UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.
Petitioner,

v.

RESONANT SYSTEMS, INC.,
Patent Owner.

Case No. IPR2024-00983
U.S. Patent No. 11,152,882

EXPERT DECLARATION OF KEITH W. GOOSSEN, PH.D.

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I. BACKGROUND

1. I have been retained as a technical expert by Patent Owner Resonant Systems, Inc. ("Patent Owner" or "Resonant Systems") in this proceeding. Resonant Systems has asked me to provide my expert opinions concerning certain technical aspects of vibration modules and associated technologies as they relate to the petition filed by Petitioner Apple Inc. ("Petitioner" or "Apple") for inter partes review of U.S. Patent 11,152,882 ("'882 patent") in Case Nos. IPR2024-00983, and the accompanying Declaration of Dr. Blake Hannaford.

2. The statements in this declaration summarize my opinions on these matters based on my over 35 years of experience in electrical engineering, electro-mechanical systems, and sensors, my education, knowledge, skills, and my review and analysis of the materials referenced herein.

3. I am being compensated for my work in this matter at the rate of $350 per hour. I am also being reimbursed for reasonable and customary expenses associated with my work and testimony in this investigation. My compensation is not contingent on the outcome of this matter or the substance of my testimony.

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II. MATERIALS CONSIDERED

4. In the preparation of this declaration and the opinions contained herein, I have considered the petitions and other materials, as listed below:

- The patents 11,152,882 (Ex. 1001)
- The petitions and accompanying exhibits in IPR2024-00983, including prior art references and the declaration of Dr. Blake Hannaford
- The deposition transcripts of Dr. Hannaford (Exs. 2011–2013)

III. SUMMARY OF OPINIONS

5. As set forth in detail below, I disagree that Apple has successfully shown that any of the challenged patent claims of the ’882 patent is obvious, either because Apple has failed to establish that the proposed combination or modification would satisfy the claims under their proper constructions, or because Apple has failed to properly demonstrate the art to be combined is analogous and to demonstrate a motivation to make the combination or modification in question.

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IV. EDUCATIONAL AND EMPLOYMENT BACKGROUND

6. Attached as Exhibit 2010 is my CV. I summarize in this section my educational background, career history, publications, and other relevant qualifications. My qualifications can be found in my curriculum vitae, including details about my employment history, fields of expertise, and publications.

7. I became an Associate Professor in Electrical and Computer Engineering at the University of Delaware in 2002 and in 2018 was promoted to Professor. I oversee the Optoelectronic Packaging and Integration laboratory at the University of Delaware. I am also the Director of the Mid-Atlantic Industrial Assessment Center, an award-winning center for research and development of energy systems and energy efficiency. The Center has won the 2012 U.S. Department of Energy Best Center award, and the 2015 U.S. Department of Energy Excellence in Applied Energy Engineering Research award.

8. I have served on professional committees including the IEEE Conference on Micro Electro Mechanical Systems and IEEE Optical Interconnect conferences. I am a Senior Member of the Institute of Electrical and Electronic Engineers (IEEE).

9. I earned a B.S. in Electrical Engineering from the University of California at Santa Barbara (1983) and an M.A. in Electrical Engineering from Princeton University (1985). I received my Ph.D. from Princeton University

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in 1988, and worked at Bell Labs from 1988 until founding Aralight, Inc. in September, 2000. I performed research at Bell Labs in MEMS-based (Micro-Electro-Mechanical Systems-based) optical switches, much of which forms the basis of today's wavelength selective switches.

10. In September of 2000, I co-founded Aralight, Inc, where I was involved in the company's raising of $10 million in capital and the growth of the company to 35 people. The company's product, an integrated optoelectronic fiber-optic transmit/receive module—showing 3x the bandwidth of previous such products—was based upon my inventions and followed on my research at Bell Labs. Aralight was later sold and its product forms the basis of today's Active Optical Cabling, which enables high-speed optical backplanes for switches and supercomputers.

11. I am the inventor (or co-inventor) on 87 issued U.S. patents. I have over 300 published papers and conference proceedings.

12. My qualifications include teaching electromagnetics and electric power systems, which address the same physics of haptic devices in that they involve converting electrical energy to mechanical energy. In electric power systems and haptic devices, currents and/or voltages are used to produce electric or magnetic forces on masses in order to cause their rotary or linear motion. For electric motors, vibration is considered a loss mechanism and not optimized.

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In haptics, essentially, the vibration loss mechanism is what is desired to be optimized.

13. A specific qualification is my invention of the Mechanical Anti-Reflection Switch, or MARS device. This is a Micro-Electromechanical System, or MEMS device, designed to produce digital movement in response to a data input. It was instrumental in early testing of various fiber optic systems, and to this date I believe holds the record for the fastest controlled mechanical device ever produced at 10 Mbits/second.

V. LEVEL OF ORDINARY SKILL IN THE ART

14. It is my opinion that a POSITA at the time of the invention would have had (1) a bachelor's degree in electrical engineering, mechanical engineering, or a comparable field of study, and (2) at least two years of professional experience with electro-mechanical control systems, or other similarly relevant industry experience. Additional relevant industry experience may compensate for lack of formal education or vice versa. I qualified as a POSITA as of the earliest claimed priority date of the '882 patent, in February 2015. I also understand the capabilities of a POSITA at the relevant time because I was working with and providing technical direction to others with similar levels of training and experience during that period.

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15. I note that Petitioners offer a similar level of ordinary skill in the art in their petition:

> a degree in mechanical engineering, electrical engineering, physics, or a related technical field, and at least 2-3 years of experience related to the design or development of systems incorporating linear actuators; additional years of experience could substitute for the advanced-level degree[1]

The meaning of this proposed level of ordinary skill is unclear, in that the phrase after the semicolon refers to "the advanced-level degree," but the phrase before the semicolon only mentioned "a degree." I assume that the intended meaning is that a person might reach the proposed level of ordinary skill if they have an advanced-level degree such as a master's degree or Ph.D., but less than 2-3 years of experience.

16. Based upon my experience as a Ph.D. electrical engineer, industry researcher, company co-founder, and university teacher and researcher, I also qualified as a POSITA and understand the capabilities of a POSITA under either my definition or Petitioner's definition of the level of ordinary skill in the art. In particular, the Mechanical Anti-Reflection Switch MEMS device that I invented and worked on was a linear-motion device. My opinions herein

[1] Petition at 9.

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would not change if the Board were to adopt either of the proposed definitions for the level of ordinary skill.

17. In this declaration, I offer opinions from the perspective of a POSITA having ordinary skill in February 2015. I note that the '882 patent also claims priority to an application filed in February 2016 and that the continuation-in-part application leading to the '882 patent was filed on March 2, 2020.[2] My opinions in this declaration would not change if offered from the perspective of a POSITA having ordinary skill in February 2016 or in March 2020.

VI. RELEVANT LEGAL STANDARDS

18. I have been informed of the legal standards for establishing patent invalidity in inter partes review proceedings before the Patent Trial and Appeal Board.

19. I understand that the petitioner must prove invalidity of a patent claim by a preponderance of the evidence, that is, the evidence must be sufficient to show that a fact or legal conclusion is more likely than not.

20. I understand that a claim may be anticipated if (1) the claimed invention was patented, described in a printed publication, or in public use, on sale, or otherwise available to the public before the effective filing date of the claimed invention; or (2) the claimed invention was described in a patent or published

[2] '882 Patent at 1.

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application, in which the patent or application names another inventor and was effectively filed before the effective filing date of the claimed invention.

21. I understand that, once the claims of a patent have been properly construed, the next step in determining anticipation of a patent claim requires a comparison of the properly construed claim language to the prior art on a limitation-by-limitation basis.

22. I understand that even if a patent claim is not anticipated, it may still be invalid if the differences between the claimed subject matter 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 of ordinary skill in the pertinent art.

23. I also understand that a patent may be rendered obvious based on an alleged prior art reference or a combination of such references plus what a person of ordinary skill in the art would understand based on his or her knowledge and the references. It is also my understanding that in assessing the obviousness of claimed subject matter one should evaluate obviousness over the prior art from the perspective of one of ordinary skill in the art at the time the invention was made (and not from the perspective of either a layman or a genius in that art).

24. I understand that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was known

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in the prior art. There must be a reason for combining the elements in the manner claimed. That is, there must be a showing that a person of ordinary skill in the art at the time of the invention would have thought of either combining two or more references or modifying a reference to achieve the claimed invention.

25. I understand that an obviousness determination includes the consideration of the following factors: (1) the scope and content of the prior art, (2) the differences between the prior art and the claims at issue, (3) the level of ordinary skill in the art, and (4) objective evidence of nonobviousness.

26. I understand that prior art references are applicable to the obviousness inquiry only when they are analogous to the claims being challenged. To be considered analogous art, the prior art must either (1) be from the same field of endeavor, regardless of the problem addressed, or (2) if not within the field of the inventor's endeavor, be reasonably pertinent to the particular problem with which the inventor is involved.

27. I understand that the burden is on the petitioner to explain how specific references could be combined, which combinations of elements in specific references would yield a predictable result, and how any specific combination would operate or read on the claims. I further understand that the petitioner

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cannot rely on conclusory statements but must instead provide a reasoned explanation supported by evidence. I also understand that obviousness does not exist where the prior art discourages or teaches away from the claimed invention. I also understand that even if a reference does not teach away, its statements regarding preferences are relevant to a finding whether a person skilled in the art would be motivated to combine that reference with another reference.

28. I understand that it is impermissible to use hindsight to arrive at the claimed invention. My understanding is that the inventor's own path never leads to a conclusion of obviousness. I also understand that, when assessing whether there was a motivation to combine references to teach a claim element, defining the problem in terms of its solution reveals improper hindsight.

29. I understand that a proper determination of the validity of patent claims can only be done after the claims have been properly construed. I understand that a claim construction inquiry begins and ends with the actual words of the claim. Apart from the written description and the prosecution history, the claims themselves provide substantial guidance as to the meaning of particular terms. I further understand that the context in which a term is used in the asserted claim can be highly instructive. The patent specification can also shed light on the meaning of claim terms.

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30. I understand that, when conducting a claim construction inquiry, courts are not required to construe every limitation present in a patent's asserted claims. I further understand that where a term is used in accordance with its plain meaning, the court should not re-characterize it using different language.

31. I understand that there is a "heavy presumption" that claim terms carry their full ordinary and customary meaning unless the accused infringer can show that the patentee expressly relinquished claim scope. The ordinary and customary meaning of a claim term is the meaning that the term would have to a POSITA at the time of the invention.

32. I understand that courts generally do not import limitations into claims from examples or embodiments appearing only in a patent's written description, even when a specification describes very specific embodiments of the invention or even only a single embodiment. Similarly, I understand that statements during patent prosecution do not limit the claims unless the statement is a clear and unambiguous disavowal of claim scope.

33. I understand that, under 35 U.S.C. § 112 ¶ 6, "[a]n element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof."

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35 U.S.C. § 112 ¶ 6. I understand that the standard for determining whether § 112 ¶ 6 applies is whether the words of the claim are understood by persons of ordinary skill in the art to have a sufficiently definite meaning as the name for structure. Where a claim term lacks the word "means," there is a presumption that § 112 ¶ 6 does not apply. To rebut this presumption, the challenger must demonstrate that the claim term fails to recite sufficiently definite structure or else recites function without reciting sufficient structure for performing that function. I understand this presumption cannot be overcome without showing that the claim limitation is devoid of anything that can be construed as a structure. I further understand that if § 112 ¶ 6 does apply, then the corresponding structure should not be limited to the structure described for a single embodiment in the specification if the patentee has disclosed multiple embodiments.

34. I understand that when a claim is subject to § 112 ¶ 6 and it recites basic processor functions, the specification need not disclose corresponding algorithms because a standard microprocessor can provide sufficient structure for functions that can be achieved by any general purpose computer without special programming. If special programming is required to perform the claimed function, I understand that a corresponding algorithm can be expressed in the patent in any understandable terms, including as a mathematical formula, in

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prose, as a flow chart, or in any other manner that provides sufficient structure. I further understand that, if a corresponding algorithm is required, steps that are not necessary to perform the claimed function must be omitted from the algorithm because the algorithm must only include what is necessary and nothing more.

35. I understand that a typographical error in a patent claim can be corrected by the Board during claim construction, as long as the correction is not subject to reasonable debate based on the claim language and specification, and as long as the prosecution history does not suggest a different interpretation of the claim.

VII. BACKGROUND OF THE '882 PATENT

36. The '882 patent generally relates to haptic devices, which can be roughly described as electro-mechanical devices that vibrate in response to an input (such as touching a touch screen). Such devices are commonplace today as a human interface feedback, for example informing the human that they have correctly made an input. A haptic device can be generalized as having an electrical driving force, either an electric or magnetic field, causing a weight or mass to move, usually in an oscillatory fashion. The movement of the mass can roughly be generalized as rotary or linear. The movement of the mass is connected either mechanically or electro-mechanically to a housing,

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which is connected in some way to whatever surface the human touches, and thus the vibration caused by the oscillatory movement is transmitted to the human.

37. While a more technological table of haptic devices is given below, a high level overview of electromechanical devices in general is:

force \ movement	rotary	linear
magnetic	electric motor	loudspeaker
electric	rotary actuators	piezoelectric

38. One can see that both electric and magnetic fields can produce both rotary and linear movement, although, magnetic devices can be generally larger and produce more mechanical power, which is inherent in that electric field requires shorter distances to generate large forces.

39. Before going forward it is useful to connect the use of the terms, electric and magnetic fields, to the driving voltages and currents, and the resulting forces. Electric actuation is easy to understand, as a voltage across two plates produces an electric field in the same direction as the voltage (perpendicular

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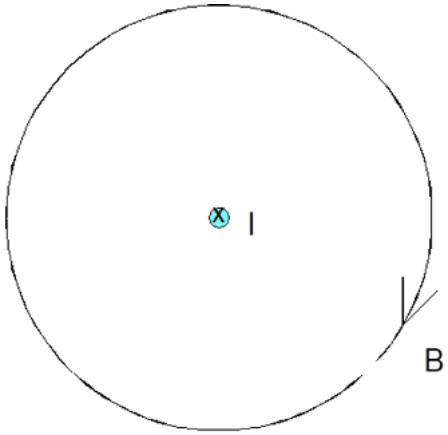
to the plates), and a charged object between the plates will experience a force in the same direction as the electric field.

40. Magnetic actuation is a bit more difficult as the vectors of the fields and both the driving currents (alternating voltages can be used to produce magnetic fields, but it is less common), and the magnetic forces, are at right angles to the magnetic fields.

41. For example, by Ampere's Law, a current-carrying wire will produce a circular magnetic field with its axis being the wire:



42. Here the current-carrying wire is perpendicular to the page and the current is directed into the page. If a current-carrying coil is formed, the direction of the magnetic field can be determined by adding up the contributions of all the wires in the coil:

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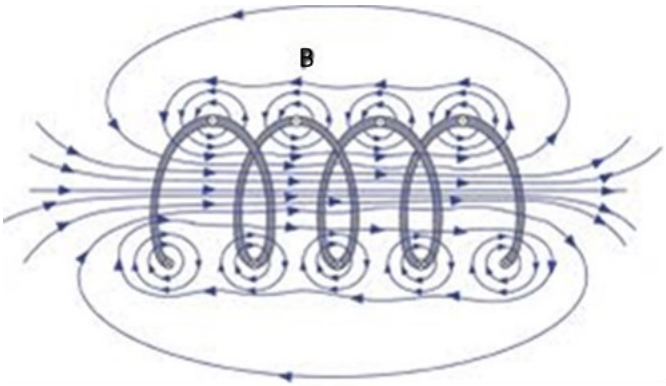
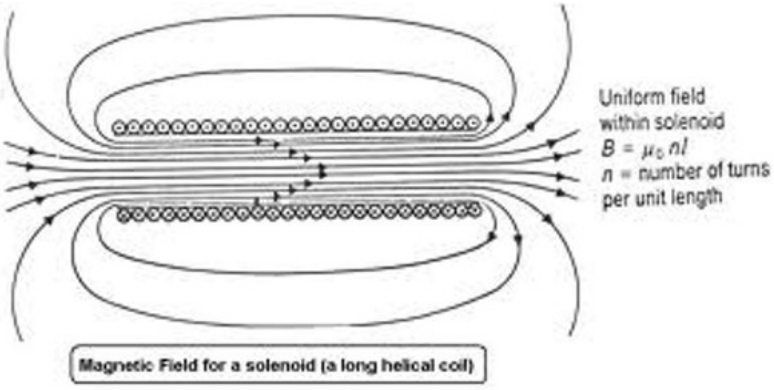


43. One sees that by considering that the effect of every point on the wire in the coil, causing a circular magnetic field around it, and adding those effects, the resulting overall magnetic field can be determined. As can be seen, as the coil is more tightly wound (sometimes then called a solenoid), the magnetic field becomes concentrated within the coil, in a direction along the axis of the coil:



44. Now we get to the forces resulting from the magnetic field. If the object in the magnetic field is itself a magnet, this is easy, the force is in the same direction as the magnetic field. The way to understand this is that a magnet is essentially itself a "coil," containing electrons rotating in the same circular

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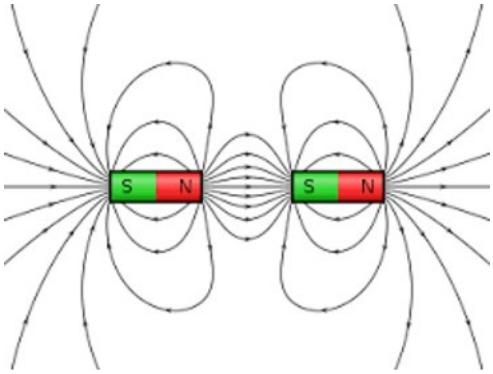
direction, resulting in a magnetic field. And, we all know that opposite poles attract:



45. One sees that the two magnets behave essentially like two solenoids producing magnetic fields in the same directions along their axes. Thus, in the above drawing, you could replace one of the magnets with the solenoid of the previous drawing, and have the same attractive forces occurring.

46. The basis of the forces between two magnets, or between a magnet and a solenoid, or between two solenoids for that matter, must be found by considering the forces on the currents embedded in each, which are circular about their axes. A magnetic field only produces a force on a moving charge, or current, and that force is at right angles to both the magnetic field and the current. In the above drawing of the two magnets, the force on the left magnet is to the right. The "currents" in the left magnet are like that in the solenoid earlier pictured. The force is at right angles to both. To understand the overall

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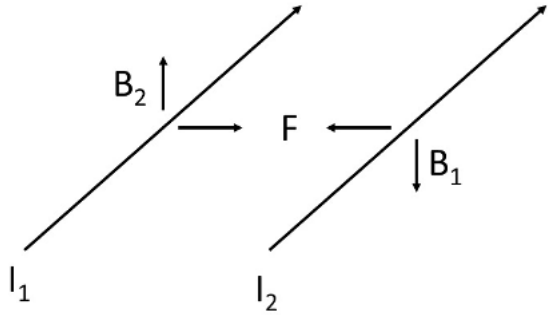
force one must consider the entire coil, and that's hard. A simple principle that helps us understand the overall effect is that like currents attract:



47. Thus, the two attracting "solenoids" in the magnet drawing have all their "currents" in the same direction, and thus they all attract. For the same reason two magnets with their poles in the same direction will attract.

48. Now that the basic electro-physics has been explained, the forced movement of any magnet or charge due to any current or voltage can be determined.

49. As mentioned, haptic devices come in a variety of forced motions and electrical forces. This table summarizes the various types (from "Development of a Human-Display Interface with Vibrotactile Feedback for Real-World Assistive Applications," in Sensors, 2021):

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Table 1

Comparison of actuators and needed characteristics for haptic feedback.

Characteristics / Actuators	Voice Coil Motor	Eccentric Rotating Mass Motor	Linear Resonant Actuator	Piezoelectric Actuator	Electrostatic Tactile Actuator
Response time	High	Low	High	High	High
Bandwidth	High	Low	Low	High	High
Displacement output	High	High	Medium	Medium	Low
Power consumption	Low	Low	Low	High	High
Mechanical simplicity	Medium	Low	High	Medium	Medium

50. The main types of haptic generators in human interfaces such as touch screens, such as on smartphones, are Eccentric Rotating Mass Motor (ERMM) and Oscillating Resonant Module (ORM) devices. ERMMs are basically unbalanced motors that when rotating thus produce a vibration. ORMs are the subject of this IPR and are devices that cause reciprocating linear motion of some mass, resulting in vibration. One sees that the ORM is superior in various respects to the ERMM, and thus have largely taken over as the technology of choice in haptic generators. The inventors of the ’882 patent understood

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these advantages, which led them to the claimed inventions, as reflected in the exemplary description below from the '882 patent:[3]

> While effective in producing vibrations, there are many problems associated with the unbalanced-electric-motor vibration-generating units, such as that shown in FIG. 1A, commonly used in the various devices, systems, and applications discussed above. Unbalancing the shaft of an electric motor not only produces useful vibrations that can be harnessed for various applications, but also produces destructive, unbalanced forces within the motor that contribute to rapid deterioration of motor parts. Enormous care and effort is undertaken to precisely balance rotating parts of motors, vehicles, and other types of machinery, and the consequences of unbalanced rotating parts are well known to anyone familiar with automobiles, machine tools, and other such devices and systems. The useful lifetimes of many devices and appliances, particularly hand-held devices and appliances, that employ unbalanced electric motors for generating vibrations may range from a few tens of hours to a few thousands of hours of use, after which the vibrational amplitude produced by the devices declines precipitously as the electric motor and other parts deteriorate. Unbalanced electric motors are relatively inefficient at producing vibrational motion. A far greater amount of power is consumed by an unbalanced electrical motor to produce a

[3] '882 Patent at 2:11–3:15.

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given vibrational force than the theoretical minimum power required to produce the given vibrational force. As a result, many hand-held devices that employ unbalanced electric motors for generating vibrations quickly consume batteries during use. Unbalanced electric motors, as discussed above, oscillating motion back and forth along a predefined-path, or space curve, cannot generally be produced by unbalanced electric motors. Unbalanced electric motors generate vibrations in only a very limited portion of the total vibrational-force/frequency space. FIG. 3 shows a graph of vibrational force with respect to frequency for various types of unbalanced electric motors. The graph is shown as a continuous hypothetical curve, although, of course, actual data would be discrete. As shown in FIG. 3, for relatively low-power electric motors used in hand-held appliances, only a fairly narrow range of frequencies centered about 80 Hz (**302** in FIG. 3) generate a significant vibrational force. Moreover, the vibrational force is relatively modest. The bulk of energy consumed by an unbalanced electric motor is used to spin the shaft and unbalanced weight and to overcome frictional and inertial forces within the motor. Only a relatively small portion of the consumed energy is translated into desired vibrational forces.

Because of the above-discussed disadvantages with the commonly employed unbalanced-electric-motor vibration-generation units, designers, manufacturers, and, ultimately, users of a wide variety of different vibration-based devices, appliances, and systems continue to seek more efficient and capable vibration-

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generating units for incorporation into many consumer appliances, devices, and systems.

SUMMARY

The current document is directed to various types of oscillating resonant modules ("ORMs"), including linear-resonant vibration modules, that can be incorporated in a wide variety of appliances, devices, and systems to provide vibrational forces. The vibrational forces are produced by back-and-forth oscillation of a weight or member along a path, generally a segment of a space curve. A controller controls each of one or more ORMs to produce driving oscillations according to a control curve or control pattern for the ORM that specifies the frequency of the driving oscillations with respect to time. The driving oscillations, in turn, elicit a desired vibration response in the device, appliance, or system in which the one or more ORMs are included. The desired vibration response is achieved by selecting and scaling control patterns in view of known resonance frequencies of the device, appliance, or system.

51. Thus in an ORM, a mass is moved in a reciprocating fashion within a housing, with the main embodiment being by wrapping the housing with a solenoid like coil, that produces a magnetic field within the housing, like de-

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scribed above. This magnetic field produces a force on a magnet in the housing, and when the coil is driven with an alternating current, the magnet first is force one way than the other, and thus oscillates, producing a vibration.

52. Further background on the claimed inventions is provided in the specification of each patent, especially the portions referenced in my analyses below.

VIII. CLAIM CONSTRUCTION

1. Preamble of Claim 1

53. In the related district court litigation, the parties have agreed that the preambles of claims 1 and 10 are limiting.[4] Apple's petition in this IPR does not address that question. For my analysis in this declaration, I have assumed that these preambles are indeed limiting, and in particular that each claim requires an "oscillating resonant module."

54. However, my opinions would not differ if the Board instead were to determine that the preambles are not limiting. Limitations [1b] and [1d] of claim 1 and limitations [10b], [10d], and [10f] of claim 10 each require at least one "oscillating resonant module," so an oscillating resonant module is required even if the preambles are not limiting.

[4] Ex. 2002 at 10.

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2. "control component"

55. In its institution decision, the Board determined that the term "control component" of independent claims 1 and 10 is a means-plus-function term.[5] In the related district court litigation, the parties had agreed that this term was a means-plus-function term, and the district court had adopted a means-plus-function construction.[6] I agree with the parties, the district court, and the Board that the "control component" limitations recite a function without reciting sufficient structure for performing that function and therefore that they are means-plus-function terms.

56. In the institution decision, the Board adopted the district court's construction for the "control component terms":

> Function: receiving control signals input to the oscillating resonant module; receiving outputs from the one or more sensors; controlling oscillation of the mass to produce a vibration response according to the received control signals by generating, using one or more of the received sensor outputs, control outputs to an actuator that drives the mass to oscillate.

[5] Paper 8 at 14.
[6] Ex. 2002 at 39–43.

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Structure: a microcontroller, a processor, a microprocessor, or a CPU that performs the algorithm shown in Figure 45 or the algorithm described in the corresponding text. See, e.g., 31:19–32:13, and equivalents thereof.[7]

57. In particular, the Board (and the district court) determined that the corresponding structure include an algorithm shown in the following Figure 45 and described in lines 31:19–32:13 of the specification[8]:

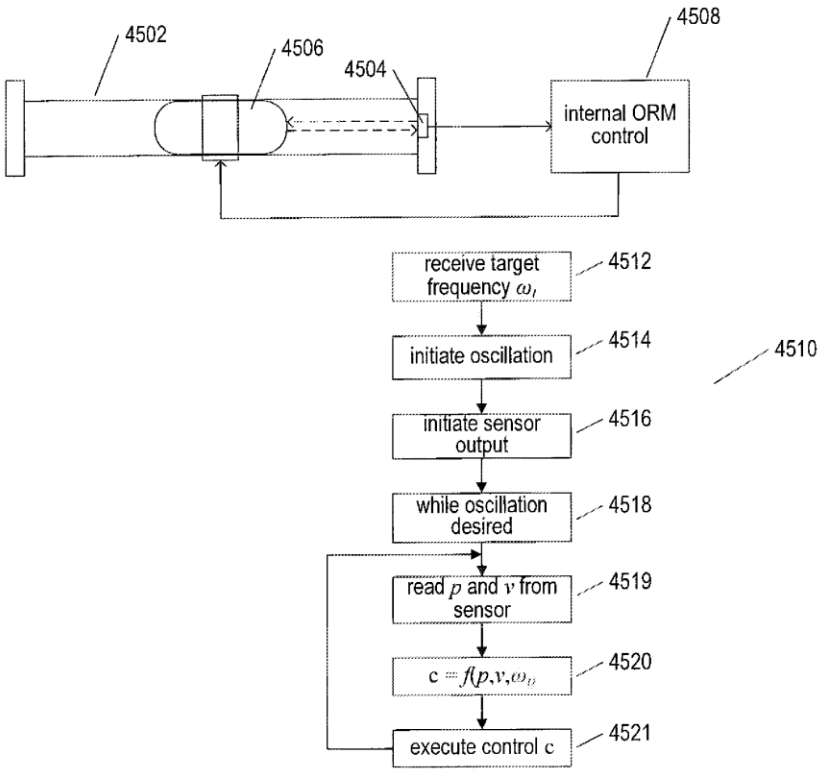

FIG. 45

58. Among other things, this algorithm requires step 4519 "read *p* and *v* from sensor" and step 4520, which the specification describes as including

[7] Paper 8 at 11–12.
[8] '882 Patent, Figure 45.

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"the appropriate control is computed based on the target frequency ω_t and the current position and velocity of the moving mass p and v."[9]

59. While the parties had taken different positions on the corresponding structure for the "control component" terms in the district court litigation, they had agreed that at least in the case where the corresponding structure was a processor, CPU, or microprocessor, it must be programmed with an algorithm that includes at least step 4520 of computing control outputs based upon target frequency and current position and velocity.[10] For each of the grounds, the petition relies on a processor and algorithm to satisfy the "control component" limitations.[11] Accordingly, even if the Board were to revisit its construction of "control component" from the institution decision, under any of the positions taken by either party in the district court litigation or in this IPR concerning the corresponding structure for control component, the algorithms of the processors that Apple's petition relies upon must include at least step 4520.

60. For these reasons, I have assumed the claim construction adopted by the Board in the institution decision for the "control component" terms, but

[9] '882 Patent at 31:44–46.
[10] Ex. 2002 at 39–40, 42.
[11] Petition at 26, 37–38, 44, 53, 59, 61–63.

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my opinions would remain the same under any of the means-plus-function constructions proposed by the parties in the district court litigation.

3. "a segment of a space curve"

61. I note that the Board's institution decision contains a section that addresses the construction of the term "a segment of a space curve," which occurs in both claims 1 and 10.[12] In particular, the Board discusses the question of whether the claimed "space curve" can be linear and determines that it does not need to resolve that question for the purposes of the institution decision.[13] I was not asked to reach a conclusion in this IPR as to whether the "space curve" can be linear. My opinions in this declaration apply whether the "space curve" can be linear or not.

IX. OBVIOUSNESS

A. Ground 1

1. Alexander and Cosper Are Not Analogous Art and a POSITA Would Not Have Been Motivated to Combine

62. Each independent claim of the '882 Patent requires an "oscillating resonant module." As I mention above, this is true whether the preambles are limiting or not. At his deposition, Dr. Hannaford explained that he understood

[12] Paper 8 at 14–15.
[13] Paper 8 at 14–15.

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the term "resonant" to mean "a use of the phenomenon of resonance or reliance on that phenomenon."[14] He explained resonance as follows:[15]

> THE WITNESS:· Resonance is a very general phenomenon of systems that can -- that have components which store and release energy.· So a very typical example is a mass connected to a spring.· Both the mass and the spring store energy but in different ways.
>
> Another one is electrical resonance where a circuit is tuned to a frequency with an inductor and a capacitor, and then the mathematics associated with those circuits have very similar properties, which, in many case, cause the system to oscillate.

63. I agree at a high level with Dr. Hannaford's explanation of resonance. A system cannot be resonant unless it can store and transfer energy between two or more different forms. A mass on a spring is a typical example. Extending or contracting the spring from its resting position requires energy. Some of that energy is lost, for example due to friction; the loss is called damping. But other than damping, the energy is not lost but rather stored in a different form. For example, the compressed spring will tend to return to a relaxed state,

[14] Ex. 2013 at 10:16–22.
[15] Ex. 2013 at 11:2–11.

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and will move the mass back towards the center, converting the stored energy into kinetic energy.

64. When a periodic external force is applied to a resonant system, the amplitude of the resulting oscillation varies with the frequency of the external force. For example, in the idealized case of an undamped or slightly damped oscillator, there is a resonant frequency at which the resulting amplitude will be greatest for a given input. On the other hand, a strongly damped system, or a system with little or ability to store energy, will not exhibit resonance.

65. The "Q factor" is a parameter of resonant systems. It describes how much energy is lost during each cycle of oscillation. A system with a higher Q factor retains more energy than a system with a lower Q factor. A highly damped system that does not effectively retain energy, on the other hand, has a low Q factor.

66. Alexander discloses a specific type of linear actuator that lacks any mechanical ability to store energy. In particular, unlike the embodiments of the '882 Patent, each of which includes either springs or magnets to provide

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a restoring force and thus resonant oscillation, Alexander teaches a linear actuator with a "mover" or "shaft" that can freely slide within the stator assembly.[16] The components of this assembly are in the following figure:[17]

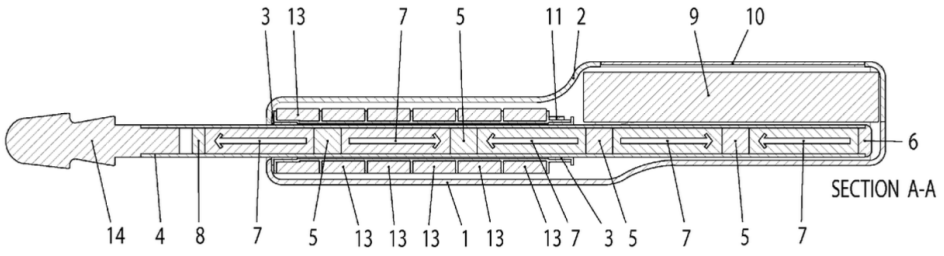

Figure 1A

67. Here, the stator is formed of a number of wire coils 13, and the mover is formed of tube 4, which comprises magnet(s) 7.[18] There are no springs, and there are no permanent magnets in the stator such as the "disk-like magnets [that] act much like springs"[19] as disclosed in the '882 Patent.

68. A POSITA would understand that Alexander does not disclose an oscillating resonant module as claimed. Reviewing Alexander's teachings and considering the expected physical behavior of the disclosed system reveals a

[16] Ex. 1005, ¶¶ [0023]–[0025].
[17] Ex. 1005, Fig. 1A.
[18] Ex. 1005, ¶ [0023].
[19] '882 Patent at 6:51-55.

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system with little or no ability to store energy (*e.g.* with springs or with stationary magnets), and thus little or no resonant behavior. Dr. Hannaford was asked at his deposition whether he believed that "the embodiments taught in Alexander would exhibit resonance associated with the movement of the mover within the stator," and he testified that he did not recall his report "containing any opinion about oscillation in Alexander alone."[20]

69. Dr. Hannaford does not show, or even suggest, that Alexander discloses or renders obvious an oscillating resonant module as claimed. For example, his discussion of the preamble of claim 1 states that Alexander creates a "vibration," without any suggestion that the limitation "resonant" is met.[21] Rather, Dr. Hannaford's opinion for "resonant" is only based on the combination of Alexander and Cosper, which would purportedly include "a bias member, based on Cosper's suggestions."[22] Therefore, Dr. Hannaford's analysis requires combining Alexander and Cosper to form an oscillating resonant module as claimed. He does not show that Alexander and Cosper are analogous art or that a POSITA would be motivated to combine them with a reasonable expectation of success.

[20] Ex. 2013 at 20:3–10.
[21] Ex. 1003, ¶ 79. *See also* Petition at 17.
[22] Ex. 1003, ¶ 79. *See also id.*, ¶¶ 66, 75; Petition at 11–12, 15–17.

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a. Alexander and Cosper are not analogous art.

70. Dr. Hannaford has not shown that Alexander and Cosper are analogous art. Alexander's stated field of endeavor is "linear motors, and more particularly, to programmable electro-magnetic sex toys using a linear motor."[23] For the reasons I explain above, a POSITA reading Alexander would understand that it discloses a non-resonant linear motor; specifically, a motor lacking any spring or other restoring force that could create a resonant effect. Alexander teaches a control system designed for its non-resonant linear motor, which is specifically intended to achieve motion patterns different from harmonic or resonant motion, such as a "'square wave' pattern", or a profile with "fast extension of the mover [and] slow retraction of the mover."[24]

71. Cosper, on the other hand, is specifically directed to "control over mechanical resonant system[s]."[25] Its recited field of invention is "systems and methods for control of a mass and bias (e.g., 'elastomeric members') subassembly, including oscillating mechanical systems, that operate in an oscillatory mode at or near their mechanical resonant frequency."[26] Cosper teaches that, within its field of related art:[27]

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[23] Ex. 1005, ¶ [0002].
[24] Ex. 1005, ¶¶ [0038], [0055].
[25] Ex. 1006, title.
[26] Ex. 1006, ¶ [0003].
[27] Ex. 1006, ¶ [0005]–[0006]

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> Mechanical systems typically have a resonant frequency, a natural frequency at which the system tends to move or oscillate when an impulse is applied. Moving the system at non-resonant frequencies may require significantly more energy. Accordingly, it may be desirable to move and control a mechanical system at or near its resonant frequency to achieve the maximum system movement for a reduced or minimal amount of energy.
>
> The resonant frequency of a mechanical system tends to vary over time, with changes in mass, mechanical or elastomeric properties, ageing, friction, wear or dampening to name but a few. Maintaining a mechanical system moving at its resonant frequency requires significantly less energy, but may involve greater complexity.
>
> Driving a mechanical resonant system for low loss, and a high Q, at or near its resonant frequency using an external frequency references may require a highly stable frequency source. It may also require that the resonant frequency of the mass and spring mechanism itself be very stable.

72. Rather, Cosper describes an optical beam scanner, e.g., where a "light source is used in conjunction with a resonant engine (not shown) having a mirror and a bias, and a mirror driver that oscillates the mirror at or near a

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resonant frequency of the mirror and bias" and "[a]s a result, the spot of light from the light source is effectively scanned over the target."[28]

73. While Cosper does use the words "linear . . . movement" in abstract, the two embodiments shown describe rotational motion of the moving mass. The embodiment shown in fig. 2 describes "the electromagnetic coil 207 can be excited by electrical current to create a magnetic field that interacts with the magnet 209 to load the bias 205 and thereby move the mirror 201 around the light source 203, projecting the light from the opening in the housing 220 in the process."[29] The second embodiment shown in Figure 15 shows clearly rotational movement[30]:

[28] Ex. 1006, ¶ [0067].
[29] Ex. 1006, ¶ [0073].
[30] Ex. 1006, Fig. 15.

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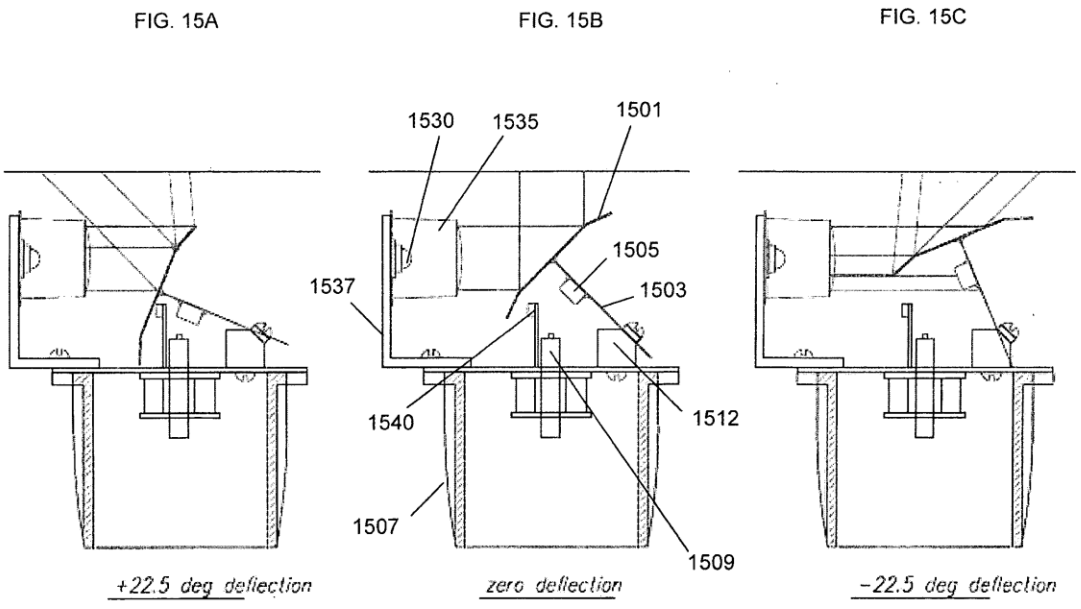

74. Cosper's field of endeavor and problems addressed have nothing to do with Alexander's. At the most general level, Alexander is directed to the field of linear motors, and Cosper is directed to resonant motors. The only overlap is "motors." Cosper is not about linear motors at all, and Alexander is not about resonant motors at all.

75. Cosper is also, plainly, not about sex toys. Cosper does not describe haptics or tactile applications at all.

76. Moreover, Alexander at the very least is not from the same field of endeavor as the challenged '882 patent claims. Claim 1 and its dependent claims are directed to an "oscillating resonant module." Claim 10 and its dependent

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claims are directed to a device containing including one or more such modules. As explained above, the teachings of Alexander are all for sex toys with non-resonant linear motors. These teachings are not in the field of oscillating resonant modules.

77. Nor are the teachings of Alexander reasonably pertinent to the particular problem the inventors of the '882 patent were involved with. The problems that the inventors were seeking to solve are problems of control, and in particular of control in the presence of resonance.[31] Because Alexander does not utilize or address resonance, its teachings are not pertinent to the problem of achieving control in the presence of resonance.

78. To the extent that Apple identifies in its reply a field of endeavor or problem for the '882 patent claims that differs from the endeavor or problem identified above, Alexander and Cosper differ so dramatically from one another in their fields of endeavor and problems they address (as explained above) that they cannot both be in the same field of endeavor or be pertinent to the same problem as the '882 patent claims. They cannot both be analogous art.

[31] '882 patent at title, abstract, 2:66–3:14, 4:51–5:9.

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b. No Motivation to Combine

79. Dr. Hannaford also does not and cannot show that a POSITA would be motivated to combine Alexander and Cosper in order to achieve all the limitations of the '882 Patent.

80. For example, in his opinion a POSITA would be motivated to combine Alexander and Cosper in order "to provide the option of oscillation at or near a resonant frequency," specifically in order to enjoy "the advantage of facilitating increased system movement for a reduced or minimal amount of energy, in at least some operating scenarios (e.g., when oscillating over at least a portion of the available stroke)."[32] Dr. Hannaford cites to nothing in Alexander that shows this would be beneficial. In fact, Dr. Hannaford's opinion at least partially contradicts itself.

81. Alexander specifically teaches that it is desirable for the "stroke" of the system (*i.e.*, how far it travels back and forth) to be a controllable parameter, and for the stroke to be as long as six inches.[33] A POSITA would therefore recognize that Alexander already possesses an advantageously wide system movement. Dr. Hannaford gives no explanation why increasing the system

[32] Ex. 1003, ¶ 71.
[33] Ex. 1005, ¶¶ [0037], [0040], [0055], [0059].

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movement even further beyond the disclosed six-inch stroke would be beneficial. And Dr. Hannaford's suggestion that this benefit might be provided only for "a portion of the available stroke" implies that there might be an overall reduction of stroke length.

82. A POSITA would also recognize that changing Alexander from a non-resonant to a resonant design would likely decrease or eliminate its ability to provide the full functionality disclosed in the reference. For example, Alexander teaches that its non-resonant system can provide a range of preferable motion patterns, such as a "'square wave' pattern", or a profile with "fast extension of the mover [and] slow retraction of the mover."[34] These motion patterns would be impaired, rather than helped, by the addition of resonance.

83. For example, in a non-resonant system producing a "square wave" pattern, such as Alexander's disclosure of "cycl[ing] between 1 inch extension and 4 inch extension, back and forth, at, for example, 1 Hz intervals,"[35] there is essentially no power required during the non-moving parts of the "square," *i.e.* the dwell time at the 1 inch and 4 inch positions respectively. But in a resonant system, *e.g.* where a spring or elastomeric member has been added, the coils must constantly supply a force at extension to counteract the

[34] Ex. 1005, ¶¶ [0038], [0055].
[35] Ex. 1005, ¶ [0038].

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spring/elastomeric restoring force. Producing that force accomplishes no useful work (because there is no motion), but consumes electrical power, all of which is wasted as heat.

84. A POSITA would also not have a reasonable expectation of success in the proposed combination. In Dr. Hannaford's theory, the POSITA would add Cosper's "bias member" to Alexander's embodiment.[36] He states without evidence that "the bias member would have been readily selected with characteristics to facilitate operation at a resonant frequency over at least a portion of the mover's stroke."[37] As I mention above, Alexander's embodiment preferably has a stroke length of at least six inches. A POSITA reviewing Alexander would recognize that many of its features are specifically tuned for a long stroke length, measured in inches not millimeters. The only frequency mentioned in Alexander is 1 Hz.[38] Dr. Hannaford does not discuss the practical application of Alexander's system in any detail, and does not explain any context in which it would be desirable or safe to operate a sex toy with a stroke length of several inches at a frequency substantially above 1 Hz. In contrast,

[36] Ex. 1003, ¶ 66.
[37] Ex. 1003, ¶ 66.
[38] Ex. 1003, ¶ 38.

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the ’882 Patent discloses modules operating at substantially higher frequencies, even above 350 Hz.[39]

85. The resonant frequency can be calculated as $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$. Assuming the mass m is in the range of a tenth of a kilogram, the spring constant must be approximately 4 N/m, or 0.023 lbf/in to achieve a resonant frequency of 1 Hz. This would be a very weak spring. At a displacement of three inches (half of the six-inch stroke), the maximum restoring force would be approximately 0.3 N, which is approximately the same as the force of gravity on a 31 gram object. Dr. Hannaford does not and cannot show that a bias member could provide any plausible benefit for resonant operation in the 1 Hz range, as taught by Alexander.

86. It is not clear what Dr. Hannaford means by “operation at a resonant frequency over at least a portion of the mover’s stroke.” If adding the bias member reduces the total stroke, then it would be disadvantageous as I describe above. If, on the other hand, the bias member only provides resonant operation within a portion of the stroke, then the behavior of the overall system would be seriously impaired.

[39] ’882 Patent at Fig. 3; *see also id.* at 2:48 (prior unbalanced electric motors could only operate at around 80 Hz).

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87. In particular, the resonant behavior of the bias member is only well behaved in region where the spring constant of the bias member is actually constant, *i.e.* where the system response is linear. Outside that region (where the spring/elastomer is expended or compressed too much), the spring "constant" will begin changing, and the system behavior will become nonlinear. At some point, the spring/elastomer will permanently deform and even break. But a POSITA would recognize that even before that point, the system will suffer unpredictable and negative effects from nonlinearity.

88. And Dr. Hannaford does not and cannot show that a POSITA would have been able to select a bias member with a working or linear range large enough to cover the full stroke length of Alexander's embodiment that would be physically compatible with the overall system. Put simply, there needs to be a place to put the spring or elastomeric member. Typically springs would be placed at the end of the movable component, as in the '882 Patent's Fig. 40A:

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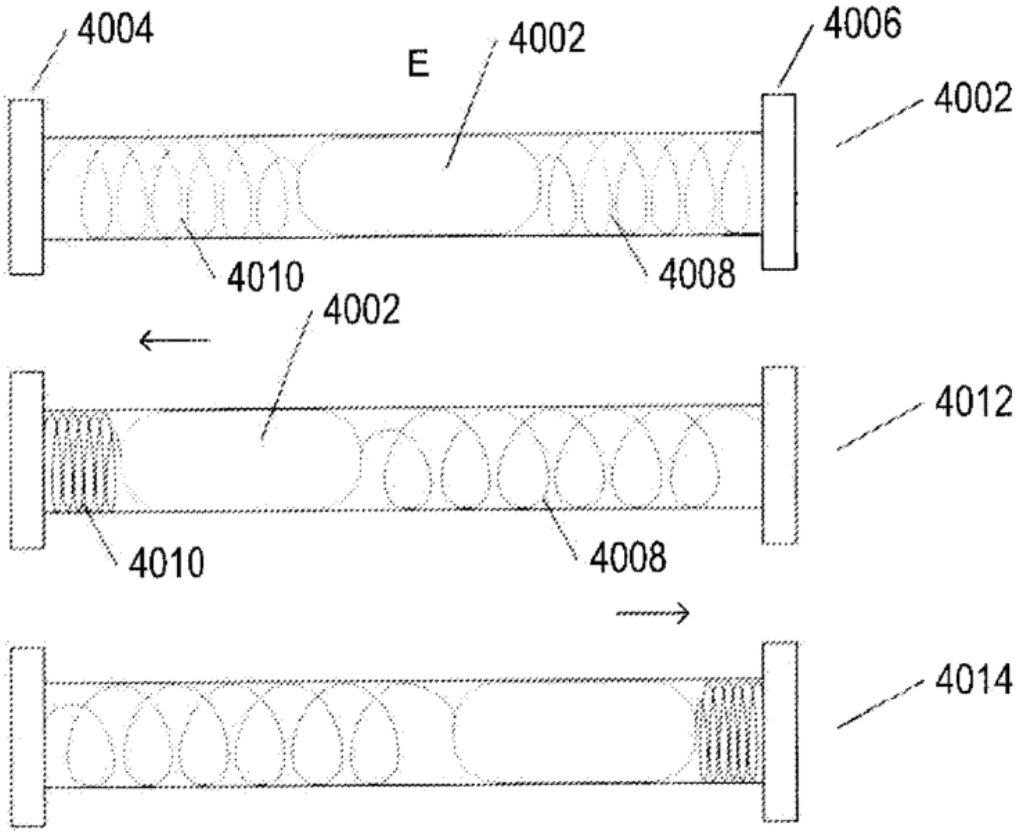

FIG. 40A

89. There is not space in Alexander's embodiment for such a spring, particularly in the "double-ended" embodiment:[40]

[40] Ex. 1005, Fig. 9B.

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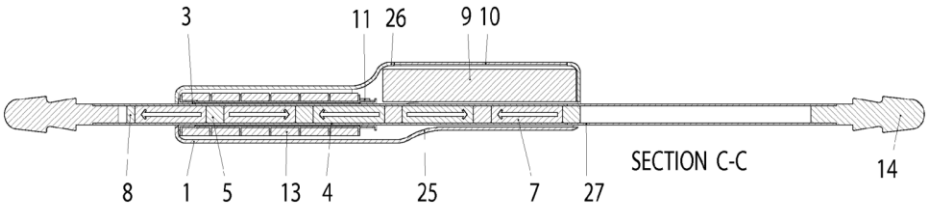

Figure 9B

90. Dr. Hannaford has failed to show that a POSITA would have been motivated to add Cosper's resonant operation to Alexander's non-resonant linear motor—much less that a POSITA could reasonably expect such a combination to be successful. Because his claim mapping for Ground 1 requires that combination, he fails to show that any claim is obvious.

B. Grounds 2A-2H

1. Failure to Satisfy Steps 4519 and 4520 of "control component"

a. Ground 2A

91. For Grounds 2A-2H, for the "sensor" limitations of claims 1 and 10, the petition points to an embodiment of Gregorio utilizing a position sensor such as a "Hall sensor" or "optical sensor."[41] In Gregorio, this embodiment is an alternative to an embodiment that makes use of measurement of "back

[41] Petition at 43, 53; '882 patent at 4:7–13.

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EMF."[42] As Gregorio says, in the position sensor embodiment, the sensed position signal is used "instead of the back EMF."[43]

92. The back EMF measurement does not measure position. Rather, as Gregorio explains, the back EMF is a "voltage generated by the internal motion inside LRA 18."[44] If the mass in Gregorio is stationary (even momentarily), the back EMF voltage will be zero, independent of what its position is at that point in time. As Dr. Hannaford testified, the back EMF voltage is proportional to the velocity of the magnet.[45] For example, he testified[46]:

> Q. Okay. So would you agree that Gregorio's back EMF measurement would not provide a measurement of the position of the magnet?
>
> A. Very generally, back EMF is caused by a magnet's velocity, and the voltage of a back EMF-based sensor is proportional to the velocity of the magnet relative to a coil. Velocity—a POSITA would have several means to convert a velocity measurement to a position measurement.
>
> Is—I'll—that's my answer, I guess.

[42] Ex. 1007 at 3:65–4:7, 4:10–14.
[43] Ex. 1007 at 4:10–14.
[44] Ex. 1007 at 4:26–27.
[45] Ex. 2012 at 17:15–21; Ex. 2013 at 34:5–35:6.
[46] Ex. 2013 at 34:5–35:6.

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> Q. Suppose that the only piece of information you had was the back EMF voltage measurement from Gregorio's system at a single point in time. Would a POSITA have a way of deducing from that single value the position of the mass—or magnet of Gregorio?
>
> A. I—I don't recall that this is anything that I formed an opinion on in my report. Answering your question in the abstract, in a digital system, probably not.
>
> An analog circuit could convert, as I said before, by a process known as integration. It could convert the velocity signal to a position, and that could be sampled at a single point in time.

93. While it may be possible to deduce position from integrating velocity measurements over a period of time, Gregorio does not describe doing so. Rather, Gregorio provides a detailed description of control utilizing the back EMF signal alone.[47] In particular, "the LRA vibration amplitude is measured based upon the derivative of the speed of the mass ('dv/dt'), which is based on the back EMF."[48] No similar description is provided for how control would be achieved if a position sensor such as a Hall sensor was used, but a POSITA

[47] Ex. 1007 at 4:15–5:55.
[48] Ex. 1007 at 4:44–46.

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desiring to measure amplitude using a position sensor would do so by comparing position measurements directly, rather than by deriving velocity from position measurements and then taking a derivative of the derived velocity.

94. The petition argues that a POSITA would have found it obvious to determine velocity from Gregorio's position data.[49] But at most the petition shows that a POSITA could have determined velocity from the position data, not that the POSITA would have been motivated to do this. The asserted benefits of an "alternative source of velocity information" or enhanced redundancy and reliability are generic, conclusory, and unsupported by any reasoning.[50] The stated purpose for tracking the motion of the mass in Gregorio is to determine the resonant frequency.[51] Apple and Dr. Hannaford do not explain how adding a velocity value to the position value provided by the sensor in Gregorio furthers the goal of determining the resonant frequency. To the extent that the position measurement is inaccurate or unreliable, velocity values calculated from the position measurement will be no better and are not really an "alternative source" of anything. Apple and Dr. Hannaford do not explain how a velocity derived from position data would improve redundancy or reliability over using the position data itself.

[49] Petition at 48.
[50] Petition at 48; Ex. 1003, ¶ 178.
[51] Ex. 1007 at 3:65–67.

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95. The petition asserts that Gregorio performs step 4520, computing the control based upon target frequency and current position and velocity, but it fails to show this is the case.[52] In particular, the petition mixes teachings from two alternative embodiments, one embodiment that uses back EMF and measures speed,[53] and a distinct embodiment that uses position measurements from a Hall sensor, optical sensor, etc.[54] Gregorio expressly presents these as alternatives, with the position signal being used in an embodiment "instead of the back EMF signal."[55] The petition provides no evidence that Gregorio suggests using both position sensing and back-EMF speed sensing in the same system or that a POSITA would have been motivated to modify Gregorio's embodiments in order to do this.

96. Step 4520 further requires computing control signals based on the target frequency and the current position and velocity. The petition and Dr. Hannaford's declaration fail to show that there is a signal that is actually based on all three of these parameters. Both the petition and Dr. Hannaford's declaration rely upon lines 2:3–9 of Gregorio as purportedly showing this,[56] but these lines refer to "determin[ing]" the resonant frequency and do not mention using

[52] Petition at 48–49.
[53] Ex. 1007 at 4:42–48.
[54] Ex. 1007 at Abstract, 6:55–58, 1:43–46, cl. 11
[55] Ex. 1007 at 4:10–14.
[56] Petition at 49; Ex. 1003, ¶ 179.

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position and velocity.[57] Nowhere does Gregorio describe computing control signals based on both position and velocity, let alone on both together with a target frequency.

97. For these reasons, the petition fails to show that Gregorio discloses or renders obvious the "control component" of limitations [1d] and [10f], under the proper construction of this term in claims 1 and 10. Claims 2–6, 17, 19, and 20 depend on claims 1 and 10 and rely on the same disclosures to satisfy limitations [1d] and [10f] and thus fail to show obviousness for the same reasons.[58]

b. Grounds 2B–2D

98. Grounds 2B, 2C, and 2D rely on the same disclosures of Gregorio for steps 4519 and 4520 in limitations [1d] and [10f] as Ground 2A.[59] These grounds thus fail to show obviousness for the same reasons as Ground 2A.

c. Grounds 2E–2H

99. Grounds 2E-2H rely upon combination with Muramatsu to satisfy limitations in dependent claims 3–6. The petition does not argue that the combination with Muramatsu satisfies limitations [1d] or [10f] in any way different

[57] Ex. 1007 at 2:3–9.
[58] Petition at 50–51, 53–55.
[59] Petition at 59, 61–65.

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than the combinations in Grounds 2A-2D.[60] Importantly, Muramatsu does not describe or teach a system that oscillates or that exhibits resonance. Rather, Muramatsu is concerned with providing a variable resistance force to a user interacting with a manipulator, for example in a virtual reality system.[61] Muramatsu does not use the words oscillate, oscillation, resonance, or frequency. It does use the words "vibrate" and "vibrations," but solely in the context of explaining how an acoustic piano works and that a hammer in the piano causes a string to vibrate.[62] There is no mention of a key or other manipulator being used by the user vibrating.

100. Because Muramatsu is not concerned with oscillations or with frequencies, its teachings concerning data tables do not make use of a target frequency, as required in step 4520 of the "control component" algorithm. Accordingly, Muramatsu does not teach a "control component" that satisfies limitation [1d], and the petition offers no argument for how combining with Muramatsu would remedy the deficiencies the of Grounds 2A–2D with respect to limitation [1d]. For these reasons, the combinations in Grounds 2E–2H fail to satisfy limitation [1d] for the same reasons as the art in Grounds 2A–2D and they therefore fail to satisfy dependent claims 3–6.

[60] Petition at 65–71.
[61] Ex. 1009 at 1:56–2:44.
[62] Ex. 1009 at 1:14–36.

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X. CONCLUSION

101. In signing this declaration, I understand that the declaration will be filed as evidence in proceedings before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

102. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct and 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 further, that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

Executed on March 4, 2025

Keith W. Goossen, Ph.D.

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