurality of stored capacitance graphs, the stored capacitance graphs comprising:

160. As discussed above, *Sleeman* teaches analyzing the shapes of different capacitance graphs to distinguish different types of touches. *See*, ¶¶73-76 above. Specifically, *Sleeman* derives “an array with signal weighting” corresponding to the capacitance measurements of the touchscreen’s nodes and compares it “to known arrays to determine the type of touch corresponding to the signals received.” *Sleeman* at [0029]. For the reasons discussed above, it would have been obvious to a person having ordinary skill in the art to configure *Sleeman*’s controller to analyze the signature shapes of these capacitance arrays in order to determine the grounding status of the sensor. *See*, ¶¶151-159 above. Therefore, it would have also been obvious to store capacitance arrays corresponding to different grounding conditions for the same reasons.

b) a grounded capacitance graph indicative of a typical touch when the touch-sensitive device is grounded

161. *Westerman* ’787 teaches the following exemplary capacitance graph representing a grounded touch:

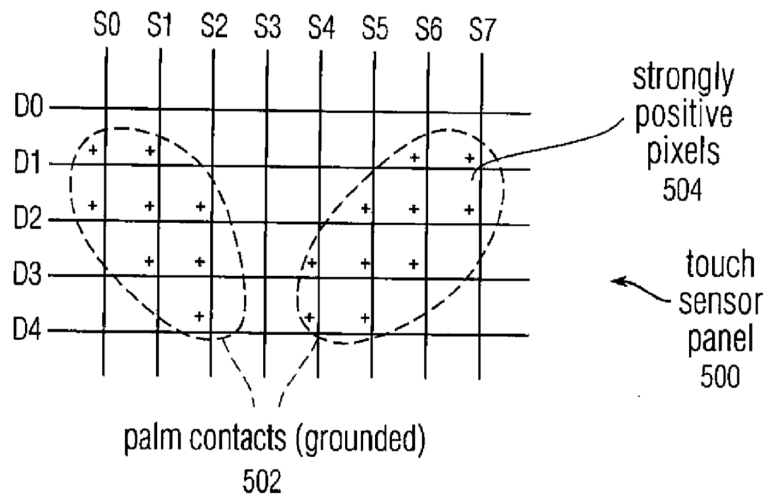


Fig. 5a

Westerman '787 at Fig. 5a; see also, *id.* at [0045] (“FIG. 5a illustrates an exemplary touch sensor panel 500 with palms 502 of a grounded user touching the panel. In this instance, the pixels 504 being touched can appear strongly positive (large output indicative of touch), and because the palms are grounded, little or no charge can be coupled onto other sense lines, and the negative pixel effect can be insignificant.”).

162. It would have been obvious to a person having ordinary skill in the art to configure *Sleeman*’s controller to store a similar capacitance array indicative of a grounded touch for all of the reasons discussed above. See, ¶160 above.

163. A person having ordinary skill the art would have a reasonable expectation of success when configuring *Sleeman*’s controller to store capacitance arrays indicative of grounded touches. As discussed above, *Sleeman* already teaches storing capacitance arrays for the purpose of determining the type of touch. It would

have been a simple modification to also store capacitance arrays corresponding to grounded touches. Based on the teachings a *Westerman* '787, a person having ordinary skill in the art would understand a grounded touch would have stronger signal weighting values than an ungrounded touch. This means a grounded touch from a small finger, for example, would have stronger capacitance signals than an ungrounded touch from a small finger. A person having ordinary skill in the art would understand that the signal weighting values in an array for a grounded, small finger touch would be greater than the signal weighting values for an ungrounded, small finger touch.

c) a floating capacitance graph indicative of a typical touch when the touch-sensitive device is floating

164. *Westerman* '787 teaches the following exemplary capacitance graph representing a floating (i.e., ungrounded) touch:

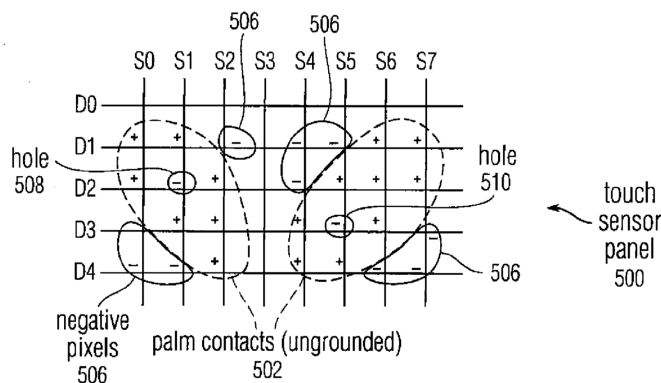


Fig. 5b

Westerman '787 at Fig. 5b; see also, *id.* at [0046] (“FIG. 5b illustrates an exemplary touch sensor panel 500 with palms 502 of an ungrounded user touching the panel. In

this instance, in addition to strongly negative or at least weakened pixels 506 in the corner areas just outside the touch regions, negative or weakened pixels 508 and 510 (holes) can form within the palm areas 502, where a relatively large number of drive lines and sense lines are being simultaneously touched.”).

165. It would have been obvious to a person having ordinary skill in the art to configure *Sleeman*’s controller to store a similar capacitance array indicative of a floating touch for all of the reasons discussed above. *See*, ¶160 above.

166. A person having ordinary skill the art would have a reasonable expectation of success when configuring *Sleeman*’s controller to store capacitance arrays indicative of floating touches. As discussed above, *Sleeman* already teaches storing capacitance arrays for the purpose of determining the type of touch. It would have been a simple modification to also store capacitance arrays corresponding to floating touches. Based on the teachings a *Westerman* ’787, a person having ordinary skill in the art would understand a grounded touch would have stronger signal weighting values than a floating touch. This means a floating touch from a small finger, for example, would have weaker capacitance signals than a grounded touch from a small finger. A person having ordinary skill in the art would understand that the signal weighting values in an array for a grounded, small finger touch would be less than the signal weighting values for an ungrounded, small finger touch.

d) determining, based on the comparison, that the touch-sensitive device is grounded if the capacitance graph matches

the grounded capacitance graph

167. *Sleeman* teaches, “An array with signal weighting may be used in one embodiment and **compared to known arrays** to determine the type of touch corresponding to the signals received.” *Sleeman* at [0029] (emphasis added). For the same reasons as discussed above, it would have been obvious to configure *Sleeman*’s controller to determine that the device is grounded if the capacitance array matches the stored grounded capacitance array. *See*, ¶¶151-159 above.

e) determining, based on the comparison, that the touch-sensitive device is floating if the capacitance graph matches the floating capacitance graph

168. *Sleeman* teaches, “An array with signal weighting may be used in one embodiment and **compared to known arrays** to determine the type of touch corresponding to the signals received.” *Sleeman* at [0029] (emphasis added). For the same reasons as discussed above, it would have been obvious to configure *Sleeman*’s controller to determine that the device is floating if the capacitance array matches the stored floating capacitance array. *See*, ¶¶151-159 above.

IV. CONCLUSION

169. I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and 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 Title 18 of the United States Code.

Date: August 7, 2020

By:


Dr. Khalil Najafi