

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

NYXOAH, INC., and
NYXOAH SA,
Petitioners,

v.

INSPIRE MEDICAL SYSTEMS, INC.,
Patent Owner.

U.S. Patent No. 10,898,709

Issue Date: January 26, 2021

Title: STIMULATION FOR TREATING SLEEP DISORDERED BREATHING

Inter Partes Review No.: IPR2026-00090

**DECLARATION OF DR. GERALD LOEB IN SUPPORT OF PETITION
FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 10,898,709**

TABLE OF CONTENTS

	Page
I. Introduction.....	15
II. Background and Qualifications	16
III. Legal standards	17
IV. Level of Ordinary Skill in the Art	23
V. Technical Background and State of the Art	25
A. Neuromuscular Stimulators.....	26
B. Obstructive Sleep Apnea Treatment	29
1. Closed-Loop Systems	31
2. Open-Loop Systems.....	32
C. Duty Cycles	32
VI. Overview of the '709 patent	35
A. Priority Date	35
B. Overview of the Disclosure of the '709 Patent	35
C. Prosecution History	43
VII. Overview of the Prior Art.....	66
A. Durand (EX-1006).....	66
1. Prior Art Status.....	66
2. Summary of Durand's Disclosure.....	67
B. Hoegh (EX-1007).....	70

1.	Prior Art Status.....	70
2.	Summary of Hoegh’s Disclosure	71
C.	Headley (EX-1008)	72
1.	Prior Art Status.....	72
2.	Summary of Headley’s Disclosure	72
D.	Tran (EX-1009, EX-1010)	74
1.	Prior Art Status.....	74
2.	Summary of Tran’s Disclosure	75
VIII.	Summary of Invalidity Grounds	80
IX.	GROUND 1: Challenged Claims 1-12, 14, and 15 are Obvious from Durand in view of Hoegh	80
A.	Reasons to Combine Durand and Hoegh	80
B.	Application of Durand and Hoegh to Challenged Claims 1-12, 14, and 15	87
1.	Claim 1	87
a.	[1.pre] <i>A device for treating obstructive sleep apnea, comprising:</i>	87
b.	[1.a1] <i>a non-cardiac stimulation element to engage and to stimulate an upper-airway-patency-related nerve;</i>	88
c.	[1.a2] <i>according to a first stimulation therapy protocol not synchronized to actively-sensed respiratory information,</i>	90
d.	[1.b] <i>wherein the first stimulation therapy protocol comprises a series of repeating stimulation cycles</i>	

	<i>in which each stimulation cycle includes a stimulation period and a non-stimulation period, ...</i>	93
e.	<i>[1.c] wherein each stimulation period includes continuous stimulation and has a minimum duration equal to or greater than an inspiratory reference of a reference respiratory cycle, wherein the inspiratory reference corresponds to a duration of an inspiratory phase of the reference respiratory cycle, and</i>	94
f.	<i>[1.d] wherein the reference respiratory cycle comprises at least one of: a historical patient-specific average respiratory cycle for stable respiration; and a multi-patient average respiratory cycle for stable respiration, and</i>	98
g.	<i>[1.e] wherein each stimulation period of each respective stimulation cycle has a duration greater than a duration of the inspiratory reference of the reference respiratory cycle and the stimulation period is followed by the non-stimulation period of the respective stimulation cycle comprising a duration less than the duration of the stimulation period.</i>	101
2.	Claim 2	104
a.	<i>[2] The device of claim 1, wherein the non-cardiac stimulation element comprises an implantable electrode and a pulse generator electrically connected to the implantable electrode.</i>	104
3.	Claim 3	106
a.	<i>[3] The device of claim 2, wherein the implantable electrode comprises a cuff electrode including at least one operative contact group through which the stimulation is deliverable non-selectively to the upper-airway-patency-related nerve.</i>	106

4.	Claim 4.....	110
a.	[4] <i>The device of claim 1, wherein a total duration of stimulation via the first stimulation protocol during a treatment period is greater than 30 percent of the total duration of the treatment period.</i>	110
5.	Claim 5.....	112
a.	[5] <i>The device of claim 1, wherein the duration of the stimulation period comprises at least 50 percent of a duration of the stimulation cycle.</i>	112
6.	Claim 6.....	113
a.	[6] <i>The device of claim 1, wherein the duration of the stimulation period comprises at least 50 percent of a duration of the reference respiratory cycle.</i>	113
7.	Claim 7	116
a.	[7] <i>The device of claim 1, wherein the duration of each respective stimulation cycle is less than the duration of the reference respiratory cycle, and a duration of the stimulation period exceeds the duration of the non-stimulation period by a factor of at least 3.</i>	116
8.	Claim 8.....	119
a.	[8] <i>The device of claim 1, wherein the duration of each respective stimulation cycle is greater than the duration of the reference respiratory cycle.</i>	119
9.	Claim 9.....	121
a.	[9] <i>The device of claim 8, wherein the stimulation period and the non-stimulation period are in a proportion of at least 1.5 to 1.</i>	121

10.	Claim 10.....	122
a.	[10] <i>The device of claim 8, wherein the duration of the stimulation cycle is less than a duration of two consecutive reference respiratory cycles.....</i>	122
11.	Claim 11	124
a.	[11] <i>The device of claim 1, wherein the duration of each respective stimulation cycle is equal to the duration of the reference respiratory cycle, and wherein the duration of the reference respiratory cycle differs from a duration of a real time respiratory cycle from actively-sensed respiration information by an amount exceeding a duration variability criteria.....</i>	124
12.	Claim 12.....	128
a.	[12a] <i>The device of claim 1, comprising: a processor; and</i>	128
b.	[12.b] <i>a non-volatile computer readable medium storing instructions, executable on the processor, to implement the non-cardiac stimulation element and to perform the first stimulation therapy protocol.....</i>	128
13.	Claim 14.....	131
a.	[14.a] <i>The device of claim 1, comprising: a sensing element to obtain the actively-sensed respiratory information; and</i>	131
b.	[14.b] <i>a control portion including: a processor; and a non-volatile memory storing instructions, executable via the processor to:</i>	132
c.	[14.c] <i>provide convertible operation via a therapy manager between: a first stimulation mode</i>	

	<i>implementing the first stimulation therapy protocol; and</i>	133
d.	<i>[14.d] a second stimulation mode of stimulating the upper-airway-patency-related nerve synchronous with a characteristic of the actively-sensed respiratory information.....</i>	135
14.	Claim 15.....	136
a.	<i>[15] The device of claim 1, wherein the stimulation period and the non-stimulation period are in a proportion of at least 1.5 to 1.</i>	136
X.	GROUND 2: Challenged Claims 1, 2, 4-10, 12, 13, and 15 are Obvious from Headley in view of Tran.....	136
A.	Reasons to Combine Headley and Tran	136
B.	Application of Headley and Tran to Challenged Claims 1, 2, 4-10, 12, 13, and 15	144
1.	Claim 1	144
a.	<i>[1.pre] A device for treating obstructive sleep apnea, comprising:</i>	144
b.	<i>[1.a1] a non-cardiac stimulation element to engage and to stimulate an upper-airway-patency-related nerve;</i>	146
c.	<i>[1.a2] according to a first stimulation therapy protocol not synchronized to actively-sensed respiratory information, ...</i>	156
d.	<i>[1.b] wherein the first stimulation therapy protocol comprises a series of repeating stimulation cycles in which each stimulation cycle includes a stimulation period and a non-stimulation period, ...</i>	158

e.	[1.c] wherein each stimulation period includes continuous stimulation and has a minimum duration equal to or greater than an inspiratory reference of a reference respiratory cycle, wherein the inspiratory reference corresponds to a duration of an inspiratory phase of the reference respiratory cycle, and	160
f.	[1.d] wherein the reference respiratory cycle comprises at least one of: a historical patient-specific average respiratory cycle for stable respiration; and a multi-patient average respiratory cycle for stable respiration, and	164
g.	[1.e] wherein each stimulation period of each respective stimulation cycle has a duration greater than a duration of the inspiratory reference of the reference respiratory cycle and the stimulation period is followed by the non-stimulation period of the respective stimulation cycle comprising a duration less than the duration of the stimulation period.	166
2.	Claim 2	167
a.	[2] The device of claim 1, wherein the non-cardiac stimulation element comprises an implantable electrode and a pulse generator electrically connected to the implantable electrode.	167
3.	Claim 4	170
a.	[4] The device of claim 1, wherein a total duration of stimulation via the first stimulation protocol during a treatment period is greater than 30 percent of the total duration of the treatment period.	170
4.	Claim 5	175

a.	<i>[5] The device of claim 1, wherein the duration of the stimulation period comprises at least 50 percent of a duration of the stimulation cycle.</i>	175
5.	Claim 6.....	177
a.	<i>[6] The device of claim 1, wherein the duration of the stimulation period comprises at least 50 percent of a duration of the reference respiratory cycle.</i>	177
6.	Claim 7.....	180
a.	<i>[7] The device of claim 1, wherein the duration of each respective stimulation cycle is less than the duration of the reference respiratory cycle, and a duration of the stimulation period exceeds the duration of the non-stimulation period by a factor of at least 3.....</i>	180
7.	Claim 8.....	181
a.	<i>[8] The device of claim 1, wherein the duration of each respective stimulation cycle is greater than the duration of the reference respiratory cycle.</i>	181
8.	Claim 9.....	183
a.	<i>[9] The device of claim 8, wherein the stimulation period and the non-stimulation period are in a proportion of at least 1.5 to 1.</i>	183
9.	Claim 10.....	184
a.	<i>[10] The device of claim 8, wherein the duration of the stimulation cycle is less than a duration of two consecutive reference respiratory cycles.....</i>	184
10.	Claim 12.....	185

a.	[12.a] <i>The device of claim 1, comprising: a processor; and</i>	185
b.	[12.b] <i>a non-volatile computer readable medium storing instructions, executable on the processor, to implement the non-cardiac stimulation element and to perform the first stimulation therapy protocol.</i>	186
11.	Claim 13	187
a.	[13.a] <i>The device of claim 1, comprising: a sensing element to at least periodically actively sense respiratory information to obtain the actively-sensed respiratory information unrelated to stimulation synchronization,</i>	187
b.	[13.b] <i>wherein the non-cardiac stimulation element is activated for stimulation upon the sensing element identifying, via at least the actively-sensed respiratory information, obstructive sleep apnea behavior which meets or exceeds a severity threshold and wherein the non-cardiac stimulation element is deactivated upon the sensing element identifying, via at least the actively-sensed respiratory information, that the obstructive sleep apnea behavior is less than the severity threshold.</i>	189
12.	Claim 15	192
a.	[15] <i>The device of claim 1, wherein the stimulation period and the non-stimulation period are in a proportion of at least 1.5 to 1.</i>	192
XI.	Secondary Considerations do not Rebut the Prima Facie Case of Obviousness	192
XII.	Conclusion	193

Petitioners' Exhibit List

<i>Exhibit #</i>	<i>Description</i>
1001	U.S. Patent No. 10,898,709 (the "'709 Patent")
1002	Select portions of the prosecution history of the '709 Patent ("File History")
1003	[Reserved]
1004	Declaration of Petitioners' Expert Dr. Ingrid Hsieh-Yee
1005	International Patent Application Publication No. WO 2016/149344
1006	U.S. Patent Application Publication No. 2006/0224211 ("Durand")
1007	U.S. Patent Application Publication No. 2015/0094962 ("Hoegh")
1008	International Patent Application Publication No. WO 2010/006218 ("Headley")
1009	Tran et al., "Development of Asynchronous, Intralingual Electrical Stimulation to Treat Obstructive Sleep Apnea," Proceedings of the 25th Annual International Conference of the IEEE EMBS, Cancun, Mexico (September 17-21, 2003) ("Tran-I")
1010	Tran et al., "First Subject Evaluated with Simulated BION™ Treatment in Posterior Genioglossus to Prevent Obstructive Sleep Apnea," Proceedings of the 26th Annual International Conference of the IEEE EMBS, San Francisco, CA (September 1-5, 2004) ("Tran-II")
1011	U.S. Patent No. 5,944,680 ("Christopherson")
1012	U.S. Patent Application Publication No. 2014/0228905 ("Bolea")
1013	Mortimer, "Electrical Excitation of Nerve," Neural Prostheses – Fundamental Studies, Chapter 3 (1990) ("Mortimer")
1014	Anagnostopoulos, et al., "Electronic Pacemakers of the Heart, Gastrointestinal Tract, Phrenic Nerve, Bladder, and Carotid Sinus: Current Status," Surgery 60:2, 480-494 (August 1966) ("Anagnostopoulos")
1015	Glenn et al., "Electrical Stimulation of Excitable Tissue by Radio-Frequency Transmission," Annals of Surgery 160:3, 338-350 (1964) ("Glenn")

<i>Exhibit #</i>	<i>Description</i>
1016	Judson et al., “Radio-Frequency Electrophrenic Respiration – Long-Term Application to a Patient with Primary Hypoventilation,” JAMA 203:12, 1033-1037 (March 18, 1968) (“Judson”)
1017	Singh, et al., “Recruitment Properties of Intramuscular and Nerve-Trunk Stimulating Electrodes,” IEEE Transactions on Rehabilitation Engineering, 8:3, 276-285 (September 2000) (“Singh”)
1018	Richmond et al., “Tactical Application of Sensorimotor Prosthetic Technology,” Proceedings of the 25th Annual International Conference of the IEEE EMBS, Cancun, Mexico (September 17-21, 2003) (“Richmond”)
1019	Edmonds, et al., “The Effects of Transcutaneous Electrical Stimulation During Wakefulness and Sleep in Patients with Obstructive Sleep Apnea,” Am Rev Respir Dis, 146:1030-1036 (1992) (“Edmonds”)
1020	Miki et al., “Effects of Submental Electrical Stimulation During Sleep on Upper Airway Patency in Patients with Obstructive Sleep Apnea,” Am Rev Respir Dis 140:1285-1289 (1989) (“Miki”)
1021	Decker et al., “Functional Electrical Stimulation and Respiration During Sleep,” Journal of Applied Physiology, 75(3): 1053-1061 (1993) (“Decker”)
1022	Eisele et al., “Direct Hypoglossal Nerve Stimulation,” Arch. Otolaryngol Head Neck Surg., 123:57-61 (1997) (“Eisele1997”)
1023	Fuller et al., “Effect of Co-Activation of Tongue Protrudor and Retractor Muscles on Tongue Movements and Pharyngeal Airflow Mechanics in the Rat,” Journal of Physiology 519, 2, 601-613 (1999) (“Fuller”)
1024	U.S. Patent No. 6,572,543 (“Christopherson ’543”)
1025	Schwartz et al., “Electrical Stimulation of the Lingual Musculature in Obstructive Sleep Apnea,” J Appl Physiol. (81(2):643-652 (1996) (“Schwartz1996”)
1026	Goding et al., “Relief of Upper Airway Obstruction With Hypoglossal Nerve Stimulation in the Canine,” Laryngoscope, 108:162-169 (1998) (“Goding”)
1027	U.S. Patent No. 4,830,008 (“Meer”)

<i>Exhibit #</i>	<i>Description</i>
1028	Yoo et al., “Selective Stimulation of the Hypoglossal Nerve: A FINE Approach to Treating Obstructive Sleep Apnea,” Proceedings of the Second Joint EMBS/BMES Conference, 2049-2050 (October 23-26, 2002) (“Yoo”)
1029	Fairbanks et al., “Neurostimulation for Obstructive Sleep Apnea,” ENT Journal (January 1993) (“Fairbanks”)
1030	Schwartz et al., “Therapeutic Electrical Stimulation of the Hypoglossal Nerve in Obstructive Sleep Apnea,” Arch Otolaryngol Head Neck Surg., Vol. 127 (Oct. 2001) (“Schwartz2001”)
1031	Oliven, “Treating Obstructive Sleep Apnea with Hypoglossal Nerve Stimulation,” Current Opinion in Pulmonary Medicine 17:419-424 (2011) (“Oliven”)
1032	Mwenge et al., “Targeted Hypoglossal Neurostimulation for Obstructive Sleep Apnoea: a 1-Year Pilot Study,” Eur Respir J. 41:360-367 (2013) (“Mwenge”)
1033	Zaidi et al., “Tongue Anatomy and Physiology, the Scientific Basis for a Novel Targeted Neurostimulation System Designed for the Treatment of Obstructive Sleep Apnea,” Neuromodulation; 16:376-386 (2013) (“Zaidi”)
1034	Steier et al., “Continuous Transcutaneous Submental Electrical Stimulation in Obstructive Sleep Apnea,” Chest 140:998-1007 (2011) (“Steier”)
1035	Agnew et al., “Considerations for Safety with Chronically Implanted Nerve Electrodes,” Epilepsia, 31 (Suppl. 2): S27-32 (1990) (“Agnew”)
1036	U.S. Patent No. 7,277,749 (“Gordon”)
1037	Meadows et al., “Effective of Targeted Activation of Tongue Muscles on Oropharyngeal Patency in the Rat,” Journal of the Neurological Sciences, 346:178-193 (August 2014) (“Meadows”)
1038	Eastwood et al., “Treating Obstructive Sleep Apnea with Hypoglossal Nerve Stimulation,” SLEEP, 34:11, 1479-1486C (2011) (“Eastwood”)
1039	Sinha et al., “Safety of Microstimulator During Radiation Therapy – A Preliminary Study on Head and Neck Cancer Patients,” J. Nucl. Med. Radiat. Ther. 5:4 (2014) (“Sinha”)

<i>Exhibit #</i>	<i>Description</i>
1040	Kaplan et al., “Preventing ischial pressure ulcers: III. Clinical pilot study of chronic neuromuscular electrical stimulation,” Applied Bionics and Biomechanics 8, 345359 (2011) (“Kaplan”)
1041	Bailey et al., “Anatomic consequences of intrinsic tongue muscle activation,” J Appl Physiol 101:1377-1385 (2006) (“Bailey”)
1042	Brennick et al., “MRI study of pharyngeal airway changes during stimulation of the hypoglosseal nerve branches in rats,” J Appl Physiol 90:1373-1384 (2001) (“Brennick”)
1043	Oliven et al., “Upper airway response to electrical stimulation of the genioglossus in obstructive sleep apnea,” J Appl Physiol 95:2023-2029 (2003) (“Oliven2003”)
1044	Oliven et al., “Effect of coactivation of tongue protrusor and retractor muscles on pharyngeal lumen and airflow in sleep apnea patients,” J Appl Physiol 103:1662-1668 (2007) (“Oliven2007”)

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

I, Dr. Gerald Loeb, declare as follows:

I. INTRODUCTION

1. I have been retained by Duane Morris on behalf of Nyxoah, Inc. and Nyxoah SA (collectively, “Nyxoah” or “Petitioners”) as an independent, technical expert consultant in this proceeding before the United States Patent and Trademark Office (USPTO).¹ I have been asked to consider whether certain references disclose or suggest the limitations found in the claims of U.S. Patent No. 10,898,709 (“’709 Patent”), which I may reference as the “Challenged Patent” in this Declaration as discussed in detail below. My opinions are set forth below.
2. I am being compensated at my rate of \$600 per hour for my services. No part of my compensation depends on my opinions or the outcome of this proceeding. I have no financial interest in any of the parties to this petition.
3. Unless otherwise noted, all emphasis in quotations and/or annotations to figures have been added.

¹ Where appropriate, I refer to exhibits that I understand are attached to the Petition for *Inter Partes Review* (IPR) of the Challenged Patent.

II. BACKGROUND AND QUALIFICATIONS

4. My complete qualifications and professional experience are described in my Curriculum Vitae, a copy of which is found in **Appendix A** to this Declaration.
5. The following is a brief summary of my relevant qualifications and professional experience.
6. I have a bachelor's and a medical degree from Johns Hopkins University. I am currently Professor of Biomedical Engineering at the Viterbi School of Engineering in the University of Southern California, a position I have held since 1999. I also have joint appointments as a Professor of Neurology and Pharmacy and I direct the Medical Device Development Facility at USC. From 1994 to 1999, I was Chief Scientist for Advanced Bionics Corp., where I was actively involved in the development of their BION® neuromuscular stimulator, their spinal cord epidural stimulator and their Clarion® cochlear implant system. From 2012 to 2020 I was Chief Scientist for General Stim Inc., where I led the development of their NuStim® neuromuscular stimulator. Most of my research and teaching has been on the development of implanted electronic medical devices and on the signal processing functions of the nervous system.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

7. I have published over 400 journal articles and I am an inventor on over 75 issued US patents, of which about 40 are directly related to neuromuscular stimulation. A list of 31 journal articles that I have published on neuromuscular stimulation can be found at <https://mddf.usc.edu/projects/bion-and-nustim-technology-application/>. I have published two papers and been awarded one US patent specifically on neuromuscular stimulation to relieve obstructive sleep apnea and one US patent for neuromuscular stimulation to relieve snoring.
8. I teach courses on the development and regulation of medical devices and specifically on implantable devices and instrumentation whereby bioelectric signals can be used to diagnose and treat neurological and neuromuscular disorders.

III. LEGAL STANDARDS

9. I am not an attorney and offer no legal opinions. My analysis and opinions are based on my expertise in this technical field and on the instructions that counsel has given me for the legal standards relating to patentability as outlined in the rest of this section. I have applied these principles in reaching the opinions set forth herein, but I do not provide any legal opinions in this Declaration. I have been informed and understand that certain legal standards

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

are to be applied by technical experts in forming opinions regarding the meaning and validity of patent claims.

10. I understand and the standard that I have used throughout my Declaration is that, in this proceeding, a patent claim may be deemed unpatentable as “anticipated” if it is shown by a preponderance of the evidence that each-and-every feature of the claim is found in a single prior art reference or rendered “obvious” if, in view of a prior art reference or a combination of prior art references, it would have been obvious to a person of ordinary skill in the art (POSITA) at the time of the invention, taking into account the following four issues: (1) the scope and intent of the prior art, (2) the differences between the prior art and the claim under consideration, (3) the level of ordinary skill in the art, and (4) any secondary evidence bearing on obviousness.
11. Counsel has informed me that legal principles regarding unpatentability of a claim due to obviousness have been addressed by the U.S. Supreme Court and that, while not absolute, the principles relating to a “motivation,” “suggestion,” or “teaching” in the prior art to combine references are useful in analyzing whether an invention is obvious. Counsel has also informed me that the suggestion or motivation may be either explicit or implicit and may come from knowledge generally available to a POSITA, from the nature of

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

the problem to be solved, or from a combination of these factors. The test for an implicit motivation, suggestion, or teaching is what the combined teachings, knowledge of a POSITA, and the nature of the problem to be solved as a whole would have suggested to those of ordinary skill in the art. The analysis is not focused on the specific problem solved by the invention, but the general problem that confronted the inventor prior to the invention.

12. Counsel has further informed me that the U.S. Supreme Court has clarified that additional principles may also be applied in such an analysis. Some of those principles are set forth below.
13. I have been informed by counsel that it is no longer always required to present evidence of an explicit teaching, suggestion, or motivation to combine prior art references for purposes of determining whether an invention is obvious. Prior art can be combined based on several factors including: an express teaching, suggestion, or motivation from the prior art itself, or from a reasoned explanation of an expert or other witness.
14. I have been informed that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known in the prior art. In evaluating whether such a claim would have been obvious, I may consider whether there is a reason that would

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

have prompted a person of ordinary skill in the field to combine the elements or concepts from the prior art in the same way as in the claimed invention.

15. To determine whether there was an apparent reason to combine the known elements in the way a patent claims, it will often be necessary to look to interrelated teachings of multiple pieces of prior art, to the effects of demands known to the design community or present in the marketplace, and to the background knowledge possessed by a POSITA. Also, in determining obviousness, one must be aware of the distortion caused by hindsight bias and be cautious of arguments relying upon hindsight reasoning. An obviousness argument cannot be sustained by mere conclusory statements. Instead, it must be some articulated reasoning with some rational underpinnings to support the legal conclusion of obviousness.
16. In an obviousness analysis, it is my understanding that there are “secondary considerations” that should be analyzed if they apply. I am told that these considerations include (a) whether the prior art teaches away from the claimed invention, (b) whether there was a long felt but unresolved need for the claimed invention, (c) whether others tried but failed to make the claimed invention, (d) skepticism of experts, (e) whether the claimed invention was

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

commercially successful, (f) whether the claimed invention was praised by others, and (g) whether the claimed invention was copied by others.

17. I have also been informed that for evidence of secondary considerations to be significant, there must be a sufficient relationship between the claimed invention and the evidence of secondary considerations. I understand that this relationship serves to provide a link between the merits of the claimed invention and the evidence of secondary considerations provided.
18. I have been informed by counsel that the Board construes claims according to the so-called “Phillips” standard. Under the Phillips standard, terms in a claim are given their ordinary and customary meaning, consistent with the patent's specification, as understood by a POSITA. I have been informed by counsel that what is to be considered includes the claims, the patent specifications and drawings, and the prosecution history, including any art listed by the examiner or the Applicant. I have been informed by counsel that information external to the patent, including expert and inventor testimony and unlisted prior art, are to be considered if ambiguities remain. However, expert testimony may be useful in helping to explain the technology.
19. I have been informed and understand that a patent claim is not patentable as obvious if the differences between the patent claim and the prior art are such

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

that the claimed subject matter, as a whole, would have been obvious at the time the claimed invention was made to a person having ordinary skill in the relevant art.

20. In analyzing the relevance of the differences between the claimed invention and the prior art, I have been informed that I must consider the impact of such differences on the obviousness or non-obviousness of the invention as a whole, not merely some portion of it. A POSITA faced with a problem can apply their experience and ability to solve the problem and also look to any available prior art to help solve the problem.
21. I have been informed and understand that there are recognized, exemplary rationales for combining or modifying references to show the obviousness of claimed subject matter. Some of the rationales include the following: combining prior art elements according to known methods to yield predictable results; simple substitution of one known element for another to yield predictable results; use of a known technique to improve a similar device (method or product) in the same way; applying a known technique to a known device (method or product) ready for improvement to yield predictable results; choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; known work in one field of endeavor

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

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; and some 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 prior art teachings to arrive at the claimed invention.

IV. LEVEL OF ORDINARY SKILL IN THE ART

22. It is my understanding that a person of ordinary skill in the art (POSITA) is a hypothetical person who is used to analyze the prior art without the benefit of hindsight. I have been instructed that the level of ordinary skill may be reflected by the prior art of record, and that a person of ordinary skill in the art to which the claimed subject matter pertains would have the capability of understanding the scientific and engineering principles applicable to the pertinent art. I have been instructed that there are multiple factors that may be considered in determining the level of ordinary skill in the art may include: (1) type of problems encountered in the prior art; (2) prior art solutions to those problems; (3) rapidity with which innovations are made; (4) sophistication of the technology; and (5) educational level of active workers in the field. I also understand that a POSITA is also a person of

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

ordinary creativity, not an automaton. They would be able to fit the teachings of multiple patents together like a puzzle and have the capability of understanding the scientific and engineering principles applicable to the pertinent art.

23. I have been asked to provide a definition for the level of ordinary skill in the art in the field of the Challenged Patent at the time priority application (i.e., U.S. Provisional Patent Application No. 62/135,305) was filed, i.e., March 19, 2015. As stated in the Challenged Patent, the disclosure is directed to methods of treating obstructive sleep apnea via applying nerve stimulation. EX-1001 3:28-30.
24. In my opinion, a POSITA at the time of the '709 Patent (i.e., March 2015) would have at least a bachelor's degree in Electrical Engineering, Biomedical Engineering, or a related field and at least five years of training or additional work experience in neurostimulators or a related field. Through this formal education and/or training, a POSITA understood neuromuscular anatomy and physiology. Additional hands-on and design experience could compensate for less formal education and vice versa at the time of the priority date.
25. When forming my opinions herein, I analyzed and applied the prior art and claim constructions from a POSITA's perspective at the time of the invention.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

26. I understand that a POSITA is presumed to have knowledge of all references that are sufficiently related to one another to the pertinent art and to have knowledge of all arts reasonably pertinent to the particular problem that the claimed invention addresses.
27. All of my opinions in this Declaration are from the perspective of a POSITA, as I have defined it above and during the relevant time frame, i.e., on or around date of the priority application. During this time frame, I possessed at least the qualifications of a person of ordinary skill in the art, as defined above, and I am capable of addressing the issues from the perspective of such a person. My opinions in this declaration reflect how a POSITA would have understood the claims and the specification of the challenged patent, the prior art to the patent, and the state of the art on or around the priority date.

V. TECHNICAL BACKGROUND AND STATE OF THE ART

28. The following section describes the state of the art for neurostimulation devices, including neurostimulation devices for treating obstructive sleep apnea (OSA). The prior art references and the knowledge of a POSITA provide the factual support for the general description of the state of the art at the time of the invention and provide additional motivation to modify and/or

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

combine reference(s). Accordingly, these references should be considered by the Board.

A. Neuromuscular Stimulators

29. Nerves in the human body can be excited by an applied electrical impulse that induces movement of ions in saltwater that surrounds the elongated axon of neurons, changing the ionic concentration differences of potassium ions (K^+) predominantly inside of the axon and sodium ions (Na^+) predominantly outside of the axon. EX-1013 (Mortimer), p. 68. This electrical excitability phenomenon has been understood for decades and is the fundamental principle behind clinical neuromuscular stimulators, which are medical devices that deliver electrical impulses to the nervous system for the purpose of providing a therapeutic benefit. EX-1013 (Mortimer), p. 82; EX-1014 (Anagnostopoulos), p. 480.
30. Cardiac pacemakers were one of the earliest stimulators used clinically and by the 1960s were available in transcutaneous or implantable form factors using asynchronous (fixed) or synchronous stimulation protocols to pace a human heart. EX-1014 (Anagnostopoulos), pp. 480-82. By the 1960s, pacemaker technology was being used to treat other neuromuscular disorders,

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

including respiratory issues. EX-1014 (Anagnostopoulos), p. 488 (phrenic nerve); EX-1015 (Glenn), pp. 339-346; EX-1016 (Judson), p. 1033.

31. Application of neuromuscular stimulation to create desired movements and prevent or reverse atrophy of muscles as a result of chronic muscle inactivity was known. EX-1017 (Singh), p. 276; EX-1018 (Richmond), p. 2018; EX-1015 (Glenn), pp. 338, 343-348. Skeletal muscles themselves require the application of very large and prolonged electrical impulses to become active and generate contractions, which are impractical to generate and potentially painful or toxic. EX-1017 (Singh), p. 276. Muscle fibers, however, are innervated by large diameter motor axons that originate in the central nervous system (typically brainstem or spinal cord). EX-1017 (Singh), p. 276. These motor axons are more sensitive to electrical stimulation, which may be applied anywhere along their length. EX-1017 (Singh), pp. 276-277.
32. Typical stimulation electrodes include (i) nerve cuff electrodes wrapped around peripheral nerve trunks or branches to individual muscles or neuromuscular compartments; (ii) patch electrodes sutured onto the connective tissue of a nerve or muscles or fascia adjacent to the nerve; and (iii) intramuscular wire electrodes implanted near the terminal branches of the motor axons as they approach the muscle fibers that they innervate. EX-1014

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

(Anagnostopoulos), pp. 481-482; EX-1019 (Edmonds), p. 1031; EX-1017 (Singh), pp. 276-277; EX-1020 (Miki), pp. 1285-1286. Because electrical excitation of any axon spreads throughout the branches of that axon regardless of where excitation was initiated, the effects on the muscle are the same for these different electrode locations and types.

33. Pulse generators for stimulating muscles, such as those available from Grass Instruments and Medtronic (e.g., the Itrel, Dynex, and Respond lines of stimulators), were known and frequently used in laboratory and clinical settings. EX-1021 (Decker), p. 1055; EX-1019 (Edmonds), p. 1031; EX-1022 (Eisele1997), p. 58; EX-1023 (Fuller), p. 603; EX-1024 (Christopherson '543) 16:13-23. These stimulators, which could be external or implanted, allowed adjustments of the voltage or current amplitude, pulse width, and/or frequency at which stimulation was to be applied, as well as the length of the burst durations and the intervals between bursts, by simply turning dials on the devices and/or through other straight-forward programmable means. EX-1021 (Decker), p. 1055; EX-1019 (Edmonds), p. 1031; EX-1022 (Eisele1997), p. 58; EX-1023 (Fuller), p. 603. These stimulators typically included a processor and memory storing instructions for execution by the processor (i.e., software/firmware) and were configured to provide pulse

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

trains of different amplitudes (e.g., current and voltage), pulse width, and frequency. EX-1006 (Durand) ¶ 15 (“The control system 22 also typically includes a processor for setting up stimulation parameters to achieve the desired outcome for the individual patient or otherwise controlling the stimulation.”); EX-1024 (Christopherson ’543) 16:13-35; EX-1012 (Bolea) ¶ 462.

B. Obstructive Sleep Apnea Treatment

34. OSA is caused by obstruction of the upper airway during sleep. EX-1020 (Miki), p. 1285. More particularly, during sleep, the tongue prolapses due to diminished neuromuscular activity of the muscle controlling tongue protrusion (i.e., the genioglossus or “GG”) causing pharyngeal occlusion. EX-1025 (Schwartz1996), p. 643; EX-1020 (Miki), p. 1285; EX-1026 (Goding), pp. 162-163. While continuous positive airway pressure (CPAP) devices were the gold standard for treating OSA, these devices were known to be limited in their effectiveness due to low patient compliance. EX-1027 (Meer), 1:47-52; EX-1012 (Bolea) ¶ 6; EX-1028 (Yoo), p. 2049.
35. By the 1990s, neuromuscular stimulation of the hypoglossal nerve/genioglossus muscle, in addition to other nerves responsible for

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

stimulating the upper airway muscles, was being investigated as an OSA treatment. EX-1020 (Miki), p. 1285; EX-1027 (Meer), 2:67-3:5, 4:16-25; EX-1019 (Edmonds), p. 1031; EX-1025 (Schwartz1996), pp. 643-644; EX-1029 (Fairbanks), pp. 52-53; EX-1021 (Decker), p. 1053; EX-1022 (Eisele1997), p. 58; EX-1026 (Goding), pp. 166-167; EX-1023 (Fuller), p. 601.

36. The development of neurostimulation therapies for OSA progressed from these early proof-of-concept studies to sophisticated clinical systems by the early 2000s. EX-1030 (Schwartz2001), p. 1217; EX-1031 (Oliven), pp. 337-339. These clinical systems included both closed-loop systems that stimulated synchronously with the patient's respiratory cycle and open-loop systems that stimulated asynchronously. EX-1031 (Oliven), p. 339; EX-1030 (Schwartz2001), p. 1217; EX-1038 (Eastwood), p. 1480.
37. Regardless of the type of therapy system (e.g., open loop or closed loop), titration was a typical step in providing the treatment and was done after implantation of the device. EX-1012 (Bolea) ¶¶ 536-537, 556-592; EX-1031 (Oliven), p. 422; EX-1032 (Mwenge), pp. 361-362. Titration typically involved applying stimulation to a patient under observation and varying one or more stimulation characteristics or parameters (e.g., pulse width,

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

amplitude, frequency, and duty cycle). EX-1012 (Bolea) ¶¶ 556-592. The goal of titration was to identify the optimal stimulation settings that would provide an effective, desired response (e.g., increased airway patency) in a manner that was safe and comfortable to the patient to ensure compliance with the treatment. EX-1012 (Bolea) ¶¶ 527, 556-558. Titration and the adjustment of one or more stimulation characteristics or parameters, including increasing/decreasing the stimulation duty cycle, involved nothing more than the exercise of routine skill in the art.

1. Closed-Loop Systems

38. Clinical closed-loop systems included an electrode(s), a pulse generator, and at least one sensor for actively sensing a patient's respiration cycle. EX-1030 (Schwartz2001), p. 1217; EX-1038 (Eastwood), p. 1480. In some systems, an intrathoracic pressure sensor was used to monitor the patient's respiratory cycle to synchronize a burst of electrical impulses (e.g., pulse train) from a pulse generator to a cuff electrode wrapped around the hypoglossal nerve, timing the stimulation to the onset of the patient's inspiration. EX-1030 (Schwartz2001), p. 1217; EX-1038 (Eastwood), p. 1480. The stimulation parameters (e.g., voltage or current amplitude, pulse width, and pulse frequency) provided by the pulse generator were configured specifically for

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

each person, as was the duration during which the stimulation was provided upon the sensing of the onset of the patient's inspiration. EX-1030 (Schwartz2001), p. 1217; EX-1038 (Eastwood), pp. 1480-81.

2. Open-Loop Systems

39. Clinical open-loop systems similarly included a pulse generator and an electrode, but differed in that they did not require the use of a sensor. EX-1032 (Mwenge), pp. 361-362; EX-1033 (Zaidi), p. 384. Instead, these systems relied on either continuous (e.g., constantly pulsed) or intermittent (e.g., periodically pulsed) stimulation protocols to reduce sleep disordered breathing. EX-1034 (Steier), p. 999; EX-1033 (Zaidi), p. 384.

C. Duty Cycles

40. Duty cycles (e.g., the proportion of time stimulation is applied to a nerve during a given period) have long been used in neurostimulation to provide the nerve being stimulated time to recover and avoid neural damage and muscle fatigue. EX-1035 (Agnew), pp. S27, S29; EX-1026 (Goding), p. 167; EX-1033 (Zaidi), pp. 382, 384; EX-1037 (Meadows), p. 191; EX-1036 (Gordon), 10:1-29. The muscle fibers in the tongue generally are less susceptible to fatigue compared to other muscles. EX-1033 (Zaidi), p. 376. However, even

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

within the tongue, the posterior muscles were known to be more susceptible to fatigue than the anterior tongue muscles due to their physical properties. EX-1033 (Zaidi), pp. 377-379. The tongue is a muscular hydrostat (e.g., muscles surrounding a fluid mass) in which the hydrostatic pressure associated with contracting muscles may cut off its blood supply. EX-1036 (Gordon), 10:6-13. Recovery periods allow blood flow to resume, avoiding muscle fatigue. EX-1036 (Gordon), 10:6-13.

41. Both open-loop and closed-loop systems for treating OSA utilized duty cycles. EX-1033 (Zaidi), p. 384; EX-1026, p. 163; EX-1030 (Schwartz2001), p. 1217. While the duty cycle in closed-loop systems could vary based on the actively sensed respiratory cycle of a patient, the duty cycle of an open-loop system typically was fixed based on a patient's historical average of sleeping respiratory rate. EX-1012 (Bolea) ¶ 266 ("Alternatively, the neurostimulation system described herein may operate in an open-loop process wherein stimulation is delivered as a function of preset conditions (e.g., historical average of sleeping respiratory rate.)"); EX-1030 (Schwartz2001), p. 1217; EX-1033 (Zaidi), p. 384; EX-1026 (Goding), p. 163.
42. Activation of the genioglossus muscle (GG) by stimulating the hypoglossal nerve (HGN) causes the tongue to protrude, which increases the aperture size

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

of the upper airway and resists collapse of the airway during inspiration, allowing unobstructed inspiration. EX-1012 (Bolea) ¶ 162; EX-1018 (Richmond), pp. 2017-2018; EX-1036 (Gordon), 7:20-28, 8:61-9:15. Stimulation of the hypoglossal nerve (and thus activation of the genioglossus) was targeted to the inspiratory phase of a patient's respiratory cycle. EX-1026 (Goding), p. 168 ("Nerve stimulation would need to coincide with inspiration."); EX-1030 (Schwartz2001), p. 1221 ("Nevertheless, when the stimulation was well synchronized with inspiration, improvement in apnea was consistently observed."); EX-1038 (Eastwood), p. 1480 ("Respiration is monitored via implanted thoracic leads that sense changes in bioimpedance with chest wall motion, delivering stimulation immediately prior to and during the inspiratory phase of respiration, when upper airway is most vulnerable to sleep related narrowing and collapse."). To ensure that an open-loop system would apply stimulation during the inspiratory phase, duty cycles of greater than 50% were used. EX-1012 (Bolea) ¶ 473 ("Thus, in some instances, the stimulation duty cycle may run above normal (e.g., above 50% to 60%) to achieve a better likelihood of covering the inspiratory phase."). If the inspiratory phase initiates when stimulation is off and the airway is occluded, the inspiratory effort tends to be prolonged, so the eventual onset of

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

asynchronous stimulation will open the airway and allow inspiratory airflow, effectively resynchronizing the patient's breathing to the applied stimulation. EX-1018 (Richmond), p. 2019; EX-1009 (Tran-I), p. 377; EX-1010 (Tran-II), p. 4288.

VI. OVERVIEW OF THE '709 PATENT

A. Priority Date

43. I have been instructed, for the purpose of this IPR, to assume the priority date for the '709 Patent is the filing date of U.S. Provisional Patent Application No. 62/135,305, which is March 19, 2015. To the extent the Challenged Claims are entitled to a different priority date, such as the March 16, 2016 filing date of International Patent Application No. PCT/US2016/022611, my analysis herein would not change.

B. Overview of the Disclosure of the '709 Patent

44. U.S. Patent No. 10,898,709 ("709 Patent") issued on January 26, 2021 from U.S. Patent Application No. 15/562,714, which is a national phase entry of International Patent Application No. PCT/US2016/022611, filed March 16, 2016, claiming priority to U.S. Provisional Patent Application No. 62/135,305, which was filed March 19, 2015.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

45. The '709 Patent is directed to a device for treating disordered breathing that includes a stimulation element to stimulate an upper-airway-patency-related nerve. EX-1001 Abstract. FIG. 1A is a block diagram of a stimulation element 12 that includes an independent stimulation function 14 that applies electrical stimulation to an airway-patency-related nerve, such as the protrusor branches of the hypoglossal nerve. More particularly, the independent stimulation function 14 provides stimulation according to a first stimulation protocol not synchronized to sensed respiratory information (also referred to as asynchronous stimulation) and in which each stimulation cycle includes a stimulation period and a non-stimulation period. EX-1001 7:48-64, 8:5-7.

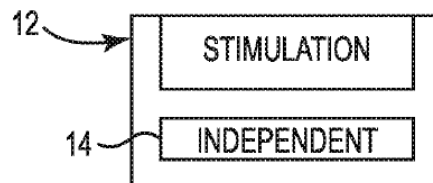


Fig. 1A

EX-1001 FIG. 1A.

46. FIG. 2A illustrates a **system** 20 includes an **implantable pulse generator** (IPG) 35 and a **stimulation lead** 32 electrically coupled with the IPG 35 via a connector. The lead 32 includes a **stimulation electrode portion** 45, which may be a cuff electrode as disclosed in U.S. Patent No. 8,340,785 that may be

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

positioned in contact with a desired nerve, enables simulation of the nerve via a lead 32 as disclosed in U.S. Patent Application Publication No. 2011/0160827 and an implantable stimulation system as disclosed in U.S. Patent No. 6,572,463 (EX-1024, Christopherson '543). The electrode portion 45 includes at least one operative contact group of at least two electrodes 52, although the stimulation electrode portion 45 may include multiple separate cuff electrodes. EX-1001 9:51-10:24.

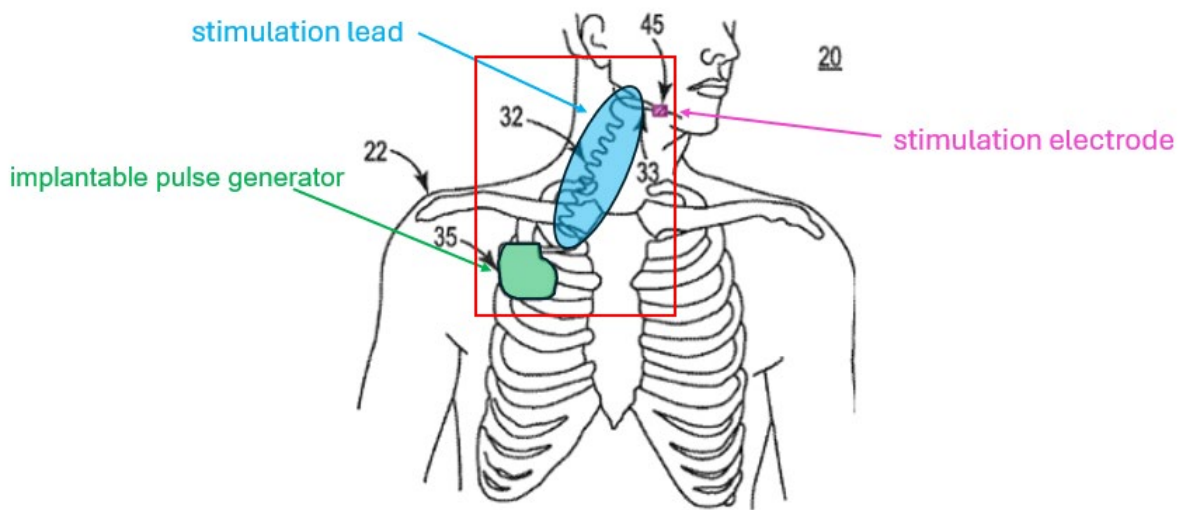


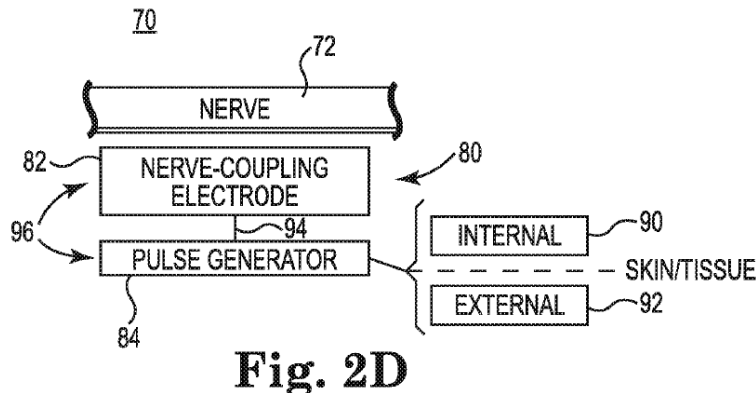
Fig. 2A

EX-1001 FIG. 2A (annotated).

47. FIG. 2D illustrates an exemplary system 80 that includes a nerve-coupling electrode portion 82 and a pulse generator 84. The nerve-coupling electrode

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

portion 82 may be a mechanically and electrically coupled relative to a nerve 72 or the nerve-coupling electrode may not be mechanically coupled to the nerve 72, but instead mechanically coupled or secured in close proximity to the nerve 72 to enable electrical coupling of the electrode portion 82 to the nerve 72. The pulse generator may be solely an internal component or it may include a combination of internal components 90 and external components 92. EX-1001 11:60-12:22.



EX-1001 FIG. 2D.

48. FIG. 3A illustrates a normal breathing pattern 150 in which a respiratory cycle 160 includes an **inspiratory phase** 162 and an **expiratory phase** 170. The inspiratory phase 162 includes an initial portion 164, an intermediate portion 165, and an end portion 165. The expiratory phase includes an initial portion

174, an intermediate portion 175, an end portion 176, and an expiratory peak 177. EX-1001 12:43-56.

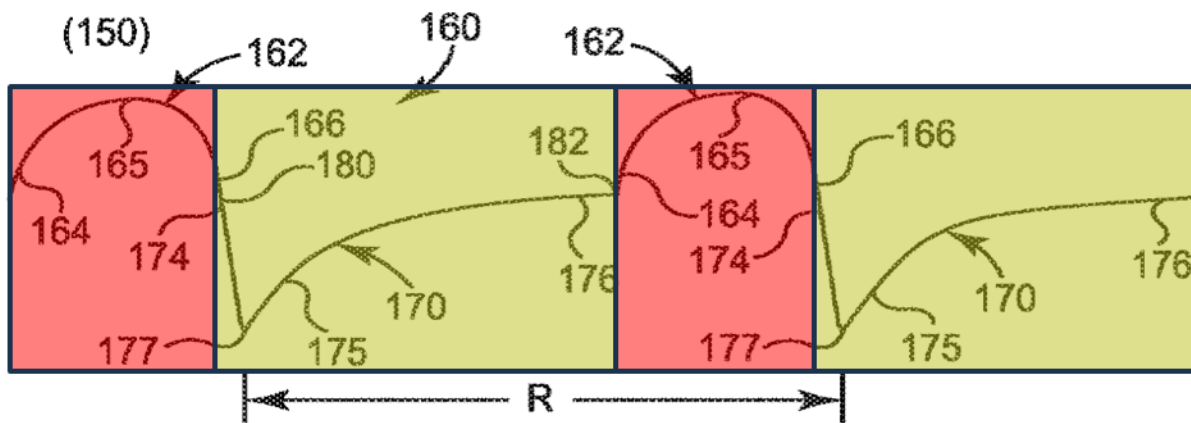
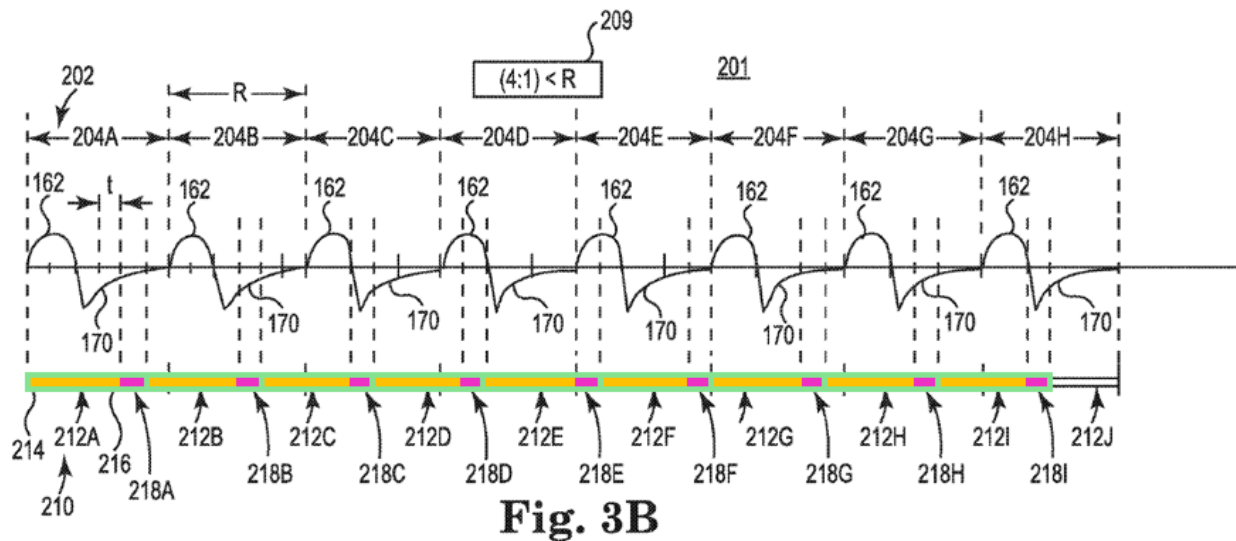


Fig. 3A

EX-1001 FIG. 3A (annotated).

49. FIG. 3B is a diagram schematically illustrating a stimulation protocol 210 implemented via the independent stimulation function 14. A respiratory pattern 202 includes a series of reference respiratory cycles 204A-204H each having a duration R. The respiratory pattern 202 represents a stable respiratory pattern, such as one that occurs during normal daytime breathing and/or from the application of stimulation protocol, and has a duration R based on at least one of a historical patient-specific average respiratory cycle or a multi-patient average respiratory cycle. EX-1001 12:57-13:20, 13:37-45.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709



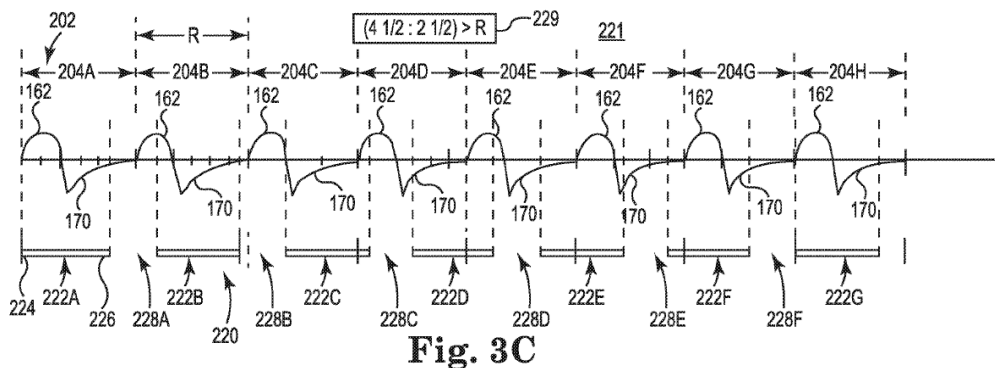
EX-1001 FIG. 3B (annotated).

50. The stimulation protocol 210 includes a series of separate **stimulation periods (pulses)** 212A-212J spaced apart by **non-stimulation periods** 218A-218I such that the respiratory cycle has a duration R divided into six time units t. For at least some of the patient population, the duration of the entire respiratory period is about 3-6 seconds, which corresponds to a respiratory rate of 10-18 breaths/minute. In FIG. 3B, the stimulation protocol 210 operates according to a **stimulation cycle** having a duration that is less than the duration R of the reference respiratory cycle, and the duration of the stimulation period exceeds the duration of the non-stimulation period by a factor of 3. EX-1001 13:21-27, 13:46-14:2.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

51. According to the '709 Patent, because the overall duration of the stimulation cycle (i.e., stimulation period and non-stimulation period) does not match the duration R of the reference respiratory cycle, the stimulation protocol 210 ensures that each successive stimulation period within the series of stimulation cycles will fall along a different portion of the successive respiratory cycles and overlap with at least a portion of the inspiratory phase. EX-1001 14:56-15:1.

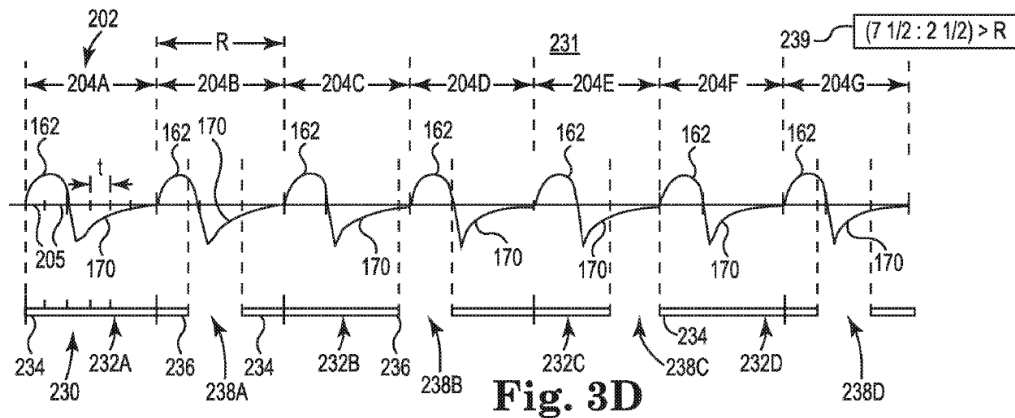
52. FIG. 3C illustrates another stimulation protocol 220 that operates according to a stimulation cycle having a duration that is greater than the duration R of the reference respiratory cycle. The stimulation period is $4\frac{1}{2}$ time units in length and the non-stimulation period is $2\frac{1}{2}$ units in length, such that the overall stimulation cycle is 7 time units in length and is greater than the 6 time unit duration of the reference respiratory cycle. EX-1001 16:39-51.



EX-1001 FIG. 3C.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

53. The '709 Patent also discloses that a duty cycle of the repeating stimulation cycle may vary on a respiratory cycle-by-respiratory cycle basis as illustrated in FIG. 3D. For example, during respiratory cycle 204A, the duty cycle is six time units of continuous stimulation, which equals 100%, but during respiratory cycles 204B and 204E the stimulation duty cycle is $3\frac{1}{2}$ time units of continuous stimulation and $2\frac{1}{2}$ time units of non-stimulation for a duty cycle of 58%. EX-1001 18:8-16.



EX-1001 FIG. 3D.

54. The '709 Patent further discloses that the stimulation system may operate in cooperation with a sensing function, which includes a sensing element 330 shown in FIG. 7A that may be incorporated into the IPG 50 illustrated in FIG. 2B. The sensing element 330 receives and tracks signals from at least one physiologic sensor to gather information regarding sleep disordered

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

breathing, such as a respiratory state, whether the patient is sleeping, or other respiratory-associated indicators. EX-1001 24:4-25:3.

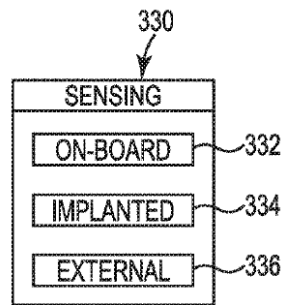


Fig. 7A

EX-1001 FIG. 7A.

C. Prosecution History

55. The '714 Application, which issued as the '709 Patent, entered U.S. national phase on September 28, 2017 with 128 claims. EX-1002 0001-135. A preliminary amendment was filed on March 6, 2018 canceling claims 1-128 and adding claims 129-148 of which claims 129, 143, and 148 were in independent form. EX-1002 0192-199. As originally presented, claims 129, 143, and 148 recited:

129. (New) A device for treating sleep disordered breathing, comprising:

a stimulation element to stimulate an airway-patency-related nerve, according to a first stimulation protocol not synchronized relative to sensed respiratory information and in which each stimulation cycle includes a stimulation period and a non-stimulation period.

EX-1002 0193.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

143. (New) A device for treating sleep disordered breathing comprising:

a stimulation element to stimulate an airway-patency-related nerve, according to a first stimulation protocol not synchronized relative to respiratory information and in which each stimulation cycle includes a stimulation period and a non-stimulation period; and

a sensing element to obtain respiratory information via at least periodically sensing a respiratory waveform without synchronization to stimulation,

wherein the stimulation element is activated for stimulation upon the sensing element identifying, via at least the respiratory information, sleep disordered breathing behavior which meets or exceeds a severity threshold and is deactivated upon the sensing element identifying, via at least the respiratory information, that the sleep disordered breathing behavior is less than the severity threshold.

EX-1002 0195.

148. (New) A device for treating sleep disordered breathing comprising:

a stimulation element to stimulate an airway-patency-related nerve, according to a first stimulation protocol not synchronized relative to respiratory information and in which each stimulation cycle includes a stimulation period and a non-stimulation period;

a sensing element to receive respiratory information; and

a control portion including:

a processor; and

a non-volatile memory storing instructions, executable via the processor, to:

provide convertible operation via a therapy manager between:

a first stimulation mode implementing the first stimulation protocol; and

a second stimulation mode of stimulating the airway-patency-related nerve synchronous with a characteristic of the sensed respiratory waveform.

EX-1002 0197.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

56. A non-final office action issued on January 3, 2019 (EX-1002 0216-227), in which claims 129-141 and 143-148 were rejected as being obvious from U.S. Patent No. 7,340,302 (Falkenberg) in view of U.S. Patent No. 8,280,513 (Tehrani). EX-1002 0220. Claim 142 was rejected as being obvious from Falkenberg in view of Tehrani and U.S. Patent No. 5,944,680 (EX-1011, Christopherson). EX-1002 0225.
57. In a response to the non-final office action filed on June 3, 2019, Applicant amended the independent claims to clarify that the device was “for treating obstructive sleep apnea” and included “a non-cardiac stimulation element to engage and to stimulate an upper-airway-patency-related nerve” according to a first stimulation protocol that “comprises a series of repeating stimulation cycles.” EX-1002 0283-308. Specifically, the independent claims were amended to recite:

129. (Currently Amended) A device for treating ~~sleep-disordered-breathing~~obstructive sleep apnea, comprising:

a non-cardiac stimulation element to engage and to stimulate an upper-airway-patency-related nerve, according to a first stimulation protocol not synchronized relative to actively-sensed respiratory information, wherein the first stimulation protocol comprises a series of repeating stimulation cycles[[and]] in which each stimulation cycle includes a stimulation period and a non-stimulation period.

EX-1002 0302.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

143. (Currently Amended) A device for treating obstructive sleep apnea~~sleep-disordered breathing~~ comprising:

a non-cardiac stimulation element to stimulate an upper-airway-patency-related nerve, according to a first stimulation protocol not synchronized relative to respiratory information, wherein the first stimulation protocol comprises a series of repeating stimulation cycles ~~[[and]]~~ in which each stimulation cycle includes a stimulation period and a non-stimulation period and wherein each respective stimulation cycle comprises a duration related to a duration of a reference respiratory cycle; and

a sensing element to obtain respiratory information via at least periodically sensing a respiratory waveform ~~without~~ unrelated to stimulation ~~synchronization to stimulation~~,

wherein the non-cardiac stimulation element is activated for stimulation upon the sensing element identifying, via at least the respiratory information, obstructive sleep apnea~~sleep-disordered breathing~~ behavior which meets or exceeds a severity threshold and is deactivated upon the sensing element identifying, via at least the respiratory information, that the obstructive sleep apnea~~sleep-disordered breathing~~ behavior is less than the severity threshold.

EX-1002 0304-305.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

148. (Currently Amended) A device for treating obstructive sleep apnea ~~sleep-disordered breathing~~ comprising:

a non-cardiac stimulation element to stimulate an upper-airway-patency-related nerve, according to a first stimulation protocol not synchronized relative to respiratory information, wherein the first stimulation protocol comprises a series of repeating stimulation cycles~~[[and]]~~ in which each stimulation cycle includes a stimulation period and a non-stimulation period and wherein each respective stimulation cycle comprises a duration related to a duration of a reference respiratory cycle;

a sensing element to receive respiratory information; and

a control portion including:

a processor; and

a non-volatile memory storing instructions, executable via the processor, to:

provide convertible operation via a therapy manager between:

a first stimulation mode implementing the first stimulation protocol; and

a second stimulation mode of stimulating the upper-airway-patency-related nerve synchronous with a characteristic of the sensed respiratory waveform.

EX-1002 0306-307.

58. After the amendment, all claims were finally rejected in the next official action that issued on August 29, 2019. EX-1002 0313-323. Specifically, claims 129, 130, 132-134, 137, 139-143, and 148 were rejected as being anticipated by U.S. Patent Application Publication No. 2014/0228905 (EX-1012, “Bolea”); claim 131 was rejected as being unpatenable over Bolea in view of U.S. Patent Application Publication No. 2014/0228905 (Bashyam);

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

and claims 135, 136, 138, and 144-147 were rejected as obvious from Bolea in view of Tehrani. EX-1002 0316-321.

59. In response to the final rejection, Applicant filed a Request for Continued Examination (RCE) and amended the claims to clarify that the first stimulation protocol was a “first stimulation therapy protocol.” EX-1002 0338-364. Specifically, the independent claims were amended to recite:

129. (Currently Amended) A device for treating obstructive sleep apnea, comprising:
a non-cardiac stimulation element to engage and to stimulate an upper-airway-patency-related nerve, according to a first stimulation therapy protocol not synchronized relative to actively-sensed respiratory information, wherein the first stimulation therapy protocol comprises a series of repeating stimulation cycles in which each stimulation cycle includes a stimulation period and a non-stimulation period.

EX-1002 0342.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

143. (Currently Amended) A device for treating obstructive sleep apnea comprising:

a non-cardiac stimulation element to stimulate an upper-airway-patency-related nerve, according to a first stimulation therapy protocol not synchronized relative to respiratory information, wherein the first stimulation therapy protocol comprises a series of repeating stimulation cycles in which each stimulation cycle includes a stimulation period and a non-stimulation period and wherein each respective stimulation cycle comprises a duration related to a duration of a reference respiratory cycle[.]; and

a sensing element to obtain respiratory information via at least periodically sensing a respiratory waveform unrelated to stimulation synchronization,

wherein the non-cardiac stimulation element is activated for stimulation upon the sensing element identifying, via at least the respiratory information, obstructive sleep apnea behavior which meets or exceeds a severity threshold and is deactivated upon the sensing element identifying, via at least the respiratory information, that the obstructive sleep apnea behavior is less than the severity threshold.

EX-1002 0344-346.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

148. (Currently Amended) A device for treating obstructive sleep apnea comprising:

a non-cardiac stimulation element to stimulate an upper-airway-patency-related nerve, according to a first stimulation therapy protocol not synchronized relative to respiratory information, wherein the first stimulation therapy protocol comprises a series of repeating stimulation cycles in which each stimulation cycle includes a stimulation period and a non-stimulation period and wherein each respective stimulation cycle comprises a duration related to a duration of a reference respiratory cycle;

a sensing element to receive respiratory information; and

a control portion including:

a processor; and

a non-volatile memory storing instructions, executable via the processor, to:

provide convertible operation via a therapy manager between:

a first stimulation mode implementing the first stimulation therapy protocol; and

a second stimulation mode of stimulating the upper-airway-patency-related nerve synchronous with a characteristic of the sensed respiratory waveform.

EX-1002 0346-347.

60. In addition to amending the claims, Applicant argued that Bolea only discloses using an asynchronous or fixed mode during daytime familiarization and not as a therapy for sleep apnea:

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Claim Rejections under 35 U.S.C. § 102

Claims 129-130, 132-134, 137, 139-143, 148 are rejected under 35 U.S.C. 102(a)(1) as being anticipated by Bolea (US 2014/0228905).

Applicants respectfully traverse this rejection regarding independent claim 129.

Applicants submit that the cited portion of Bolea in Paragraphs 473-474, taken in context with the full passage of Paragraphs 466-474 regarding FIGS. 64A-64D, conflicts with at least the recitation “a non-cardiac stimulation element to engage and to stimulate an upper-airway-patency-related nerve, according to a **first stimulation therapy protocol not synchronized relative to actively-sensed respiratory information**” in Applicants’ independent claim 129.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Paragraphs 472-474 of Bolea (cited in the rejection of Applicants' independent claim 129) describe aspects of various stimulation duty cycles. In doing so, it would be apparent to one skilled in the art that such stimulation duty cycles relate to the embodiments of preceding Paragraphs 466-471 of Bolea, which depend on stimulation timing synchronized relative to a detected peak of the respiration signal "Z."

In particular, Paragraphs 466-467 relate to a bio-impedance respiration signal and triggering stimulation based on a fiducial (e.g. begin-expiration) within this respiration signal, among other details. As noted in Paragraph 468 of Bolea, "an algorithm is used to predict respiratory period and determine stimulation trigger time. The predictive algorithm is contained in software and executed by a microprocessor resident in the INS circuitry 1130, thus enabling the INS 1100 to generate stimulation synchronous with inspiration." Example predictive algorithms are described in Paragraphs 469, 470 in association with FIGS. 64B, 64C. As further noted in Paragraph 471:

A feature common to the predictive algorithms is illustrated in FIG. 64D. This feature provides a sequence of predicted respiratory periods in case the respiration impedance signal ("Z") is temporarily lost (e.g. due to change in respiratory effort). Until a subsequent respiratory peak is detected, stimulation parameters which are based on the measured respiratory period (e.g. stimulation period) are unchanged. **Thus, stimulation timing remains synchronous to the last detected peak.** (emphasis added)

With this in mind, as the following Paragraphs 472-474 of Bolea (cited in the Office Action) describe aspects of various stimulation duty cycles, it would be apparent to one skilled in the art that such stimulation duty cycles relate to the embodiments of Paragraphs 466-471, which depend on stimulation timing synchronized relative to a detected peak of the respiration signal "Z."

Accordingly, at least this cited portion of Bolea (relied in the rejection of Applicants' independent claim 129) conflicts with at least the recitation "a non-cardiac stimulation element to engage and to stimulate an upper-airway-patency-related nerve, according to a **first stimulation therapy protocol not synchronized relative to actively-sensed respiratory information**" in Applicants' independent claim 129.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

For at least this reason, Bolea fails to meet each and every recitation of Applicants' independent claim 129, and therefore fails to anticipate independent claim 129.

Applicants further submit that FIGS. 80A-80 and Paragraphs 489-499 of Bolea, which are cited elsewhere in the Office Action also conflict with Applicants' independent claim 129 at least because such passages (particularly Paragraph 496) provide substantially similar information to Paragraphs 466-471 at least with respect to being conflicting relative to Applicants' independent claim 129.

Applicants further submit that Paragraph 515 of Bolea (as cited in the Office Action) fails to meet the recitations of Applicants' independent claim 129. In particular, while Paragraph 514-515 does refer to asynchronous stimulation, this Paragraph 515 explains that "the asynchronous mode (fixed mode) may be used during daytime familiarization", which is not a therapy for sleep apnea. Bolea further explains:

This mode may be used to test the benefits of asynchronous stimulation compared to inspiratory synchronous stimulation. Asynchronous stimulation may be initiated by programming the device to fixed mode and starting a therapy session. Fixed mode stimulation may be in any available pulse train configuration.

In view of the particular context in which asynchronous stimulation is described (e.g. daytime familiarization, testing), and given that other portions of Bolea do not appear to directly address such asynchronous stimulation, it would appear to one skilled in the art that Bolea does not address asynchronous stimulation as a "first stimulation therapy protocol" in the manner recited in Applicants' independent claim 129. Rather, Bolea relies on inspiratory synchronous stimulation, such as in at least the predictive algorithms as noted in the above-highlighted passages.

Accordingly, for at least these reasons, Bolea fails to meet each and every recitation of Applicants' independent claim 129, and therefore fails to anticipate independent claim 129.

Claims 130, 132-134, 137, 139-142 are patentable at least based on their dependency from independent claim 129.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Applicants submit that claim 132 (depending from independent claim 129) is further patentably distinguishable over Bolea. In particular, Applicants' claim 132 recites that "each stimulation period includes continuous stimulation and has a minimum duration equal to or greater than an inspiratory reference of a reference respiratory cycle, wherein the reference respiratory cycle comprises at least one of: a historical patient-specific average respiratory cycle for stable respiration; and a multi-patient average respiratory cycle for stable respiration.

These recitations stand in sharp contrast to the portions of Bolea cited regarding base independent claim 129. In particular, at least some of those cited portions (e.g. Paragraphs 473-474 with preceding Paragraphs 466-472) address a predictive algorithm which is synchronized relative to a detected peak of inspiration, which therefore does not relate to a "reference respiratory cycle" which comprises an "average respiratory cycle for stable respiration" (either a historical patient-specific average or a multi-patient average) in the manner recited in Applicants' claim 132.

Accordingly, for at least these reasons, Bolea fails to meet each and every recitation of Applicants' claim 132, and therefore fails to anticipate claim 132.

Applicants submit that claim 134 (depending from dependent claim 133) is further patentably distinguishable over Bolea. In particular, Applicants' claim 134 recites "each stimulation period of each respective stimulation cycle has a duration greater than a duration of the inspiratory reference of the reference respiratory cycle" and further recites that "the stimulation period is followed by the non-stimulation period of the respective stimulation cycle comprising a duration less than the duration of the stimulation period."

Paragraph 420 of Bolea (cite in the Office Action) addresses ramping stimulation intensity, the number of pulses per second, amplitudes, and pulse width. The Paragraph concludes by stating that "Each of these ramp methods would require a predictive algorithm that would stimulate based on the previous inspiration cycle."

Accordingly, this Paragraph 420 does not even remotely address the recitation in Applicants' claim 134 of a duration of a stimulation period being greater than a "duration of the

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

inspiratory reference of the reference respiratory cycle” and Paragraph 420 does not address the recitation in Applicants’ claim 134 of the non-stimulation period (of a stimulation cycle) having a duration less a duration of the stimulation period.

Paragraph 357 of Bolea (cited in the Office Action) addresses measuring an inspiratory stage and related effort for comparison to a threshold, such as to identify a disordered breath if the inspiratory period is at least 40% of the entire respiratory period. However, this Paragraph 357 does not even remotely address a stimulation cycle as recited in claim 134, and more particularly, Paragraph 357 of Bolea does not address either the duration of a stimulation period or the duration of a non-stimulation period in the manner recited in Applicants’ claim 134.

Among other things, Paragraph 129 of Bolea (cited in the Office Action) addresses that “the stimulus may be delivered for only a portion of the respiratory cycle, such as during inspiration which corresponds to negative pressure in the upper airway” and addresses triggering the stimulation. Paragraph 129 also cautions against overstimulation, while stating that “a 40% to 50% duty cycle may be safely tolerated, thus enabling limited over-stimulation.” However, neither of these portions nor other portions of Paragraph 129 meet the recitations of claim 134.

The Abstract of Bolea (cited in the Office Action) states:

A method of treating a patient, comprising: sensing a biological parameter indicative of respiration; analyzing the biological parameter to identify a respiratory cycle; identifying an inspiratory phase of the respiratory cycle; and delivering stimulation to a hypoglossal nerve of the patient, wherein stimulation is delivered if a duration of the inspiratory phase of the respiratory cycle is greater than a predetermined portion of a duration of the entire respiratory cycle.

However, this Abstract does not even remotely address a stimulation cycle as recited in claim 134, and more particularly, Paragraph 357 of Bolea does not address either the duration of a stimulation period or the duration of a non-stimulation period *in the manner recited in* Applicants’ claim 134. Rather, the Abstract identifies merely that “stimulation is delivered **IF** a duration of the inspiratory phase of the respiratory cycle is greater than a predetermined portion of a duration of the entire respiratory cycle.”

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Therefore, the Office Action has failed to state a prima facie case of unpatentability based on anticipation because, in citing Bolea, the Office Action has failed to meet each and every recitation of Applicants' claim 134, and therefore Bolea fails to anticipate claim 134.

Applicants submit that claim 137 (depending from dependent claim 134) is further patentably distinguishable over Bolea. First, claim 137 depends from at least claim 134, and is therefore patentable over Bolea for at least the reasons explained above regarding claim 134 and/or patentable for the reasons explained above regarding independent claim 129 and (additional intervening claims 132, 133). In particular, Applicants' claim 137 recites that "the duration of each respective stimulation cycle is less than the duration of the reference respiratory cycle, and a duration of the stimulation period exceeds the duration of the non-stimulation period by a factor of at least 3.

Paragraphs 492-499 of Bolea (cited in the Office Action) appear in association with FIGS. 80A-80C. As shown in FIG. 80C and described in at least Paragraph 496, the duration of each (of several) predicted respiratory period coincides with (e.g. matches) a duration of a combination of a stimulation period and a period of no-stimulation.

This arrangement in Bolea directly conflicts with the recitation in Applicants' claim 137 that "the duration of each respective stimulation cycle is less than the duration of the reference respiratory cycle," wherein the base independent claim 129 (from which claim 137 indirectly depends) recites that "each stimulation cycle includes a stimulation period and a non-stimulation period." Via Applicant's claimed arrangement, the duration of the stimulation cycle does not match or coincide with the duration of the reference respiratory cycle, such that upon the application of multiple stimulation cycles, the stimulation period will coincide with a different portion of each reference respiratory cycle of a sequence of reference respiratory cycles. This arrangement may ensure that "no matter where the stimulation protocol is started relative to the pattern of ongoing reference respiratory cycles, the stimulation period of each stimulation cycle will overlap with at least a portion of the inspiratory phase of the reference respiratory cycles for

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

a significant majority of the treatment period.” See, for example, Applicants’ specification at 0049.

Moreover, as previously noted in association with at least claim 129, Applicants’ arrangement “a first stimulation therapy protocol [is] not synchronized relative to actively-sensed respiratory information”, which stands in sharp contrast to the arrangement in FIGS. 80A-80C (Paragraphs 492-499, particularly Paragraph 496) in which “the stimulation timing remains synchronous to the last detected peak” and in which the stimulation period is centered at 75% of the respiratory period from the last detected peak, as shown in FIG. 80B (Paragraph 495).

Finally, Applicants respectfully traverse the assertion in the Office Action regarding the comparison of the 69% to the recitation of “a factor of at least 3” because the duty cycle in Bolea of 69% is a maximum (e.g. not to exceed), whereas the recited ratio of at least 3:1 is a minimum. Therefore, contrary to the assertion in the Office Action the maximum quantity of 69% in Bolea cannot reasonably or fairly be equated to the recitation of a ratio of at least 3:1 in Applicants’ claim 137.

Accordingly, for at least these reasons, Bolea fails to meet each and every recitation of Applicants’ claim 137, and therefore fails to anticipate claim 137.

Applicants submit that claim 139 (depending from dependent claim 129) is further patentably distinguishable over Bolea. First, claim 139 depends from at least claim 134, and is therefore patentable over Bolea for at least the reasons explained above regarding independent claim 129.

Accordingly, for at least these reasons, Bolea fails to meet each and every recitation of Applicants’ claim 139, and therefore fails to anticipate claim 139.

Applicants submit that claim 140 (depending from dependent claim 134) is further patentably distinguishable over Bolea. First, claim 140 depends from claim 134, and is therefore patentable over Bolea for at least the reasons explained above regarding claim 134 and/or

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

patentable for the reasons explained above regarding independent claim 129 and (additional intervening claims 132, 133) from which both claims 134 and 140 depend.

Second, Applicants note that the portions of Bolea (e.g. at least FIGS. 64A-64D, FIGS. 80A-80D with Paragraphs 492-499) cited in the Office Action cannot be reasonably be asserted to meet the recitations of all three of Applicants' claim 137 ("the duration of each respective stimulation cycle is less than the duration of the reference respiratory cycle"), Applicants' claim 138 ("the duration of each respective stimulation cycle is greater than the duration of the reference respiratory cycle"), and Applicants' claim 140, which recites "the duration of each respective stimulation cycle is equal to the duration of the reference respiratory cycle."

Moreover, Applicants further submit that the assertion in the Office Action is not supportable by the cited portions of Bolea. In particular, Applicants' claim 140 recites that "the duration of the reference respiratory cycle differs from a duration of a real time respiratory cycle from actively-sensed respiration information by an amount exceeding a duration variability criteria."

For example, within the cited portions of Bolea, Paragraph 0496 states:

A feature common to the predictive algorithms is illustrated in FIG. 80C. This feature provides a sequence of predicted respiratory periods in case the respiration impedance signal ("Z") is temporarily lost (e.g., due to change in respiratory effort). Until a subsequent respiratory peak is detected, stimulation parameters which are based on the measured respiratory period (e.g., stimulation period) are unchanged. Thus, stimulation timing remains synchronous to the last detected peak

By referencing the "respiration signal ("Z") is temporarily lost" and "Until a subsequent respiratory peak is detected", this passage of Bolea would clearly indicate to one skilled in the art the expectation in Bolea to normally perform stimulation synchronized to sensed respiration, which directly conflicts with base independent claim 129 ("first stimulation therapy protocol not synchronized relative to actively-sensed respiratory information") from which claim 140 depends indirectly.

Moreover, this passage in Paragraph 496 would further indicate to one skilled in the art that upon the respiratory signal being lost, no comparison (e.g. do the values differ ?) could

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

reasonably be made between “a duration of a real time respiratory cycle of actively sensed respiration” and “the duration of the reference respiratory cycle” as recited in Applicants’ claim 140. Accordingly, the arrangement in the cited portions of Bolea cannot reasonably meet the recitations of Applicants’ claim 140.

With this in mind, this passage of Bolea fails to contemplate a “duration variability criteria” in the manner recited in Applicants’ claim 140 by which it is determined to whether apply each respective stimulation cycle having a duration equal to the duration of the reference respiratory cycle. For example, see at least Paragraph 238 in Applicants’ specification and at least 506 in FIG. 15B.

Accordingly, for at least these reasons, Bolea fails to meet each and every recitation of Applicants’ claim 140, and therefore fails to anticipate claim 140.

Applicants submit that independent claim 143 is patentable over Bolea for at least some of substantially the same reasons as previously presented in favor of the patentability of independent claim 129 and/or its dependent claims.

Moreover, Applicants submit that claim 143 is further patentably distinguishable over Bolea at least because independent claim 143 recites “a sensing element to obtain respiratory information via at least periodically sensing a respiratory waveform unrelated to stimulation synchronization” which stands in sharp contrast to the cited portions of Bolea use of a sensed respiratory signal used for synchronization (e.g. at least Paragraphs 471, 496 “stimulation timing remains synchronous to the last detected peak”).

Accordingly, for at least these reasons, Bolea fails to meet each and every recitation of Applicants’ independent claim 140, and therefore fails to anticipate independent claim 140.

Applicants submit that independent claim 148 is patentable over Bolea for at least some of substantially the same reasons as previously presented in favor of the patentability of independent claim 129 and/or independent claim 143.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Moreover, Applicants submit that claim 148 is further patentably distinguishable over Bolea at least because

For at least the reasons previously described in association with claim 129, Bolea (as cited in the Office Action) fails to provide for “a stimulation therapy protocol not synchronized to respiratory information” as recited in independent claim 148, and therefore Bolea also fails to disclose the recitation in Applicants’ independent claim 148 for “instructions, executable via the processor, to: provide convertible operation via a therapy manager between:

a first stimulation mode implementing the first stimulation therapy protocol; and

a second stimulation mode of stimulating the upper-airway-patency-related nerve synchronous with a characteristic of the sensed respiratory waveform.

Moreover, the portions of Bolea cited regarding claim 148 also fails to disclose the “convertible operation” in the manner recited in Applicants’ independent claim 148. In particular, cited Paragraphs such as Paragraph 498 of Bolea provide an adaptive mode, which can vary (e.g. different percentage) a duty cycle depending on a function of characteristic of respiration. However, it would appear to one skilled in the art that this discussion falls into the discussion relating to FIGS. 80A-80C, which includes Paragraph 496 of Bolea stating that even when a respiratory signal is lost, “stimulation timing remains synchronous to the last detected peak.”

Accordingly, Bolea fails to disclose the “convertible operation” recited in Applicants’ claim 148 at least because the cited portions of Bolea fails to disclose the first stimulation mode recited in Applicants’ claim 148.

In view of the above, Applicants respectfully request withdrawal of the Section 102 rejections.

EX-1002 0348-357.

61. I disagree with the foregoing attorney argument as to what a POSITA understood from Bolea. For example, Bolea expressly discloses that the

asynchronous (fixed) mode may be used during a therapy session, including as when the signal received from the sensing lead is lost.

Stimulation may also be delivered in two modes which are not inspiratory synchronous: manual stimulation and asynchronous (fixed) stimulation.

EX-1012 (Bolea) ¶ 514.²

Asynchronous mode (fixed mode) is when stimulation is delivered at regular programmable intervals (e.g., 2.5 seconds of stimulation, followed by 2.5 seconds off). The intervals may be set to a rate similar to a respiratory cycle, (e.g., 5 seconds)...In addition, ***this mode may be used to test the benefits of asynchronous stimulation compared to inspiratory synchronous. Asynchronous stimulation may be initiated by programming the device to fixed mode and starting a therapy session.*** Fixed mode stimulations may be in any available pulse train configuration.

EX-1012 (Bolea) ¶ 515.

The stimulation duty cycle may be fixed or adaptive. In the fixed mode, the stimulation duty cycle is set using to programmer

² All ***bold-italics*** emphasis added unless otherwise stated.

system 2100 to a fixed value. ***This fixed value may be increased when the respiratory signal is lost, increasing the likelihood of aligning with actual inspiration.***

EX-1012 (Bolea) ¶ 498.

62. Thus, while Bolea discloses that the asynchronous (fixed) mode may be used during the daytime for testing, Bolea expressly discloses that the asynchronous stimulation is applied during a “therapy session,” may be used in testing whether asynchronous stimulation is more beneficial than synchronous stimulation, and may be used when a respiratory signal is lost.
63. If a respiratory signal is lost, a POSITA understood that there is no active sensing of the patient’s respiratory cycle. Once there is no actively-sensed respiration information, then there cannot be any synchronization to actively-sensed respiratory information. Indeed, if the respiratory signal is lost, then the device would either not provide stimulation or provide stimulation asynchronously because there is no respiratory signal with which the system may use to perform the synchronization. However, Bolea does not disclose that the stimulation ceases when the respiratory signal is lost, but instead expressly discloses providing stimulation with an increased duty cycle to ensure overlap with the inspiratory period of the patient.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

64. Further, Bolea expressly discloses that a patent's respiratory rate may vary, which a POSITA understood means that the older actively-sensed respiratory information would not provide synchronicity or be considered actively-sensed. See EX-1012 (Bolea) ¶ 493 ("In people without OSA, inspiration is typically 25%-50% of the respiratory cycle, with variations in respiration rate being common. Variations may cause inspiration to differ from predicted inspiration.").
65. Moreover, Bolea expressly discloses that a therapy controller may allow a patient (or other individual) to control select therapy settings, including the stimulation mode.

The therapy controller may have additional functionality (e.g., more buttons) which can be set to give the patient limited ***control over select therapy settings***. These settings include, but are not limited to, stimulation intensity (e.g., amplitude), ***stimulation mode***, pulse train configuration, core hours stimulation settings, ramp, programmable schedule clock, and motion inhibit programmable values.

EX-1012 (Bolea) ¶ 528.

66. As noted above, Bolea expressly discloses that asynchronous stimulation is non-synchronous mode of stimulation. EX-1012 (Bolea) ¶ 514 ("Stimulation

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

may also be delivered in *two modes which are not inspiratory synchronous*: manual stimulation and *asynchronous (fixed) stimulation*.”). As such, a POSITA understood that asynchronous stimulation could be selected by a patient to be used in a therapy session. In sum, Bolea expressly contemplates using asynchronous stimulation during a therapy session, including in the complete absence of a sensor signal for actively sensing the respiration of the patient. EX-1012 (Bolea) ¶¶ 498-501, 515-516, 528.

67. The Examiner, having apparently been persuaded by Applicant’s arguments regarding Bolea (and overlooking several of the above-identified disclosures in Bolea), issued another non-final rejection on April 2, 2020 in which claims 134, 137-140, and 149 were identified as including allowable subject matter, and the rest of the claims were rejected based on U.S. Patent No. 5,944,680 (EX-1011; Christopherson) alone or in combination with other prior art references, including Bolea. EX-1002 0365-375.
68. In response to the April 2, 2020 office action (EX-1002 0409-417), Applicant significantly amended the independent claims to require each stimulation period to include continuous stimulation having a duration equal to or greater than an inspiratory reference of a reference respiratory cycle that comprises at least of a patient-specific or multi-patient average respiratory cycle and that

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

each stimulation period has a duration greater than a duration of the inspiratory reference and the non-stimulation period.

129. (Currently Amended) A device for treating obstructive sleep apnea, comprising:

a non-cardiac stimulation element to engage and to stimulate an upper-airway-patency-related nerve, according to a first stimulation therapy protocol not synchronized relative to actively-sensed respiratory information, wherein the first stimulation therapy protocol comprises a series of repeating stimulation cycles in which each stimulation cycle includes a stimulation period and a non-stimulation period,

wherein each stimulation period includes continuous stimulation and has a minimum duration equal to or greater than an inspiratory reference of a reference respiratory cycle, wherein the inspiratory reference corresponds to a duration of an inspiratory phase of the reference respiratory cycle, and wherein the reference respiratory cycle comprises at least one of:

a historical patient-specific average respiratory cycle for stable respiration; and

a multi-patient average respiratory cycle for stable respiration. and

wherein each stimulation period of each respective stimulation cycle has a duration greater than a duration of the inspiratory reference of the reference respiratory cycle and the stimulation period is followed by the non-stimulation period of the respective stimulation cycle comprising a duration less than the duration of the stimulation period.

EX-1002 0410.

69. Independent claims 143 and 148 were amended to depend from independent claim 129. EX-1002 0412-413. A Notice of Allowance issued on September 29, 2018. EX-1002 0422. The Examiner set forth the following reasons for allowance.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Reasons for Allowance

4. The following is an examiner's statement of reasons for allowance: Claims 129-131, 135-143, and 148-150 are allowable over the prior art because the examiner found that none of the cited prior art taught stimulating at a duration equal to or greater an inspiratory reference of a reference respiratory cycle based on a historical patient-specific average or multi-patient average. The examiner notes close prior art Tehrani (US 2008/0161878 A1) discloses a stimulation time greater than one inspiration cycle but does not specify a non-stimulation period less than the duration of a stimulation period and applies these stimulations to the hemidiaphragms which are not upper airway nerves.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

EX-1002 0428.

VII. OVERVIEW OF THE PRIOR ART

A. Durand (EX-1006)

1. Prior Art Status

70. U.S. Patent Application Publication No. 2006/0224211 in the name of Durand et al. ("Durand") published on October 5, 2006. I understand that Durand qualifies as prior art to the '709 Patent. The patent corresponding to Durand, i.e., U.S. Patent No. 7,680,538, was cited (EX-1002 0165) in one of three information disclosure statements filed on January 23, 2018 (EX-1002 0144-

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

185), along with over 300 other references, but was not applied by the Office during the prosecution of the Challenged Claims.

2. Summary of Durand's Disclosure

71. Durand, titled “Method of treating obstructive sleep apnea using electrical nerve stimulation,” is directed to a method of treating obstructive sleep apnea using electrical nerve stimulation. EX-1006 (Durand), Title, Abstract. Specifically, Durand describes a method for treating obstructive sleep apnea by electrically stimulating the hypoglossal nerve, which uses at least one of the following techniques: (a) continuous low-level electrical stimulation; (b) electrical stimulation synchronized with a physical process, such as inspiration, without feedback from the nerve being stimulated; and (c) intermittent electrical stimulation at controlled intervals based on the patient's metabolism. EX-1006 (Durand), Abstract, ¶ 1. Durand explains that “electrical stimulation of the hypoglossal nerve...can maintain the patency of the upper airway by activating the upper airway dilator muscles, thereby minimizing or eliminating airway collapse during sleep.” EX-1006 (Durand) ¶ 12.
72. FIG. 1 of Durand shows apparatus 20 for stimulating a nerve, including **control system** 22 for generating the desired electrical stimulus and **electrode**

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

24 in the form of a nerve cuff connected to the nerve to transmit the electrical stimulus to the nerve:

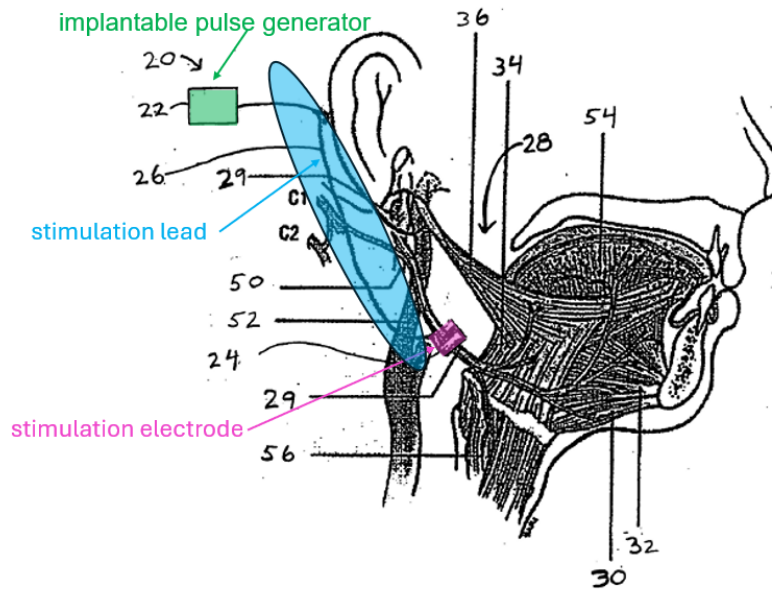


FIG. 1

EX-1006 (Durand) FIG. 1 (annotated), ¶ 14 (“The electrode 24 preferably is a cuff electrode that provides an intimate connection to the nerve.”).

73. Durand describes that “control system 22 controls the application of the electrical stimulation” and that “[p]ortions of the control system 22, in addition to the electrode 24, can be implanted in the patient’s body.” EX-1006 (Durand) ¶ 16. Durand explains that “the muscles that control the upper airway 28 and are innervated by the hypoglossal nerve 29 include the geniohyoid muscle 30, the genioglossus muscle 32, the hyoglossus muscle 34

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

and the styloglossus muscle 36.” EX-1006 (Durand) ¶ 19. Durand further explains that “genioglossus 32 is the main tongue protruder (the muscle that pushes the tongue out) and plays an important role in maintaining the patency of the upper airway.” EX-1006 (Durand) ¶ 19.

74. Durand discloses both synchronous and asynchronous techniques for treating OSA. With respect to asynchronous stimulation, Durand discloses that “initiation of the electrical stimulation can be synchronized with a physical process, such as inspiration sensed by a remote sensor, without feedback from the nerve being stimulated.” EX-1006 (Durand) ¶ 23. In one embodiment, Durand discloses that “the controller can be programmed to provide stimulation at a predetermined interval without either detecting a physical process or requiring feedback from the nerve being stimulated.” EX-1006 (Durand) ¶ 25. “In this method, the stimulation interval can be determined from the patient’s nighttime basal metabolism, e.g., based on the patient’s observed nighttime resting respiratory rate. The resultant timing of the stimulation pulse trains will closely simulate the patient’s normal nighttime respiration cycle.” EX-1006 (Durand) ¶ 25. Durand describes that “a train of stimulus pulses can be applied for about 2 seconds to about 3 seconds, and

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

more particularly, for about 2½ seconds, with a wait of at least 2 seconds to about 3 seconds between the pulse trains.” EX-1006 (Durand) ¶ 25.

75. A POSITA understood that a typical respiratory rate for an adult was around 12-20 breaths per minute (BPM), which corresponds to a respiratory cycle duration of around three seconds (20 BPM) to five seconds (12 BPM). Durand’s disclosure of four (i.e., two seconds of stimulation; two seconds off) to six (i.e., three seconds of stimulation; three seconds off) second stimulation cycle durations overlaps with, and generally corresponds to, these typical adult respiratory rates.

B. Hoegh (EX-1007)

1. Prior Art Status

76. U.S. Patent Application Publication No. 2015/0094962 in the name of Hoegh et al. (“Hoegh”) is the pre-grant publication of U.S. Patent Application No. 14/505,151, which was filed on October 2, 2014, claiming priority to U.S. Provisional Application Nos. 61/885,991, filed October 2, 2013, and 62/058,914, filed October 2, 2014. I understand that Hoegh qualifies as prior art to the ’709 Patent. Hoegh was not cited or applied by the Office during the prosecution of the Challenged Claims.

2. Summary of Hoegh's Disclosure

77. Hoegh, titled "Obstructive sleep apnea treatment screening methods," relates to methods for treatment of obstructive sleep apnea. EX-1007 (Hoegh) Title, Abstract, ¶ 2 ("[T]he embodiments described herein relate to devices, systems and methods for treating obstructive sleep apnea."). Hoegh discloses "a screening method for evaluating patient suitability for an implanted hypoglossal nerve stimulation (HGNS) device." EX-1007 (Hoegh) Abstract.
78. FIG. 1 of Hoegh shows hypoglossal nerve stimulation (HGNS) system 100 comprising internal components 1000 and external components 2000:

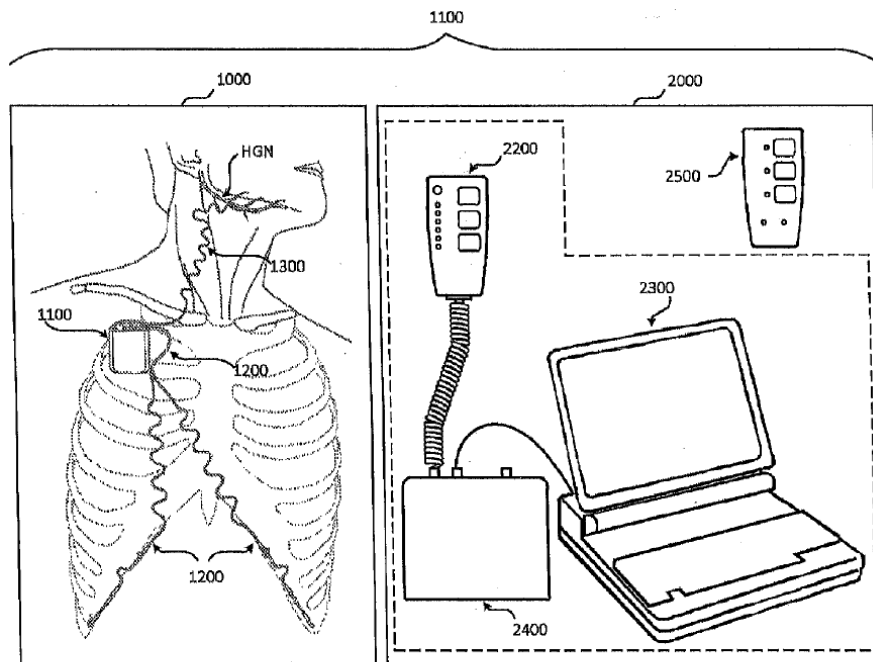


FIG. 1

EX-1007 (Hoegh), FIG. 1.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

79. Hoegh describes that “HGNS system 100 may treat obstructive sleep apnea (OSA) by increasing neuromuscular activity to the genioglossus muscle via stimulation of the hypoglossal nerve (HGN), such as synchronous with inspiration, to mitigate upper airway collapse during sleep.” EX-1007 (Hoegh) ¶ 50. Hoegh further describes that “[s]timulation may be generated by an implantable neurostimulator (INS) 1100, for example synchronized with inspiration as measured by the respiration sensing lead (RSL) 1200 using bio-impedance, and delivered to the hypoglossal nerve by a stimulation lead (STL) 1300.” EX-1007 (Hoegh) ¶ 50.

C. Headley (EX-1008)

1. Prior Art Status

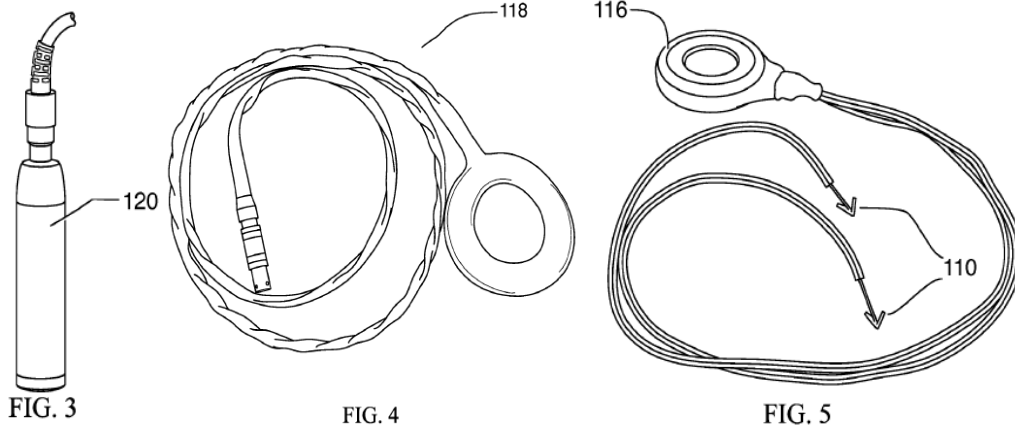
80. International Patent Application Publication No. WO 2010/006218 in the name of Headley (“Headley”) published on January 14, 2010, I understand qualifies the references as prior art to the ’709 Patent. Headley was not cited or applied by the Office during prosecution of the Challenged Claims.

2. Summary of Headley’s Disclosure

81. Headley is titled “Sleep Apnea Device and Method” and “involves the implantation of a muscle stimulation electrode directly into the muscle of the genioglossus that advances the posterior aspect of the tongue anteriorly thus

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

relieving the obstruction of the tongue in sleep apnea.” EX-1008 (Headley) Abstract. More particularly, the device includes a power source 120 (FIG. 3), an antenna 118 (FIG. 4), a receiver 116, and a stimulating electrode 110 (FIG. 5). EX-1008 (Headley) ¶29.



EX-1008 (Headley) FIGS. 3-5.

82. In use, the device provides for alternating on/off “intermittent” treatment where tissue is stimulated for a given period, then allowed to rest for a given period. EX-1008 (Headley) ¶ 48. Headley discloses on/off duty cycles ranging from 12/1 (e.g., 60 seconds on; 5 seconds off) to 1/1 (e.g., five seconds on; five seconds off), with on/off periods as short as one second each. EX-1008 (Headley) ¶ 48.

D. Tran (EX-1009, EX-1010)

1. Prior Art Status

83. Tran are the collective works of Tran et al. and includes two papers, i.e., Tran et al., “Development of Asynchronous, Intralingual Electrical Stimulation to Treat Obstructive Sleep Apnea,” which was presented as the Proceedings of the 25th Annual International Conference of the IEEE EMBS in Cancun, Mexico, September 17-21, 2003 (EX-1009, “Tran-I”), and Tran et al., “First Subject Evaluated with Simulated BION™ Treatment in Posterior Genioglossus to Prevent Obstructive Sleep Apnea,” which was presented at the Proceedings of the 26th Annual International Conference of the IEEE EMBS in San Francisco, CA, September 1-5, 2004 (EX-1010, “Tran-II”) and cites to and builds on Tran-I.
84. Tran-I was publicly accessible no later than February 2004, EX-1004 (Hsieh-Yee Decl.) ¶¶ 48-50, and I understand qualifies as prior art to the ’709 Patent. Tran-II was publicly accessible no later than November 2004, EX-1004 (Hsieh-Yee Decl.) ¶¶ 86-89, and I understand qualifies as prior art to the ’709 Patent. Neither Tran-I nor Tran-II was cited or applied by the Office during prosecution of the Challenged Claims.

2. Summary of Tran's Disclosure

85. Tran-I discloses using asynchronous electrical stimulation via an implantable stimulator electrode to treat obstructive sleep apnea. EX-1009 (Tran-I) Title, Abstract, p. 375 (“using a single intralingual BION™ microstimulator to prevent airway obstruction in patients with obstructive sleep apnea (OSA)”). Tran-I describes that “[n]euromuscular and hypoglossal nerve stimulation of the genioglossus” was known “to expand the oropharyngeal airway and reduce[] the severity of sleep disordered breathing.” EX-1009 (Tran-I), Abstract, p. 375. Tran-I further describes that “OSA occurs when the soft tissues of the upper airway collapse and occlude airflow during inspiration” and “[c]ollapse of the tongue is the most common cause of OSA.” EX-1009 (Tran-I), p. 375.
86. Tran-I describes that the implantable electrode can be injected in or near muscles and nerves and receives power and digital command data via an RF transmission coil to produce stimulation pulses. EX-1009 (Tran-I), p. 375. FIG. 3 of Tran-I shows that the device can be implanted into the patient from under the chin along the midline, where it would stimulate the intramuscular branches of the same motor axons as may be stimulated in the hypoglossal nerve:

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

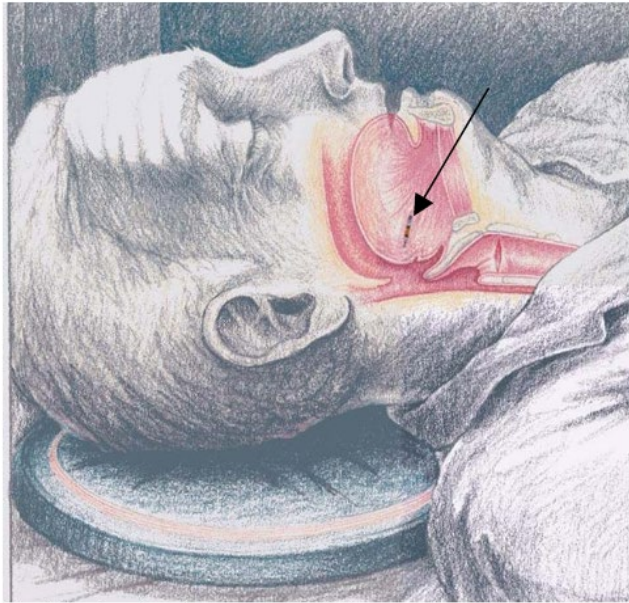


Fig. 3. Implantation site of a single BION in posterior midline of the genioglossus muscle with tantalum electrode (effective cathode) near the endplates (toward the tongue base).

EX-1009 (Tran-I), FIG. 3, p. 376.

87. Regarding asynchronous electrical stimulation, Tran-I discloses that “intermittent opening of airway at the same rate but not synchronized to the respiratory cycle may be effective” to treat OSA. EX-1009 (Tran-I), p. 375. Tran-I explains that “if brief trains of stimulation pulses were applied to the [genioglossus] at intervals close to the respiratory cycle of the patient, the patient would tend to synchronize spontaneously with the resulting intermittent periods of patency in the airway.” EX-1009 (Tran-I), p. 377. Tran-I explains that this occurs “because an inspiratory phase that happens not to coincide with [genioglossus] stimulation will tend to be prolonged until

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

the next train of [genioglossus] stimulation opens the airway.” EX-1009 (Tran-I), p. 377.

88. Tran-II, titled “First Subject Evaluated with simulated BION™ Treatment in Posterior Genioglossus to Prevent Obstructive Sleep Apnea,” describes “using percutaneous electrical stimulation to simulate BION™ activation of posterior genioglossus during sleep to prevent occurrences of obstructive sleep apnea (OSA).” EX-1010 (Tran-II), Title, Abstract, p. 4287. Tran-II explains that OSA is a “common breathing disorder caused by repetitive upper airway obstruction that stops breathing during sleep” and “the primary mechanism causing the obstruction is the pronounced decrease in muscle tone during sleep...permitting the tongue to prolapse, closing the airway during the negative pressure of inspiration.” EX-1010 (Tran-II), p. 4287. Tran-II further explains that “[p]reventing obstructive sleep apnea will reduce the patient’s susceptibility to cardiovascular and cerebrovascular diseases and will improve their quality of life.” EX-1010 (Tran-II), p. 4287.
89. Like Tran-I, Tran-II describes using an implantable stimulation electrode to prevent airway obstruction in patients with OSA. EX-1010 (Tran-II), p. 4287 (disclosing “a single channel, wireless microelectronic stimulator...that can be injected into a muscle such as the tongue” and “receives power and digital

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

command data from a nearby RF transmission coil to produce stimulation pulses”). Tran-II discloses that the device is “used to stimulate the tongue muscle to move it out of the airway of the sleeping patient and help prevent OSA.” EX-1010 (Tran-II), p. 4287.

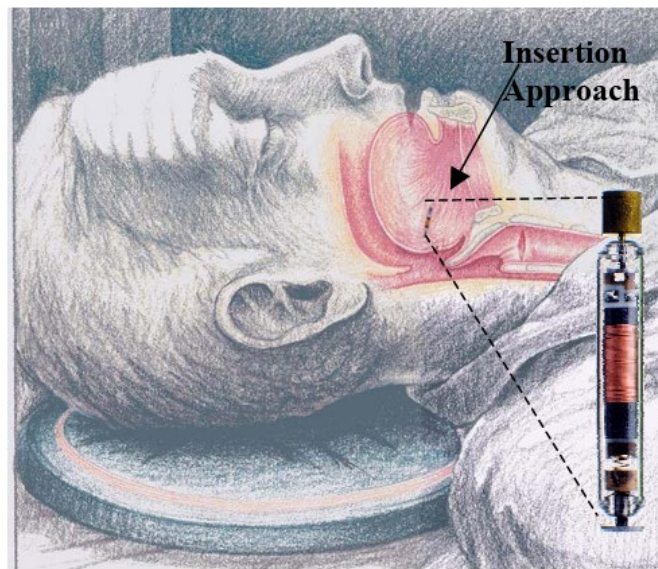


Fig. 1. Closure of the airway during sleep can be prevented by stimulating the tongue protrusor motor units, whose endplates are located near the midline at the posterior genioglossus. A single BION inserted into the posterior genioglossus can be powered and controlled by a transmitting coil located in the pillow.

EX-1010 (Tran-II), FIG. 1.

90. Regarding asynchronous electrical stimulation, Tran-II discloses that “electrical stimulation does not have to synchronize with inspiration to prevent OSA.” EX-1010 (Tran-II), p. 4287. Tran-II discloses that “repetitive intermittent electrical stimulation could be used to recover or maintain airway

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

patency.” EX-1010 (Tran-II), p. 4287. In one example, Tran-II describes applying “a brief train of electrical pulses during an ON period followed by no stimulation during an OFF period” and explains that “[t]his method of stimulation is repeated in continuous cycles at approximately the natural respiratory rhythm of the sleeping participant, obviating the need for a sensor to synchronize stimulation with breathing.” EX-1010 (Tran-II), p. 4287.



Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

that “using neuromuscular stimulation without synchronizing with breathing (repetitive intermittent electrical stimulation) in [the] posterior genioglossus... may be useful to prevent development of hypopnea and OSA.” EX-1010 (Tran-II), p. 4288.

VIII. SUMMARY OF INVALIDITY GROUNDS

92. The Challenges are set forth in detail below and summarized as follows:

Ground	Claims	Basis	Reference
1	1-12 and 14	§ 103	Durand in view of Hoegh
2	1, 2, 4-10, 12-13, and 15	§ 103	Headley in view of Tran

IX. GROUND 1: CHALLENGED CLAIMS 1-12, 14, AND 15 ARE OBVIOUS FROM DURAND IN VIEW OF HOEGH

A. Reasons to Combine Durand and Hoegh

93. As discussed above in VII.A.2 (Summary of Durand’s Disclosure), Durand discloses a device including a cuff electrode and a control system for treating OSA by stimulating the HGN that uses trains of stimulus pulses at stimulation intervals that are “determined from the patient’s nighttime basal metabolism, e.g., based on the patient’s observed nighttime resting respiratory rate” such that “[t]he resultant timing of the stimulation pulse trains will closely simulate

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

the patient's normal nighttime respiration cycle," which avoids "the added complexity of closed-loop feedback." EX-1006 (Durand) ¶ 25. Durand further discloses that the duration of the stimulation period (2-3 seconds) may be equal to or longer than the non-stimulation period (2-3 seconds). EX-1006 (Durand) ¶ 25 ("For example, a train of stimulus pulses can be applied for about 2 seconds to about 3 seconds, and more particularly, for about 2½ seconds, with a wait of at least 2 seconds to about 3 seconds between pulse trains.").

94. Durand recognizes that the stimulation interval can be based on the patient normal nighttime interval, but does not provide further details including any example numbers for a typical respiration cycle and its relative duration compared to the stimulus interval. However, this is not surprising because as discussed in V (Technical Background and State of the Art), it was well-known how to determine an effective stimulus interval based on a patient's typical respiration cycle. EX-1012 (Bolea) ¶¶ 266, 527, 556-558. Further, as noted above, a POSITA understood that a typical respiratory rate for an adult was around 12-20 breaths per minute (BPM), which corresponds to a respiratory cycle duration of around 3 seconds (20 BPM) to 5 seconds (12 BPM). Durand's disclosure of four (i.e., two seconds of stimulation; two

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

seconds off) to six (i.e., three seconds of stimulation; three seconds off) second stimulation cycle durations overlaps with, and generally corresponds to, these typical adult respiratory rates.

95. While Durand does not expressly disclose the duration of the stimulation period relative to the patient's inspiratory phase or provide much detail regarding nighttime metabolism and how the stimulation cycle may be optimized for a given patient to improve the efficacy of the OSA treatment, Hoegh does, and a POSITA would have been motivated to look for other references that provide a more detailed discussion of OSA and treatment protocols.
96. For example, Hoegh, which is in the same field of endeavor as Durand, provides a detailed description of a suitable implantable neurostimulator ("INS") (EX-1007 (Hoegh) ¶¶ 74-119), stimulation lead (STL) (EX-1007 (Hoegh) ¶¶ 53-59), programmer system (EX-1007 (Hoegh) ¶¶ 120-125), and therapy controller (EX-1007 (Hoegh) ¶¶ 126-130) that may be used to treat OSA. In addition to providing a more robust description of the relevant hardware, Hoegh provides a detailed description of the surgical technique for implanting the device and an exemplary titration process. EX-1007 (Hoegh) ¶¶ 134-158, 190-213.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

97. Hoegh further discloses a detailed analysis of the patient's natural physiology and its relationship to treating OSA, including that "[t]he hypoglossal nerve usually activates approximately 300 ms before inspiration and remains active for the entire respiratory phase" and "[t]o mimic this natural physiology, stimulation may be delivered during to the hypoglossal nerve during the inspiratory phase plus a brief pre-inspiratory period of about 300 ms." EX-1007 (Hoegh) ¶ 92. Hoegh further discloses various duty cycles (i.e., the ratios of stimulation periods to non-stimulation periods) that may be used to treat OSA, including that "the maximum stimulation duty cycle may be set from 41% to 69% in 3% increments" and that the duration of the stimulation cycle may be increased to "decrease the probability of missing two consecutive inspirations, and increase the probability of providing the patient with stimulation during the entire respiratory cycle." EX-1007 (Hoegh) ¶¶ 98, 114. A duty cycle of 40% means that the duration a stimulus is applied is 40% of the duration of the stimulation cycle duration, which is based on the patient's respiratory cycle. As such, the 40% duration cycle corresponds to stimulus being applied for 40% of the patient's respiratory cycle.
98. A POSITA would have been motivated to combine the teachings of Hoegh and Durand and would have expected that the teachings could be combined

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

with a reasonable expectation of success at least because both references are directed to methods for treating OSA using implanted devices for electrical stimulation of the hypoglossal nerve and because Hoegh's disclosure is consistent with Durand's disclosure. EX-1006 (Durand), Title, Abstract, ¶¶ 13, 14, 21, 25; EX-1007 (Hoegh), Abstract, ¶ 92.

99. A POSITA would have had a reasonable expectation of success combining Durand's and Hoegh's teachings for several reasons. *First*, both references disclose treatment methods for OSA using implantable devices, including a nerve cuff and control system/pulse generator, to electrically stimulate the hypoglossal nerve asynchronously. EX-1006 (Durand) ¶¶ 13-16, 21, 25; EX-1007 (Hoegh) ¶¶ 50-51, 92-93.
100. *Second*, both references disclose similar device types and implantation locations:

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

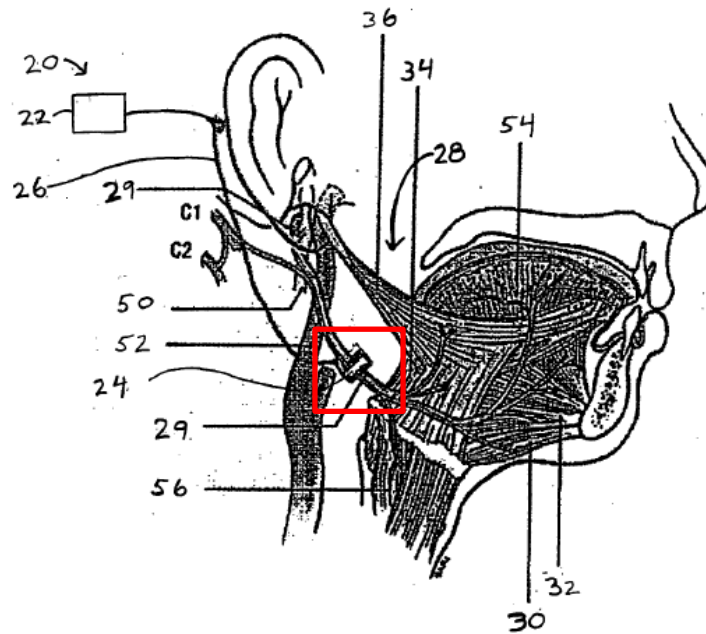
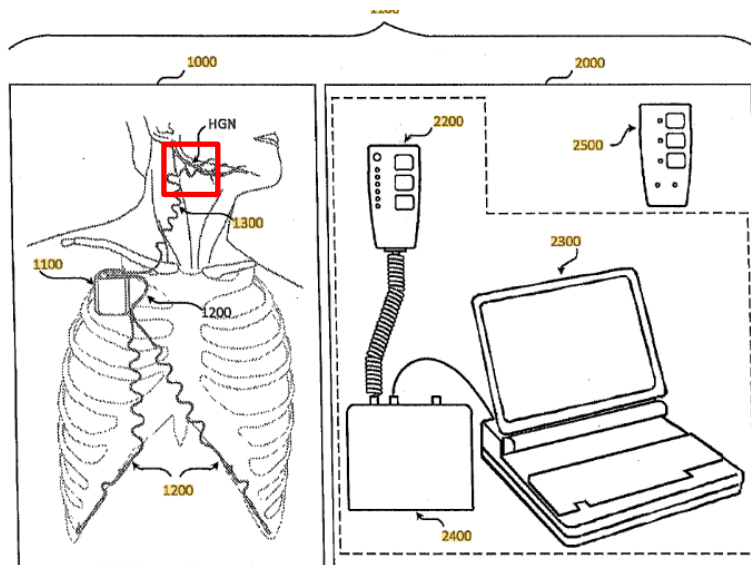


FIG. 1

EX-1006 (Durand), FIG. 1 (annotated).



EX-1007 (Hoegh), FIG. 1 (annotated).

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

101. *Third*, both references disclose a duty cycle that is determined based on a typical respiration cycle duration for a patient, with the only difference being that Hoegh provides more details of a typical respiration cycle and its relative duration compared to the stimulus interval. EX-1006 (Durand) ¶ 25; EX-1007 (Hoegh) ¶¶ 98, 114. A POSITA would have recognized that such modifications disclosed by Hoegh, such as varying the duty cycle and/or duration of the overall stimulation cycle were well within the routine in the art. Specifically, these modifications simply required changes to the software to increase the stimulation period and/or overall duration of the stimulation cycle of Durand's intermittent on/off electrical stimulation. Such modifications could be done at the time of manufacture, such as in the firmware or other program code, or could be made by a practitioner during a titration procedure after the device was implanted, as expressly disclosed by Hoegh. As discussed above in V.B (Technical Background, OSA Treatment), titration involved the adjustment of one or more stimulation parameters (e.g., duty cycle, cycle duration, pulse width, amplitude, etc.) and was routinely performed after the patient healed from the implantation procedure and was about to use the device therapeutically. *See also* EX-1007 (Hoegh) ¶¶ 190-213.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

102. A POSITA had a reasonable expectation of success in combining Durand's and Hoegh's teachings because both references disclose applying methods (asynchronous stimulation) using devices (implantable pulse generator and cuff electrodes) to achieve results (treatment of OSA) that were known in the art before the priority date of the '709 Patent, such that their teachings would have been readily applied to the other using only routine skill.

B. Application of Durand and Hoegh to Challenged Claims 1-12, 14, and 15

1. Claim 1

a. [1.pre] *A device for treating obstructive sleep apnea, comprising:*

103. To the extent the preamble is limiting, Durand discloses an apparatus [*device*] for treating OSA.

FIG. 1 is a schematic illustration of an *apparatus* and the nerves and muscles *used in treating obstructive sleep apnea*.

EX-1006 (Durand) ¶ 11.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

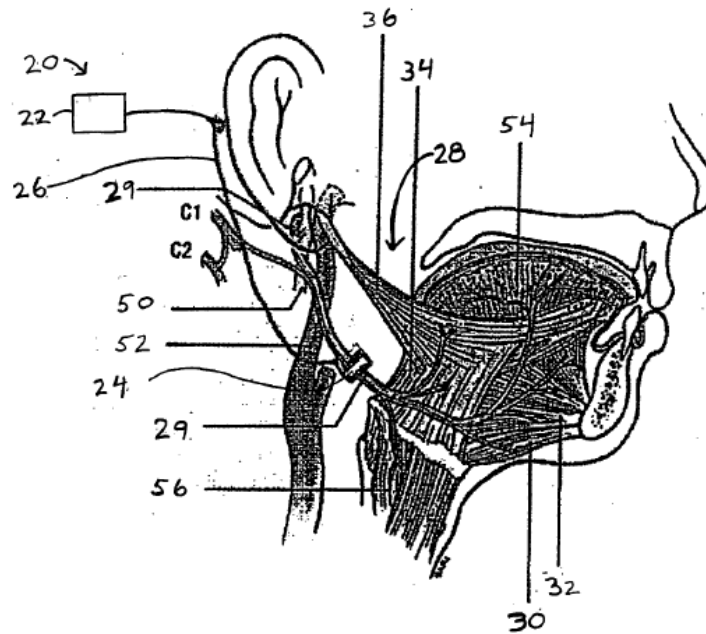


FIG. 1

EX-1006 (Durand), FIG. 1.

104. Accordingly, Durand discloses a device for treating OSA.

b. [1.a1] *a non-cardiac stimulation element to engage and to stimulate an upper-airway-patency-related nerve;*

105. Durand discloses that the apparatus [*device*] includes a control system 22 and a cuff electrode 24 [*non-cardiac stimulation element*] that is intimately connected to [*engage*] the hypoglossal nerve [*upper-airway-patency-related nerve*] and which provides electrical stimulation.

In the case of obstructive sleep apnea, electrical stimulation of the hypoglossal nerve, for example, can

maintain the patency of the upper airway by activating the upper airway dilator muscles, thereby minimizing or eliminating airway collapse during sleep.

EX-1006 (Durand) ¶ 12.

An exemplary *apparatus 20 for stimulating a nerve* in accordance with the present invention is shown schematically in FIG. 1. *The apparatus 20 includes a control system 22 (shown schematically) for generating the desired electrical stimulus, and an electrode 24 connected to the nerve to transmit the electrical stimulus to the nerve. The electrode 24 preferably is a cuff electrode that provides an intimate connection to the nerve.* The cuff electrode 24 can have a variety of geometries or configurations, but preferably provides an intimate connection around the nerve. A lead wire 26 connects the electrode 24 to the control system 22 in the illustrated embodiment.

EX-1006 (Durand) ¶ 14.

106. Accordingly, Durand discloses claim element [1.a1].

- c. **[1.a2] according to a first stimulation therapy protocol not synchronized to actively-sensed respiratory information,**

107. Durand discloses that the control system generates intermittent electrical stimulation at controlled intervals that are based on the patient's previously observed respiratory rate [*first stimulation therapy protocol*].

More particularly, a method provided in accordance with the invention includes ***controlling the patency of a patient's airway by stimulating a nerve using at least one of the following techniques***: (a) continuously electrically stimulating at least one fascicle of the hypoglossal nerve at a predetermined a low level amplitude throughout the respiratory cycle; (b) electrically stimulating a nerve and initiating the stimulation in response to a physical process, such as inspiration, using a remote sensor, without feedback from the nerve being stimulated; and (c) ***intermittently electrically stimulating a nerve at controlled intervals, predetermined based on the patient's resting nighttime metabolism, which can be determined from the patient's observed respiratory rate***, for example.

EX-1006 (Durand) ¶ 13.

108. Durand further discloses that the controller does not detect a physical process or require feedback from the nerve being stimulated because the rate is predetermined [*not synchronized to actively-sensed respiratory information*].

In a third embodiment of the method, *the controller can be programmed to provide stimulation at a predetermined interval without either detecting a physical process or requiring feedback from the nerve being stimulated. In this method, the stimulation interval can be determined from the patient's nighttime basal metabolism, e.g., based on the patient's observed nighttime resting respiratory rate.* The resultant timing of the stimulation pulse trains will closely simulate the patient's normal nighttime respiration cycle. For example, a train of stimulus pulses can be applied for about 2 seconds to about 3 seconds, and more particularly, for about 2½ seconds, with a wait of at least 2 seconds to about 3 seconds between the pulse trains. The pulse trains can each have an amplitude that is at or greater than the patient's activation threshold, up to about 20% above the patient's activation threshold, for example. In this embodiment, *the stimulation is provided at predetermined rate or pace without the added complexity of closed-loop feedback.*

EX-1006 (Durand) ¶ 25.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

109. As noted above, Durand identifies the benefits of providing asynchronous stimulation (i.e., providing stimulation that is not based on actively-sensed information) is that the added complexity of closed-loop feedback can be avoided. EX-1006 (Durand) ¶ 25. Further, a POSITA understood that providing such feedback typically included the use of a sensor, which was known in the art to add complexity in programming and, sometimes, additional surgical intervention to implant a sensing lead. EX-1032 (Mwenge), p. 366 (“The THN method appears, in this regard, to be simpler, in that it obviates the need for sensors and extra hardware, thereby decreasing the surgical procedure time and associated risks.”); EX-1033 (Zaidi), p. 384 (“This stimulator design is able to avoid fatigue, without the need for additional implanted feedback sensors....”); EX-1010 (Tran-II), p. 4288 (“This method of stimulation is repeated in continuous cycles at approximately the natural respiratory rhythm of the sleeping participant, obviating the need for a sensor to synchronize stimulation with breathing.”). Thus, providing asynchronous stimulation reduced the complexity of the system while at the same time reduced the time and complexity of the surgical intervention required to implant the device.
110. Accordingly, Durand discloses claim element [1.a2].

- d. ***[1.b] wherein the first stimulation therapy protocol comprises a series of repeating stimulation cycles in which each stimulation cycle includes a stimulation period and a non-stimulation period,***

111. Durand discloses that the intermittent electrical stimulation [*first stimulation therapy protocol*] in which a train of stimulation pulses are applied for a period of time [*stimulation period*] and then applied again [*repeating stimulation cycle*] after a wait period [*non-stimulation period*].

In a third embodiment of the method, ***the controller can be programmed to provide stimulation at a predetermined interval without either detecting a physical process or requiring feedback from the nerve being stimulated.*** In this method, the stimulation interval can be determined from the patient's nighttime basal metabolism, e.g., based on the patient's observed nighttime resting respiratory rate. The resultant timing of the stimulation pulse trains will closely simulate the patient's normal nighttime respiration cycle. For example, ***a train of stimulus pulses can be applied for about 2 seconds to about 3 seconds, and more particularly, for about 2½ seconds, with a wait of at least 2 seconds to about 3 seconds between the pulse trains.*** The pulse trains can each have an amplitude that is at or greater than the patient's activation threshold, up to about 20% above the patient's activation threshold, for example. In this embodiment,

***the stimulation is provided at predetermined rate or pace
without the added complexity of closed-loop feedback.***

EX-1006 (Durand) ¶ 25.

112. A POSITA understood from the foregoing disclosure in Durand that the train of stimulation pulses would be repeated after the wait period given that OSA may happen at any time while an individual is sleeping. As such, the periods of stimulation and non-stimulation would be repeated while the patient sleeps.

113. Accordingly, Durand discloses claim element [1.b].

e. ***[1.c] wherein each stimulation period includes continuous stimulation and has a minimum duration equal to or greater than an inspiratory reference of a reference respiratory cycle, wherein the inspiratory reference corresponds to a duration of an inspiratory phase of the reference respiratory cycle, and***

114. Durand discloses this claim element, either alone or in combination with Hoegh. As noted above, the '709 Patent describes continuous stimulation as “a train of stimulation pulses which occur in a relatively short time frame,” such as “a finite number (e.g. 5, 10, etc.) of stimulation pulses per second”:

In some examples, each stimulation period within a stimulation cycle includes continuous stimulation. In some examples, continuous stimulation refers to a train of stimulation pulses which occur in a relatively short time frame. For instance, in

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

some examples, continuous stimulation corresponds to at least a finite (e.g. 5, 10, etc.) of stimulation pulses per second.

EX-1001 4:37-43.

115. Similarly, Durand discloses that the train of stimulation pulses, having pulses provided at a frequency of about 10-30 Hertz (i.e., 10-30 pulses per second) [*continuous stimulation*], is applied for about 2-3 seconds [*stimulation period*] so that the stimulation pulse trains closely simulate the patient's normal nighttime respiration cycle [*reference respiratory cycle*].

Other suitable combinations of stimulation amplitude and frequency can be provided on a patient-dependent basis. For example, *the electrical stimulation can be provided by pulse trains of an intermittent duration or continuously, at a frequency of about 10 Hertz (Hz) to about 30 Hertz (Hz), with a pulse width of about 50 microseconds (μ s).*

EX-1006 (Durand) ¶ 21.

In a third embodiment of the method, the controller can be programmed to provide stimulation at a predetermined interval without either detecting a physical process or requiring feedback from the nerve being stimulated. In this method, the stimulation interval can be determined from the patient's nighttime basal metabolism, e.g., based on the patient's observed nighttime

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

resting respiratory rate. The resultant timing of the stimulation pulse trains will closely simulate the patient's normal nighttime respiration cycle. *For example, a train of stimulus pulses can be applied for about 2 seconds to about 3 seconds, and more particularly, for about 2½ seconds, with a wait of at least 2 seconds to about 3 seconds between the pulse trains.* The pulse trains can each have an amplitude that is at or greater than the patient's activation threshold, up to about 20% above the patient's activation threshold, for example. In this embodiment, *the stimulation is provided at predetermined rate or pace without the added complexity of closed-loop feedback.*

EX-1006 (Durand) ¶ 25.

116. A POSITA understood that by simulating the patient's observed nighttime resting respiratory rate [*reference respiratory cycle*], the train of stimulation pulses would be applied [*stimulation period*] for a period at least as long as (if not longer) the patient's inspiratory phase to ensure that the tongue is protruding during inspiration to maintain airway patency. EX-1006 (Durand) ¶ 20 ("Thus, co-activation of the tongue protruder and retractor muscles can have a synergistic effect that is advantageous during inspiration.").
117. To the extent Patent Owner argues that Durand does not expressly disclose this limitation, Hoegh does, and a POSITA would have combined the

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

reference for the reasons discussed above in IX.A (Reasons to Combine Durand and Hoegh).

118. Specifically, Hoegh discloses delivering stimulation to the hypoglossal nerve [upper-airway-patency-related nerve] for 300 ms longer than the inspiratory phase of a patient's respiratory cycle to mimic the patient's natural physiology.

In people without OSA, *inspiration is typically 25-50% of the respiratory cycle*, with variations in respiration rate being common. Variations may cause actual inspiration to differ from predicted inspiration. *The hypoglossal nerve usually activates approximately 300 ms before inspiration and remains active for the entire inspiratory phase. To mimic this natural physiology, stimulation may be delivered to the hypoglossal nerve during the inspiratory phase plus a brief pre-inspiratory period of about 300 ms.*

EX-1007 (Hoegh) ¶ 92.

119. Accordingly, claim element [1.c] is disclosed by Durand, either alone or in combination with Hoegh.

- f. **[1.d] wherein the reference respiratory cycle comprises at least one of:
a historical patient-specific average respiratory cycle for stable respiration; and
a multi-patient average respiratory cycle for stable respiration, and**

120. Durand discloses this claim element, either alone or in combination with Hoegh. Durand expressly discloses that the stimulation is provided to closely simulate the patient's normal nighttime respiration cycle [*historical patient-specific average respiratory cycle for stable respiration*].

In a third embodiment of the method, the controller can be programmed to provide stimulation at a predetermined interval without either detecting a physical process or requiring feedback from the nerve being stimulated. In this method, ***the stimulation interval can be determined from the patient's nighttime basal metabolism, e.g., based on the patient's observed nighttime resting respiratory rate. The resultant timing of the stimulation pulse trains will closely simulate the patient's normal nighttime respiration cycle.***

EX-1006 (Durand) ¶ 25.

121. Similarly, Hoegh discloses that asynchronous (fixed) mode stimulation may be applied without being synchronized to the patient's breathing based on actively sensed respiratory information, during an OSA therapy session by

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

using a stimulation cycle duration that is based on the patient's respiratory cycle.

Asynchronous mode (fixed mode) is when stimulation is delivered at regular programmable intervals (e.g., 2.5 seconds of stimulation), followed by 2.5 seconds off). *The intervals may be set to a rate similar to a respiratory cycle (e.g., 5 seconds)...Asynchronous stimulation may be initiated by programming the device to fixed mode and starting a therapy session.*

EX-1007 (Hoegh) ¶ 114.

The therapy controller may have additional functionality (e.g., more buttons) which can be set to give the patient limited control over *select therapy settings*. *These settings include*, but are not limited to, stimulation intensity (e.g., amplitude), *stimulation mode*, pulse train configuration, core hours stimulation settings, ramp, programmable schedule, clock, and motion inhibit programmable values.

EX-1007 (Hoegh) ¶ 127.

122. A POSITA understood that using the patient's respiratory cycle as a basis for the duration of the stimulation cycle meant that the patient would have been monitored such that the patient's respiratory cycle could be determined. This

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

monitoring would result in a patient-specific average (e.g., patient's respiratory cycle as determined by monitoring the patient over a given duration). Indeed, Hoegh expressly discloses using historical patient-specific data when the system attempts to predict the patient's inspiration. EX-1007 (Hoegh) ¶ 94 ("The predictive algorithm uses historical peak data (i.e., begin-expiration data) to predict the time to the next peak, which is equivalent to the predicted respiratory period."). Thus, to the extent Patent Owner argues that Durand does not expressly disclose this limitation, Hoegh does and a POSITA would have been motivated to base the reference respiratory cycle used on at least a historical patient-specific average respiratory cycle for stable respiration to simulate the patient's normal nighttime respiration cycle and mimic the patient's natural physiology. EX-1006 (Durand) ¶ 25; EX-1007 (Hoegh) ¶ 92; *see also* IX.A (Reasons to Combine Durand and Hoegh).

123. Accordingly, Durand discloses claim element [1.d], either alone or in combination with Hoegh.

- g. ***[1.e] wherein each stimulation period of each respective stimulation cycle has a duration greater than a duration of the inspiratory reference of the reference respiratory cycle and the stimulation period is followed by the non-stimulation period of the respective stimulation cycle comprising a duration less than the duration of the stimulation period.***

124. Durand and Hoegh disclose this claim element. For example, Durand discloses providing a train of stimulation pulses for 2-3 seconds (preferably 2.5 seconds) [*stimulation period*] and a wait period of at least 2-3 seconds between pulse trains [*non-stimulation period*].

In this method, the stimulation interval can be determined from the patient's nighttime basal metabolism, e.g., based on the patient's observed nighttime resting respiratory rate. The resultant timing of the stimulation pulse trains will closely simulate the patient's normal nighttime respiration cycle. For example, ***a train of stimulus pulses can be applied for about 2 seconds to about 3 seconds, and more particularly, for about 2½ seconds, with a wait of at least 2 seconds to about 3 seconds between the pulse trains.***

EX-1006 (Durand) ¶ 25.

125. Thus, Durand discloses a two-second wait period [*non-stimulation period*], which has a duration that is less than a 2½-second train of stimulation pulses

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

[*stimulation period*] that closely simulates the patient's normal nighttime respiratory cycle. As such, Durand discloses that the duration of the non-stimulation period is less than the duration of the stimulation period.

126. Hoegh discloses stimulating the hypoglossal nerve for at least 300 ms longer than the inspiratory phase of the patient to mimic the natural physiology of the patient [*each stimulation period of each respective stimulation cycle has a duration greater than a duration of the inspiratory reference of the reference respiratory cycle*].

To mimic this natural physiology, ***stimulation may be delivered to the hypoglossal nerve during the inspiratory phase plus a brief pre-inspiratory period of about 300 ms.***

EX-1007 (Hoegh) ¶ 92.

127. Thus, while Durand discloses that a duration of the non-stimulation period may be less than a duration of the stimulation period, Hoegh provides further teachings and motivation as to why it would be beneficial to increase the duration of the stimulation period, i.e., to mimic the patient's physiology by at least 300 ms relative to the natural inspiratory phase duration of the patient and to increase the probability of overlapping the inspiratory phase with stimulation.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

128. Hoegh further discloses that the length of stimulation [*stimulation period*] may be increased when operating asynchronously (i.e., when the respiratory signal is lost) to increase the likelihood overlapping the stimulation with the patient's inspiratory period.

The stimulation duty cycle may be fixed or adaptive. In the fixed mode, the stimulation duty cycle may be set using the programmer system 2100 to designate a fixed percentage value. ***This fixed value may be increased when the respiratory period signal is lost, increasing the likelihood of aligning with actual inspiration.*** In adaptive mode, the duty cycle may be allowed to vary as a function of a characteristic of respiration. For example, the adaptive duty cycle may increase when prediction is less accurate (higher variability in respiration rate) or when the respiratory signal is lost. Thus, in some instances, ***the stimulation duty cycle may run above normal (e.g., above 50% to 60%) to achieve a better likelihood of covering the inspiratory phase.***

EX-1007 (Hoegh) ¶ 97.

129. Thus, the teachings of Durand and Hoegh disclose that each stimulation period of each respective stimulation cycle has a duration greater than a duration of the inspiratory reference of the reference respiratory cycle (i.e., by

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

at least 300 ms). Further, a POSITA would have been motivated to provide a stimulation period with a duration that exceeds the duration of the non-stimulation period to mimic the patient's natural physiology and to increase the likelihood of the stimulation period overlapping the patient's inspiratory phase. See V.C (Duty Cycles) (referencing Goding, Bolea, Schwartz2001, Eastwood, and others). As such, Durand and Hoegh disclose claim element [1.e].

130. Accordingly, claim 1 is obvious from Durand in view of Hoegh.

2. Claim 2

- a. [2] *The device of claim 1, wherein the non-cardiac stimulation element comprises an implantable electrode and a pulse generator electrically connected to the implantable electrode.*

131. Durand in view of Hoegh render obvious claim 1, as discussed above in IX.B.1 (Ground 1, claim 1). Durand further discloses a cuff electrode 24 that provides intimate connection to the hypoglossal nerve [*implantable electrode*] and a control system 22 for generating the desired electrical stimulus [*pulse generator*] that is connected to the cuff electrode 24 by a lead wire 26 [*electrically connected*].

An exemplary apparatus 20 for stimulating a nerve in accordance with the present invention is shown schematically in FIG. 1. The

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

apparatus 20 includes *a control system 22 (shown schematically) for generating the desired electrical stimulus, and an electrode 24 connected to the nerve to transmit the electrical stimulus to the nerve.* The electrode 24 preferably is a cuff electrode that provides an intimate connection to the nerve. The cuff electrode 24 can have a variety of geometries or configurations, but preferably provides an intimate connection around the nerve. *A lead wire 26 connects the electrode 24 to the control system 22 in the illustrated embodiment.*

EX-1006 (Durand) ¶ 14.

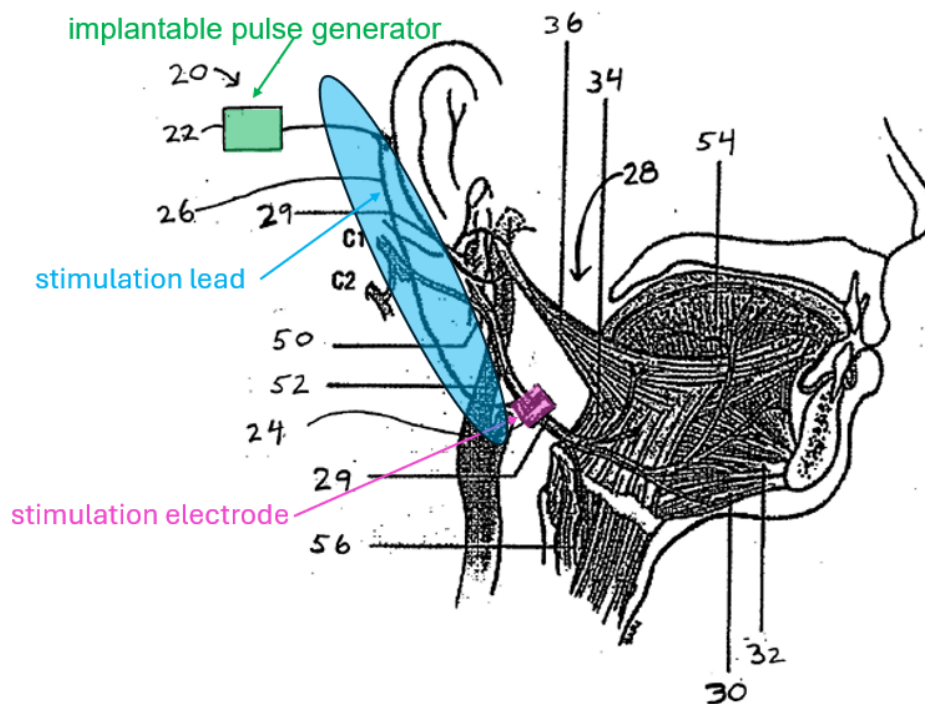


FIG. 1

EX-1006 (Durand), FIG. 1.

132. A POSITA understood that a cuff electrode, as disclosed by Durand, would be considered an “implantable electrode” given that the cuff is wrapped around the hypoglossal nerve and is thus implanted within a patient, shown in FIG. 1 of Durand. Indeed, Durand expressly discloses that the electrode 24 and at least portions of the control system 22 may be implanted. EX-1006 (Durand) ¶ 16 (“Portions of the control system 22, in addition to the electrode 24, can be implanted in the patient’s body.”). A POSITA further understood that the lead wire 26 connecting the electrode 24 and the control system 22 provided an electrical connection between the two components.
133. Accordingly, Durand discloses the limitations of claim 2.

3. Claim 3

- a. [3] *The device of claim 2, wherein the implantable electrode comprises a cuff electrode including at least one operative contact group through which the stimulation is deliverable non-selectively to the upper-airway-patency-related nerve.*

134. Durand in view of Hoegh renders obvious claim 2, as discussed above in IX.B.2 (Ground 1, claim 2). Durand further discloses that the electrode 24 is a cuff electrode [*cuff electrode*] that provides stimulation non-selectively to the hypoglossal nerve [*upper-airway-patency-related nerve*].

The electrode 24 preferably is a cuff electrode that provides an intimate connection to the nerve. The cuff electrode 24 can have a variety of geometries or configurations, but preferably provides an intimate connection around the nerve.

EX-1006 (Durand) ¶ 14.

135. To the extent Patent Owner argues that Durand does not expressly disclose “at least one operative contact group” for providing non-selective stimulation, Hoegh does. Specifically, Hoegh discloses a cuff electrode that includes platinum iridium electrodes, including a cathode and an anode [*at least one operative contact group*].

The cuff body may carries [sic] four platinum-iridium electrodes 1360 (e.g., 2.0 mm² exposed area each for small cuff, 3.0 mm² exposed area each for large cuff), ***with one cathode electrode 1360 on the short side 1352, another cathode electrode 1360 (not visible) diametrically opposed on the long side 1354, and two anode electrodes 1360 guarding the cathode electrode 1360 on the long side 1354. This guarded dual cathode arrangement may provide a more uniform electrical field throughout the cross-section of the nerve while minimizing electrical field outside of the cuff.*** One conductor 1390 may be connected to the cathode electrode 1360 on the long side, to which the other cathode electrode 1360 on the short side

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

may be connected by a jumper wire. Similarly, the other conductor 1390 may be connected to the distal anode electrode 1360, to which the proximal anode electrode 1360 may be connected by jumper wire. With this arrangement, the cathode electrodes may be commonly connected to one conductor 1390 and the anode electrodes may be commonly connected to the other conductor 1390.

EX-1007 (Hoegh) ¶ 98.

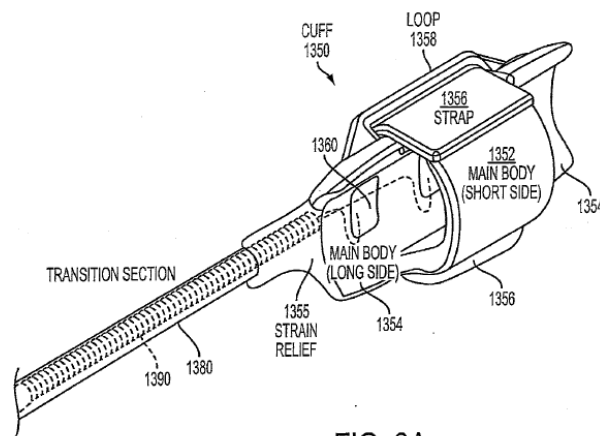


FIG. 3A

EX-1007 (Hoegh), FIG. 3A.

136. A POSITA understood that an anode and a cathode formed an operative contact group, as they would be configured to apply electrical stimulation to the hypoglossal nerve. At the very least, the Hoegh's disclosure is consistent with the disclosure of a "contact group" set forth in the '709 Patent.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

In some examples, stimulation electrode portion 45 comprises a cuff electrode including a single operative contact group of at least two electrodes through which the stimulation is deliverable non-selectively to the airway-patency-related nerve. FIG. 2E is a top view schematically illustrating one example of such an electrode 50 including a single operative contact group of at least two electrodes 52. In some examples, the stimulation electrode portion 45 comprises a cuff electrode including at least one operative contact group through which the stimulation is deliverable non-selectively to the airway-patency-related nerve. Accordingly, more than one operative contact group of electrodes can be incorporated in a single cuff electrode. In some examples, the stimulation electrode portion 45 can include multiple, separate cuff electrodes with each having at least one operative contact group of electrodes.

EX-1001 10:9-24.

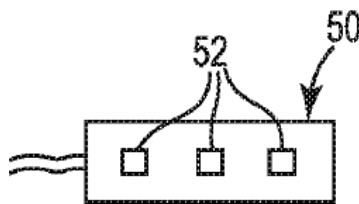


Fig. 2E

EX-1001, FIG. 2E.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

137. Further, a POSITA understood that Hoegh's disclosure regarding the dual cathode arrangement providing uniform electrical field throughout the cross-section of the nerve would mean that the electrode provides non-selective stimulation. This is because the uniform electrical field would stimulate all of the axons in the hypoglossal nerve and thus would not selectively stimulate certain axons.
138. Accordingly, claim 3 is obvious from Durand in view of Hoegh.

4. Claim 4

- a. ***[4] The device of claim 1, wherein a total duration of stimulation via the first stimulation protocol during a treatment period is greater than 30 percent of the total duration of the treatment period.***

139. Durand in view of Hoegh render obvious claim 1, as discussed above in IX.B.1 (Ground 1, claim 1). Durand further discloses providing a train of stimulation pulses for 2-3 seconds, waiting 2-3 seconds, and then again applying the stimulation pulses. EX-1006 (Durand) ¶ 25 ("For example, a train of stimulus pulses can be applied for about 2 seconds to about 3 seconds, and more particularly, for about 2½ seconds, with a wait of at least 2 seconds to about 3 seconds between the pulse trains."). As such, Durand discloses a total duration of stimulation applied during a treatment period to range from 40% to 60%, which is greater than 30%.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

2 seconds on; 3 seconds off; 5 second cycle length:

$$\frac{2}{5} \times 100 = 40\%$$

3 seconds on; 2 seconds off; 5 second cycle length:

$$\frac{3}{5} \times 100 = 60\%$$

140. Further, as discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle, was routine in the art and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the '709 Patent does not identify any unexpected results resulting from providing a total duration of stimulation via the first stimulation protocol during a treatment period that is greater than 30 percent of the total duration of the treatment period as claimed. As such, not only do Durand and Hoegh disclose the limitations of claim 4, but the claim itself recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).
141. Accordingly, claim 4 is obvious from Durand in view of Hoegh.

5. Claim 5

- a. **[5] *The device of claim 1, wherein the duration of the stimulation period comprises at least 50 percent of a duration of the stimulation cycle.***

142. Durand in view of Hoegh render obvious claim 1, as discussed above in IX.B.1 (Ground 1, claim 1). As discussed above with respect to claim 4, Durand further discloses providing a train of stimulation pulses for 2-3 seconds, waiting 2-3 seconds, which corresponds to stimulation being applied [*stimulation period*] between 40-60% of the stimulation cycle. IX.B.4 (Ground 1, claim 4); EX-1006 (Durand) ¶ 25 (“For example, a train of stimulus pulses can be applied for about 2 seconds to about 3 seconds, and more particularly, for about 2½ seconds, with a wait of at least 2 seconds to about 3 seconds between the pulse trains.”). Thus, Durand discloses a range of stimulation that includes 50% as claimed.

2½ seconds of stimulation (stimulation period);

5 second stimulation cycle length:

$$\frac{2.5}{5} \times 100 = 50\%$$

3 seconds of stimulation (stimulation period);

5 second stimulation cycle length:

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

$$\frac{3}{5} \times 100 = 60\%$$

143. Further, as discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle, was routine in the art and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the '709 Patent does not identify any unexpected results resulting from providing a stimulation period having a duration that comprises at least 50 percent of a duration of the stimulation cycle. As such, not only do Durand and Hoegh disclose the limitations of claim 5, but the claim itself recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).
144. Accordingly, claim 5 is obvious from Durand in view of Hoegh.

6. Claim 6

- a. [6] *The device of claim 1, wherein the duration of the stimulation period comprises at least 50 percent of a duration of the reference respiratory cycle.***

145. Durand in view of Hoegh render obvious claim 1, as discussed above in IX.B.1 (Ground 1, claim 1). Durand similarly discloses that the stimulation protocol can be based on the patient's respiratory rate [*reference respiratory*

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

period] and stimulation pulses can be provided for about 2-3 seconds
[*stimulation period*] followed by a wait period of 2-3 seconds.

The resultant timing of the stimulation pulse trains will closely simulate the patient's normal nighttime respiration cycle. For example, a train of stimulation pulses can be applied for about 2 seconds to about 3 seconds, and more particularly, for about 2½ seconds, with a wait of at least 2 seconds to about 3 seconds between pulse trains.

EX-1006 (Durand) ¶ 25.

146. Hoegh discloses that a patient's respiratory cycle is about five seconds [*duration of the reference respiratory cycle*] and the stimulation may be delivered for 2.5 seconds [*stimulation period*], which is at least 50 percent of the reference respiratory cycle.

Asynchronous mode (fixed mode) is when stimulation is delivered at regular programmable intervals (e.g., 2.5 seconds of stimulation, followed by 2.5 seconds off). The intervals may be set to a rate similar to a respiratory cycle, (e.g., 5 seconds).

EX-1007 (Hoegh) ¶ 114.

147. A POSITA understood that providing pulse trains for 2½-3 seconds [*stimulation period*] of a patient's five second respiratory cycle [*reference*

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

respiratory cycle] corresponds to a duration of the stimulation period comprising at least 50% of a duration of the reference respiratory cycle.

2½ seconds of stimulation (stimulation period);

5 second respiratory cycle length:

$$\frac{2.5}{5} \times 100 = 50\%$$

3 seconds of stimulation (stimulation period);

5 second respiratory cycle length:

$$\frac{3}{5} \times 100 = 60\%$$

148. Further, as discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle, was routine in the art and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the '709 Patent does not identify any unexpected results resulting from providing a stimulation period that comprises at least 50 percent of a reference respiratory cycle. As such, not only do Durand and Hoegh disclose the limitations of claim 6, but the claim itself recites nothing more than routine optimization

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

(i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).

149. Accordingly, Durand and Hoegh disclose claim 6.

7. **Claim 7**

- a. [7] *The device of claim 1, wherein the duration of each respective stimulation cycle is less than the duration of the reference respiratory cycle, and a duration of the stimulation period exceeds the duration of the non-stimulation period by a factor of at least 3.*

150. Durand in view of Hoegh render obvious claim 1, as discussed above in IX.B.1 (Ground 1, claim 1). Durand discloses stimulation cycles as short as four seconds (2 seconds of stimulation pulses; 2 seconds waiting). EX-1006 (Durand) ¶ 25 (“For example, a train of stimulus pulses can be applied for about 2 seconds to about 3 seconds, and more particularly, for about 2½ seconds, with a wait of at least 2 seconds to about 3 seconds between the pulse trains.”). Hoegh discloses that a patient’s respiratory cycle is about 5 seconds, EX-1007 (Hoegh) ¶ 114 (“The intervals may be set to a rate similar to a respiratory cycle (e.g., 5 seconds)”), and using exemplary duty cycles ranging between 41% to 69%.

The following stimulation duty cycle parameters are given by way of example, *not limitation*. In fixed mode, the maximum

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

stimulation duty cycle may be set from 41% to 69% in 3% increments, and the default setting may be 50%.

EX-1007 (Hoegh) ¶ 98.

151. A POSITA understood a four second stimulation cycle, as disclosed by Durand, to have a duration less than a duration of a patient's five second respiratory rate, as disclosed by Hoegh, and that a 69% duty cycle would provide stimulation pulses [*stimulation period*] for a duration that exceeds the wait period [*non-stimulation period*] by over a factor of 2 (i.e., $69\%/31\% = 2.23$). However, Hoegh expressly discloses that the disclosed duty cycles are not limiting (*see* ¶ 98, *supra*) and that “[t]he stimulation duty cycle may vary to meet efficacy and safety requirements.” EX-1007 (Hoegh) ¶ 96.

152. Given these express teachings, a POSITA understood that the duty cycle could be increased beyond 69%, such as to 75% to provide a duration of the stimulation period that exceeds a duration of the non-stimulation period by a factor of three ($75\%/25\% = 3$), to meet the desired efficacy. Indeed, the prior art includes examples of duty cycles of up to 92% (e.g., an on/off period of 60/5). EX-1008 (Headley) ¶ 48 (“On/off intermittent periods include from 5/5, 20/5, 10/10, 5/60, **60/5**, 20/20, 30/30, 40/40, 50/50, 60/60, and so forth.”). Indeed, Durand discloses providing constant stimulation to improve upper-

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

airway patency. EX-1006 (Durand) ¶ 22 (“In a first embodiment of the method, electrical stimulation can be provided to the hypoglossal nerve continuously throughout the respiration cycle, during both inspiration (breathing in) and expiration (breathing out) phases, to maintain the desired muscle tone for patency of the upper airway.”).

153. Further, as discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle, was routine in the art and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the ’709 Patent does not identify any unexpected results resulting from providing each respective stimulation cycle with a duration that is less than a duration of a reference respiratory cycle and in which a duration of the stimulation period exceeds a duration of the non-stimulation period by a factor of at least three. As such, not only do Durand and Hoegh disclose the limitations of claim 7, but the claim itself recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).
154. Accordingly, providing stimulation cycles in which a duration of the stimulation period exceeds the duration of the non-stimulation period by a

factor of at least three required nothing more than the exercise of routine skill, i.e., optimizing a duty cycle, which a POSITA would have been motivated to provide to increase the efficacy while maintaining the safety. EX-1007 (Hoegh) ¶ 96.

155. Accordingly, claim 7 is obvious from Durand and Hoegh.

8. Claim 8

- a. [8] *The device of claim 1, wherein the duration of each respective stimulation cycle is greater than the duration of the reference respiratory cycle.*

156. Durand in view of Hoegh render obvious claim 1, as discussed above in IX.B.1 (Ground 1, claim 1). Hoegh discloses that a patient's respiratory cycle is about five seconds and that stimulation intervals [*stimulation cycle*] of eight seconds may be used to increase the probability of providing the patient with stimulation during an entire respiratory cycle.

Asynchronous mode (fixed mode) is when stimulation is delivered at regular programmable intervals (e.g., 2.5 seconds of stimulation, followed by 2.5 seconds off). *The intervals may be set to a rate similar to a respiratory cycle, (e.g. 5 seconds). Alternatively, longer intervals (e.g. 8 seconds) may decrease the probability of missing two consecutive inspirations, and increase the probability of providing the patient with stimulation during an entire respiratory cycle.*

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

EX-1007 (Hoegh) ¶ 114.

157. Thus, Hoegh discloses a duration of a stimulation cycle (i.e., eight seconds) that is greater than the duration of a patient's respiratory cycle (i.e., five seconds) [*reference respiratory cycle*] as recited in claim 8.
158. Further, as discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle and duration of a stimulation cycle, was routine in the art and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the '709 Patent does not identify any unexpected results from providing each respective stimulation cycle with a duration greater than the duration of the reference respiratory cycle. As such, not only do Durand and Hoegh disclose the limitations of claim 8, but the claim itself recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).
159. Accordingly, claim 8 is obvious from Durand and Hoegh.

9. Claim 9

- a. [9] *The device of claim 8, wherein the stimulation period and the non-stimulation period are in a proportion of at least 1.5 to 1.*

160. Durand in view of Hoegh render obvious claim 8, as discussed above in IX.B.8 (Ground 1, claim 8). As discussed above with respect to claim 7, Hoegh discloses exemplary, non-limiting duty cycles of up to 69%, which equates to the stimulation pulses [*stimulation period*] being applied by over a proportion of 2 (69% stimulation / 31% non-stimulation = 2.23 stimulation:non-stimulation).

The following stimulation duty cycle parameters are given by way of example, not limitation. In fixed mode, the maximum stimulation duty cycle may be set from 41% to 69% in 3% increments, and the default setting may be 50%.

EX-1007 (Hoegh) ¶ 96; IX.B.7 (Ground 1, claim 7).

161. Thus, Hoegh discloses that the stimulation pulses [*stimulation period*] and the wait period [*non-stimulation period*] are in a proportion of over 2 to 1, which is at least 1.5 to 1, as recited in claim 9.

162. As discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle, was routine in the art

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the '709 Patent does not identify any unexpected results from providing a stimulation period and a non-stimulation period in a proportion of at least 1.5 to 1. As such, not only do Durand and Hoegh disclose the limitations of claim 9, but the claim itself recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).

163. Accordingly, claim 9 is obvious from Durand and Hoegh.

10. Claim 10

a. [10] *The device of claim 8, wherein the duration of the stimulation cycle is less than a duration of two consecutive reference respiratory cycles.*

164. Durand in view of Hoegh render obvious claim 8, as discussed above in IX.B.8 (Ground 1, claim 8). Further, as discussed above, both Durand and Hoegh disclose applying stimulation pulses and wait periods [*stimulation cycles*] for durations based on the patient's resting respiratory rate [*reference respiratory cycles*], which have durations of about five seconds.

The resultant timing of the stimulation pulse trains will closely simulate the patient's normal nighttime respiration cycle. For example, a train of stimulus pulses can be applied for about 2 seconds to about 3 seconds, and more particularly, for about 2½

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

seconds, with a wait of at least 2 seconds to about 3 seconds between the pulse trains.

EX-1006 (Durand) ¶ 25.

Asynchronous mode (fixed mode) is when stimulation is delivered at regular programmable intervals (e.g., 2.5 seconds of stimulation, followed by 2.5 seconds off). *The intervals may be set to a rate similar to a respiratory cycle, (e.g., 5 seconds).*

EX-1007 (Hoegh) ¶ 114.

165. Given the foregoing disclosures from Durand and Hoegh, a POSITA understood both references as disclosing that the duration of a stimulation cycle (i.e., a period including both simulation and waiting) to be about five seconds, which is less than a duration of two consecutive reference respiratory periods (i.e., ten seconds).
166. As discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle and duration of a stimulation cycle, was routine in the art and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the '709 Patent does not identify any unexpected results from providing a stimulation cycle with a duration less than a duration

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

of two consecutive respiratory cycles. As such, not only do Durand and Hoegh disclose the limitations of claim 10, but the claim itself recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).

167. Accordingly, claim 10 is obvious from Durand and Hoegh.

11. Claim 11

- a. [11] *The device of claim 1, wherein the duration of each respective stimulation cycle is equal to the duration of the reference respiratory cycle, and wherein the duration of the reference respiratory cycle differs from a duration of a real time respiratory cycle from actively-sensed respiration information by an amount exceeding a duration variability criteria.*

168. Durand in view of Hoegh render obvious claim 1, as discussed above in IX.B.1 (Ground 1, claim 1). As discussed above, Durand and Hoegh disclose the duration of each stimulation cycle (e.g., period of stimulation pulses and wait period) is based on/equal to the patient's respiratory cycle [*reference respiratory cycle*]. IX.B.1.d-IX.B.1.g (Ground 1, claim elements [1.b]-[1.e]); EX-1006 (Durand) ¶ 25; EX-1007 (Hoegh) ¶ 114. Hoegh further discloses that a patient's respiratory rate may change overtime and that the INS (implantable neurostimulator) may record the patient's respiratory rate and use such data to change stimulation levels.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

The INS 1100 may be programmed to change stimulation level between therapy sessions, days, or other programmable value. The stimulation level may be recorded alongside therapy session data, for example cycling rate (via the cycling detector), oxygen desaturation frequency and severity, stimulation time, ***variations in respiratory rate***, variations in respiratory prediction, etc.

EX-1007 (Hoegh) ¶ 91.

In people without OSA, inspiration is typically 25-50% of the respiratory cycle, ***with variations in respiratory rate being common***.

EX-1007 (Hoegh) ¶ 92.

169. Hoegh further discloses that an adaptive mode may be used when predicted inspiration is less accurate due to higher variability in respiratory rate [*duration variability criteria*] in which case the stimulation is applied for increased amounts of time as the duty cycle is increased [*the duration of the reference respiratory cycle differs from a duration of a real time respiratory cycle from actively-sensed respiration information*].

In adaptive mode, the duty cycle may be allowed to vary as a function of a characteristic of respiration. ***For example, the adaptive duty cycle may increase when prediction is less***

accurate (higher variability in respiration rate) or when respiratory signal is lost. Thus, in some instances, the stimulation duty cycle may run above normal (e.g., above 50% to 60%) to achieve a better likelihood of covering the inspiratory phase.

EX-1007 (Hoegh) ¶ 97.

As mentioned above, *the adaptive mode allows the duty cycle to decrease when respiratory period is stable and increase with respiratory period variability*, for example, and the stimulation duty cycle may run in excess of 53% for a limited period of time, but those periods are proportionally offset by periods where the stimulation duty cycle runs less than 53% (e.g., according to an exponentially weighted moving average).

EX-1007 (Hoegh) ¶ 98.

170. A POSITA understood from at least the foregoing disclosures in Hoegh that a patient's respiratory rate may vary, either naturally or due to low signal quality, but that the overall duration of the reference respiratory cycle (i.e., the patient's observed nighttime basal metabolism, as taught by Durand, or the rate that is similar to a patient's respiratory cycle, as taught by Hoegh) would not change due to the detected variability and/or lack of respiratory signal.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

EX-1006 ¶¶ 22-23, 25; EX-1007 ¶¶ 91-92, 97-98. In such instances, the duty cycle within the reference respiratory cycle would be increased, but the overall duration of the stimulation cycle would not change. EX-1007 ¶¶ 91-92, 97-98.

171. As discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle and duration of a stimulation cycle, was routine in the art and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the '709 Patent does not identify any unexpected results from providing each respective stimulation cycle with a duration that is equal to the duration of the reference respiratory cycle and in which the duration of the reference respiratory cycle differs from a duration of a real time respiratory cycle from actively-sensed respiration information by an amount exceeding a duration variability criteria. As such, not only do Durand and Hoegh disclose the limitations of claim 11, but the claim itself recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).
172. Accordingly, Durand and Hoegh render obvious claim 11.

12. Claim 12

**a. [12a] *The device of claim 1, comprising:
a processor; and***

173. Durand in view of Hoegh render obvious claim 1, as discussed above in IX.B.1 (Ground 1, claim 1). Durand further discloses that the control system includes a processor for setting up stimulation parameter and controlling the stimulation [*first stimulation therapy protocol*].

The control system 22 also typically includes a processor for setting up stimulation parameters to achieve the desired outcome for the individual patient or otherwise controlling the stimulation.

EX-1006 (Durand) ¶ 15.

174. Accordingly, Durand discloses claim element [12.a].

b. [12.b] *a non-volatile computer readable medium storing instructions, executable on the processor, to implement the non-cardiac stimulation element and to perform the first stimulation therapy protocol.*

175. As noted above, Durand discloses that the control system includes a processor for setting up stimulation parameters to achieve the desired outcome or otherwise control the stimulation [*perform the first stimulation therapy protocol*]. IX.B.12.a (Ground 1, claim 12). A POSITA understood that a

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

processor functions by executing instructions that are stored in a non-volatile computer-readable medium. V.A (Neuromuscular Stimulators). Consistent with this understanding, Hoegh expressly discloses that processors include such non-volatile storage elements and control the stimulation provided to a patient.

The microprocessor may contain built-in support circuits (***RAM, flash memory***), analog to digital (A/D) converter, timers, serial ports and digital IO) used to interface with the rest of the [implantable neurostimulator] circuit 1130, including accelerometer 1150.

EX-1007 (Hoegh) ¶ 82.

The stimulation output circuits may deliver bursts of biphasic stimulation pulses to the STL 1300...***The microprocessor may select the amplitude*** (e.g., 0.4 mA to 5 mA) of the output current from the current source circuit which may be applied through the switching network.

EX-1007 (Hoegh) ¶ 85.

The INS 1100 may deliver stimulation as a train of pulses with constant pulse width and amplitude at a set frequency for a duration limited by duty cycle. This train of pulses may be described as a pulse train envelope and is illustrated in FIG. 6D.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

The envelope describes a series of biphasic pulses delivered consecutively during a stimulation burst. When the stimulation level of the positive phase of each biphasic pulse is uniform, this level is the level of the stimulation burst. The INS 1100 may also deliver stimulation in pulse train envelopes wherein the pulses are non-uniform (e.g., pulses may have different amplitudes).

EX-1007 (Hoegh) ¶ 100.

176. Given the foregoing, to the extent Patent Owner argues that Durand does not expressly disclose this limitation, Hoegh does, and a POSITA understood Durand and Hoegh disclosing a processor and non-volatile computer readable medium that together implement the non-cardiac stimulation element as claimed.
177. It is worth noting that the non-cardiac stimulation element recited in claim 12 and disclosed in the specification, i.e., a software engine or controller, appear to conflict with the non-cardiac stimulation element recited in claim 2, which takes the form of a stimulation electrode and pulse generator. *Compare* '709 Patent, claims 1, 2, and 12; EX-1001 7:48-57, 9:34-32, 11:3-14, 15:45-64, FIGS. 1A, 2B. Regardless, Durand and Hoegh disclose the claimed non-cardiac stimulation element regardless of its configuration.

178. Accordingly, Durand and Hoegh disclose this claim element and render obvious claim 12.

13. Claim 14

a. [14.a] *The device of claim 1, comprising:
a sensing element to obtain the actively-sensed
respiratory information; and*

179. Durand and Hoegh render obvious claim 1, as discussed above in IX.B.1 (Ground 1, claim 1). Durand discloses providing one or more sensors [*sensing element*] to detect a physical process, such as inspiratory efforts [*actively-sensed respiratory information*].

In a second embodiment of the method, the initiation of the electrical stimulation can be synchronized with a physical process, such as inspiration sensed by a remote sensor, without feedback from the nerve being stimulated. ***Thus the system can include one or more sensors for detecting a physical process, such as inspiratory efforts (i.e. the beginning of an attempt to breathe), for example, other than through the signals present in the hypoglossal nerve itself for activating the muscles.*** Various types of sensors are well known, including a pressure transducer for monitoring the pressure in the upper airway, and sensors that detect movement of the chest wall.

EX-1006 (Durand) ¶ 23.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

180. As such, Durand discloses claim element [14.a].
181. To the extent Patent Owner argues that Durand does not disclose this claim element, Hoegh discloses the use of a respiratory sensing lead (“RSL”) [*sensing element*] that measures bio-impedance indicating a patient’s inspiration [*actively-sensed respiratory information*].

Stimulation may be generated by an implantable neurostimulator (INS) 1100, for example *synchronized with inspiration as measured by the respiration sensing lead (RSL) 1200 using bio-impedance*, and delivered to the hypoglossal nerve by a stimulation lead (STL) 1300.

EX-1007 (Hoegh) ¶ 50.

182. Accordingly, Durand, either alone or in combination with Hoegh, discloses claim element [14.a].

**b. [14.b] a control portion including:
a processor; and
a non-volatile memory storing instructions, executable
via the processor to:**

183. Durand, either alone or in combination with Hoegh, disclose this claim element as demonstrated above with respect to claim 12. IX.B.12 (Ground 1, claim 12).

- c. [14.c] *provide convertible operation via a therapy manager between:
a first stimulation mode implementing the first stimulation therapy protocol; and*

184. Hoegh discloses that the INS circuit 1130 [*control portion*], which includes a microprocessor [*processor*], for delivering stimulation in two modes [*provide convertible operation via a therapy manager*], including an asynchronous mode [*first stimulation mode implementing the first stimulation therapy protocol*]:

With reference to FIG. 5B, a block diagram of an example of the INS circuit 1130 is shown schematically. *The INS circuit 1130 may utilize a microprocessor to control* telemetry communications with the programmer system 2100, *operating the sensing circuits to monitor respiration via the RSL 1200, controlling the delivery of output stimuli via the STL 1300,* monitoring the accelerometer, magnetically sensitive reed switch and the real-time clock.

EX-1007 (Hoegh) ¶ 82.

Stimulation may also be delivered in two modes which are not inspiratory synchronous: manual stimulation and asynchronous (fixed) stimulation.

EX-1007 (Hoegh) ¶ 113.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

The stimulation duty cycle may be fixed or adaptive. In the fixed mode, *the stimulation duty cycle may be set using the programmer system 2100 to designate a fixed percentage value. This fixed value may be increased when the respiratory signal is lost*, increasing the likelihood of aligning with actual inspiration.

EX-1007 (Hoegh) ¶ 97; *see also* IX.B.12 (Ground 1, claim 12).

185. Thus, Hoegh discloses that the implantable neurostimulation (INS) includes a microprocessor that controls the stimulation applied to the hypoglossal nerve and may automatically provide fixed/asynchronous stimulation if the respiratory signal from the respiratory sensing lead (RSL) is lost during a therapy session. EX-1007 ¶¶ 82, 97, 113. A POSITA understood that being able to switch from actively sensing the respiratory information for providing synchronous stimulation to providing fixed/asynchronous stimulation as providing convertible operation, which was known in the art. EX-1007 ¶¶ 82, 97, 113.

186. Accordingly, Durand and Hoegh disclose this claim element.

- d. [14.d] *a second stimulation mode of stimulating the upper-airway-patency-related nerve synchronous with a characteristic of the actively-sensed respiratory information.*

187. Hoegh discloses monitoring bio-impedance via the RSL [*characteristic of the actively-sensed respiratory information*] and stimulating the hypoglossal nerve [*upper-airway-patency-related nerve*] via the stimulation lead (“STL”) synchronously with the patient’s inspiration.

The HGNS system 100 may treat obstructive sleep apnea (OSA) by increasing neuromuscular activity to the genioglossus muscle via *stimulation of the hypoglossal nerve (HGN), such as synchronous with inspiration, to mitigate upper airway collapse during sleep*. Stimulation may be generated by an implantable neurostimulator (INS) 1100, for example *synchronized with inspiration as measured by the respiration sensing lead (RSL) 1200 using bio-impedance*, and delivered to the hypoglossal nerve by a stimulation lead (STL) 1300.

EX-1007 (Hoegh) ¶ 50.

188. Accordingly, Durand and Hoegh disclose this claim element and render obvious claim 14.

14. Claim 15

- a. [15] *The device of claim 1, wherein the stimulation period and the non-stimulation period are in a proportion of at least 1.5 to 1.*

189. Durand and Hoegh render obvious claim 1, as discussed above in IX.B.1 (Ground 1, claim 1). Durand and Hoegh further disclose the limitations of claim 15 for the same reasons discussed in IX.B.1 (Ground 1, claim 1), as the limitations of claims 8 and 15 are identical.

190. Accordingly, Durand and Hoegh render obvious claim 15.

X. GROUND 2: CHALLENGED CLAIMS 1, 2, 4-10, 12, 13, AND 15 ARE OBVIOUS FROM HEADLEY IN VIEW OF TRAN

A. Reasons to Combine Headley and Tran

191. As detailed above in VII.C.2 (Summary of Headley’s Disclosure), Headley discloses an implantable device that is used to stimulate asynchronously the genioglossus (GG), which is in close proximity to the HGN, to treat OSA. Specifically, Headley discloses providing the stimulation in the form of alternating on/off treatment in which the tissue is stimulated for a given period then allowed to rest for a given period before being stimulated again. EX-1008 (Headley) ¶ 48 (“In use, the device as described herein and/or the method as described herein provides for alternating on/off ‘intermittent’

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

treatment wherein the tissue is stimulated for a given period, and then the tissue is allowed to rest for a given period.”). Headley states that the intermittent treatment periods and parameters may be adjusted based on patient-specific characteristics, such as, the “patient’s physical condition” or “quality of sleep,” but does not elaborate on these characteristics and parameters. EX-1008 (Headley) ¶¶ 10, 13.

192. Headley concludes by citing and incorporating by reference a number of references that “relate to teaching the level of ordinary skill in this art and for any disclosure necessary for the commoner understanding of the subject matter of the claimed invention.” EX-1008 (Headley) ¶¶ 50-62. Thus, a POSITA would have been motivated to look at these and other references (e.g., Tran) to obtain a greater understanding of Headley’s disclosure and the relevant state of the art given Headley’s express instruction to do so.
193. Tran discloses a device that had been actually reduced to practice, i.e., a BION™, for treating OSA that operates like the device disclosed by Headley in that the device may be implanted in the tongue in close proximity to where the hypoglossal nerve branches to the GG enter the tongue. EX-1009 (Tran-I) p. 376 (“The hypoglossal nerve branches to the GG muscle enter the tongue inferolaterally to innervate muscles that are oriented transversely,

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

longitudinally and radially in parasagittal fans.”). The device recruits the motor units stimulated by the hypoglossal nerve to produce symmetrical protrusion of the tongue thereby opening the airway. EX-1009 (Tran-I) p. 376 (“This suggests that a single site of stimulation located in the midline (near these endplates as illustrated in Fig. 3) would recruit selectively those motor units that will produce symmetrical protrusion of the tongue, thereby opening the airway.”). Brief trains of stimulation pulses are applied “at intervals close to the respiratory cycle of the patient” to synchronize the patient “spontaneously with the resulting intermittent periods of patency in the airway.” EX-1009 (Tran-I) p. 377.

194. While Headley provides a high-level disclosure of the stimulation device and parameters, Tran discloses an actual device that operates similar to the one disclosed by Headley along with clinical results, including stimulation parameters. For example, Tran discloses the duration of stimulation relative to the patient’s respiratory rate, including the duration of the stimulation relative to the duration of the inspiratory phase. EX-1009 (Tran-I), p. 377; EX-1010 (Tran-II), p. 4288. Further, Tran teaches the use of historical patient-specific averages to estimate the patient’s respiratory rate. EX-1009 (Tran-I), p. 377. A POSITA would have been motivated to combine the

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

teachings of Headley to provide a stimulation device that could be programmed with the stimulation parameters disclosed by Tran for treating OSA that provides stimulation based on the patient's respiratory rate to have the patient spontaneously synchronize with the intermittent periods of patency in the airway. Advantageously, the combination of the references would provide a device that obviates the need for a sensor to synchronize stimulation with breathing while effectively improving airway patency. EX-1010 (Tran-II), p. 4288 ("This method of stimulation is repeated in continuous cycles at approximately the natural respiratory rhythm of the sleeping participant, obviating the need for a sensor to synchronize stimulation with breathing."). The construct of the BIONTM disclosed by Tran were "low-risk, reliable and cost-effective" (EX-1009 (Tran-I), p. 375) and had been implanted adjacent to various nerves, including the HGN.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

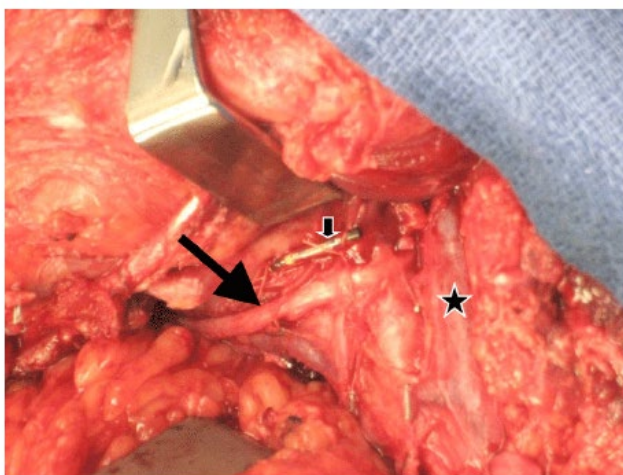


Figure 3: MS (small arrow) is placed above the left hypoglossal nerve (large arrow) during left modified radical neck dissection. Star indicates the origin of ansa cervicalis nerve.

EX-1039 (Sinha), p. 3.

195. A POSITA would have been motivated to combine the teachings of Headley and Tran to provide an improved method to prevent development of OSA, and would have had a reasonable expectation of success in doing so for several reasons.
196. *First*, both references disclose treatment methods for OSA using implantable electrodes that are externally powered to stimulate the tongue, which is in close proximity to the HGN, asynchronously (i.e., without actively sensing the patient's respiration in order to synchronize the stimulation to the patient's respiration).

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

This present invention is generally directed toward the implantation of a medical device for treating patients with a specific physiologic dysfunction and in particular, treating patients with obstructive sleep apnea.

EX-1008 (Headley) ¶ 1.

In use, the device as described herein and/or the method as described herein provides for alternating on/off “intermittent” treatment wherein the tissue is stimulated for a given period, and then the tissue is allowed to rest for a given period.

EX-1008 (Headley) ¶ 48.

197. Like Headley, Tran discloses treatment methods involving “intermittent electrical stimulation” applied to the tongue in “a brief train of electrical pulses during an ON period followed by no stimulation during an OFF period.” EX-1010 (Tran-II), p. 4287.

Each BION receives power and digital command data via an RF transmission coil to produce stimulation pulses with controlled current (0-30mA) and duration 4-512 μ s).

EX-1009 (Tran-I), p. 375.

We hypothesized that if brief trains of stimulation pulses were applied to the GG at intervals close to the respiratory cycle of the

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

patient, the patient would tend to synchronize spontaneously
with the resulting intermittent periods of patency in the airway.

EX-1009 (Tran-I), p. 377.

198. *Second*, both references disclose similar implantation locations (i.e., within the tongue near the hypoglossal nerve to stimulate the hypoglossal nerve and genioglossus):



EX-1008 (Headley), FIG. 1 (annotated).

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

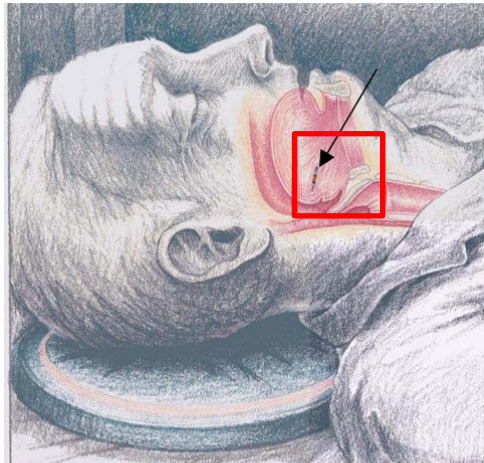


Fig. 3. Implantation site of a single BION in posterior midline of the genioglossus muscle with tantalum electrode (effective cathode) near the endplates (toward the tongue base).

EX-1009 (Tran-I), FIG. 3 (annotated).

199. *Third*, the modifications to Headley based on the teachings of Tran were well within the routine skill in the art. Specifically, because both references disclose using implantable electrodes to stimulate the tongue asynchronously in substantially the same way, a POSITA would have recognized that modifying Headley's asynchronous stimulation cycle to approximate the patient's respiratory cycle, as taught by Tran, would require only simple software modifications and routine modifications to Headley's intermittent on/off electrical stimulation periods and parameters. As discussed above in V.B (Technical Background, OSA Treatment), titration involved the adjustment of one or more stimulation parameters (e.g., duty cycle, cycle duration, pulse width, amplitude, etc.) and was routinely performed after the

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

patient healed from the implantation procedure and was about to use the device therapeutically. A POSITA would have had a reasonable expectation of success in combining Headley's and Tran's teachings, such as basing the simulation cycle duration on the patient's respiratory rate, because both references disclose applying methods (asynchronous stimulation) using devices (implantable electrodes) to achieve results (preventing development of OSA) that were known in the art before the priority date of the '709 Patent, such that their teachings would have been readily applied to the other using only routine skill.

B. Application of Headley and Tran to Challenged Claims 1, 2, 4-10, 12, 13, and 15

1. Claim 1

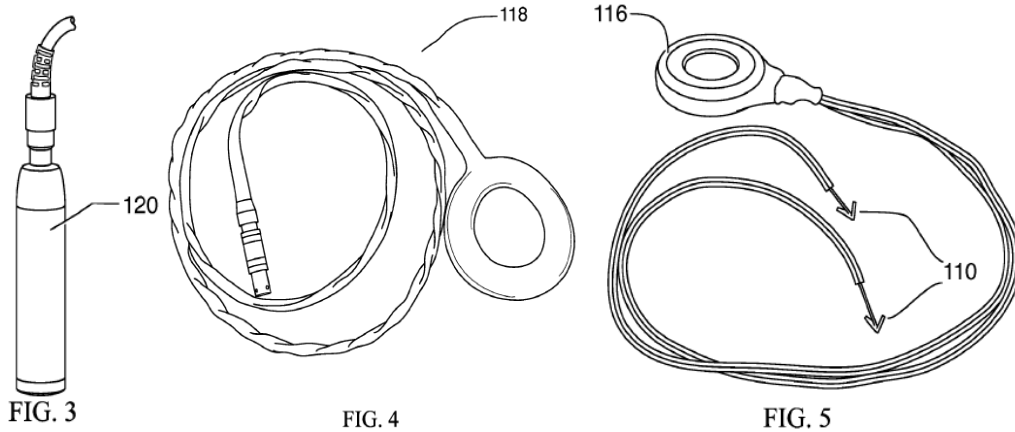
a. [1.pre] *A device for treating obstructive sleep apnea, comprising:*

200. To the extent the preamble is limiting, Headley discloses a device for treating obstructive sleep apnea. For example, Headley expressly discloses “[a] *device* and method is described *for the treatment of obstructive sleep apnea.*”

EX-1008 (Headley), Abstract. The device includes a power source 120 (FIG.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

3), an antenna 118 (FIG. 4), a receiver 116, and a stimulating electrode 110 (FIG. 5). EX-1008 (Headley) ¶ 29.



EX-1008 (Headley), FIGS. 3-5.

201. Thus, Headley discloses the limitations of [1.pre] to the extent the preamble is limiting.

202. Although not believed necessary to demonstrate that prior art of Ground 2 discloses the limitations of [1.pre] given the foregoing disclosures of Headley, I note that Tran also discloses a device as claimed. Specifically, as discussed above, Tran discloses a device, i.e., a BION™, that actually had been reduced to practice and implanted adjacent to the HGN. VII.D.2 (Summary of Tran's Disclosure); EX-1039 (Sinha); EX-1040 (Kaplan). Thus, to the extent Patent Owner were to argue Headley does not disclose the limitations of the

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

preamble, Tran does and a POSITA would have combined the references for the reasons disclosed in X.A (Reasons to Combine Headley and Tran).

203. Accordingly, Tran also discloses a device for treating OSA to the extent the preamble is limiting.

b. [1.a1] *a non-cardiac stimulation element to engage and to stimulate an upper-airway-patency-related nerve;*

204. Headley, either alone or in combination with Tran, discloses claim element [1.a1]. Headley discloses a receiver 116 and a stimulating electrode 110 that are inserted into the genioglossal muscle of the tongue to apply electrical stimulation [*non-cardiac stimulation element*] to stimulate the genioglossus muscle.

In one embodiment, there is provided a method of treating obstructive sleep apnea in a patient comprising the steps of:
applying direct intramuscular electrical stimulation to a specific set of muscle fibers in a muscle of the patient's airway,
wherein the electrical stimulation is provided by ***an implanted electrode assembly, wherein the electrode assembly comprises one or more electrodes connected to an implanted receiver....***

EX-1008 (Headley) ¶ 8.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Referring now to the figures, FIG. 1 shows a cross section of the upper airway in particular the tongue (genioglossus muscle) 20. FIG. 1 also shows the locations, L1 and L2, of the specific placements for the electrodes 110.

EX-1008 (Headley) ¶ 28.



EX-1008 (Headley), FIG. 1.

205. A POSITA understood that by inserting the electrodes into the genioglossus, the electrodes would not be providing cardiac stimulation given that the applied stimulation to the tongue would not stimulate the heart. *See, e.g.*, EX-1014 (Anagnostopoulos) (distinguishing between cardiac pacemakers (pp. -

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

480-486) and other types of neurostimulators (pp. 486-490), i.e., non-cardiac neurostimulators); EX-1015 (Glenn) (same); EX-1016 (Judson) (same). As such, a POSITA understood the receiver 116 and electrodes 110 implanted within the tongue/genioglossus as providing non-cardiac stimulation. EX-1008 (Headley) ¶ 28, FIG. 1; EX-1014 (Anagnostopoulos); EX-1015 (Glenn); EX-1016 (Judson).

206. Further, a POSITA understood that the genioglossus is innervated by (i.e., supplied by) the hypoglossal nerve (also known as cranial nerve XII or CN-XII) thus forming a neuromuscular system. EX-1023 (Fuller), pp. 601-603; EX-1033 (Zaidi), p. 379; V.A-V.B. A POSITA thus understood that implanting an electrode into the genioglossus engages the neuromuscular system, including the motor axons (nerve fibers) of the hypoglossal nerve that extend from the brain to the neuromuscular interface at the genioglossus muscle. EX-1033 (Zaidi) pp. 379 (“The human HGN, or XII cranial nerve, is the primary motor nerve that innervates seven of the eight muscles of the hemi-tongue.”), 382; V.A-V.B. The motor axons control the muscle activity of the genioglossus muscle. EX-1023 (Fuller), pp. 601-603; EX-1033 (Zaidi) p. 379; V.A-V.B. A POSITA further understood that electrical stimulation applied by the electrode implanted into the genioglossus muscle would

conduct to and be applied to the same motor axons passing through the hypoglossal nerve and result in movement of the genioglossus muscle. EX-1023, pp. 601-603; EX-1033 (Zaidi) p. 379; V.A-V.B.

207. The foregoing understanding is consistent with the disclosure of the '709 Patent, which discloses that a nerve-coupling electrode simply may be electrically coupled to the hypoglossal nerve:

In some examples, the electrode portion 82 comprises a cuff, such as one of the stimulation electrode portions 45 described in association with FIG. 2A in which the electrode portion is both mechanically and electrically coupled relative to the nerve 72. However, in some examples, the nerve-coupling electrode portion 82 comprises a cuff-less structure that is both mechanically and electrically coupled relative to the nerve 72.

In some examples, the nerve-coupling electrode portion 82 is not mechanically coupled to the nerve 72, but is mechanically coupled or secured in a location in close proximity to the nerve 72 and that enables electrically coupling of the electrode portion 82 relative to the nerve 72. In one instance, such examples include the electrode portion 82 being delivered to the target nerve 72 via a percutaneous access delivery. In one instance, such examples include the electrode portion 82 being delivered to the target nerve 72 via a transvenous delivery

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

method in which the electrode portion 82 is delivered on a lead
maneuvered within and through the vasculature of the patient.

EX-1001 11:60-12:12.

208. A POSITA understood from the foregoing disclosure that the intramuscular stimulation disclosed by Headley would activate motor axons. EX-1033 (Zaidi) pp. 379, 382; V.A-V.B. The activation of the motor axons would then synaptically activate muscle fibers – the muscle fibers themselves would not be directly excited by the electrical stimulus. EX-1033 (Zaidi) pp. 379, 382; V.A-V.B.
209. Moreover, Headley expressly incorporates by reference several papers, including papers by Brennick (EX-1042) and Yoo (EX-1028) that expressly reference hypoglossal nerve stimulation in their titles and several others (e.g., Bailey (EX-1041)) that describe the neuromuscular relationship between the genioglossus muscle and hypoglossal nerve. EX-1008 (Headley) ¶¶ 50 -62 (citing EX-1014 Anagnostopoulos), EX-1041 (Bailey), EX-1042 (Brennick), EX-1021 (Decker), EX-1019 (Edmonds), EX-1023 (Fuller), EX-1016 (Judson), EX-1020 (Miki), EX-1043 (Oliven2003), EX-1044 (Oliven2007), EX-1025 (Schwartz1996), EX-1028 (Yoo)). As such, a POSITA understood that implanting the electrodes 110 into the genioglossus includes engaging the

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

hypoglossal nerve, at least as disclosed in the '709 Patent. A POSITA further understood that applying electrical stimulation at the site identified in FIG. 1 and as described in paragraphs 8 and 28-30 of Headley results in stimulation of the hypoglossal nerve [*upper-airway-patency-related nerve*] to achieve the desired result of maintaining upper airway patency to treat OSA.

In one embodiment, there is provided a method for treating obstructive sleep apnea in a patient comprising the steps of: applying direct intramuscular electrical stimulation to a specific set of muscle fibers in a muscle of the patient's airway, wherein the electrical stimulation is provided by an implanted electrode assembly, wherein the electrode assembly, wherein the electrode assembly comprises one or more electrodes connected to an implanted receiver, and wherein the implanted electrode assembly is in operative associated with an external electromagnetic frequency transmitting antenna located on or near a patient's body, such that said electrical stimulation is provided when the antenna transmits an electromagnetic frequency to the implanted electrode, wherein upon receiving the frequency the implanted electrode assembly generates an electrical current in the one or more electrodes, and wherein the electrical current is delivered directly by wire to specific set of muscle fibers.

EX-1008 (Headley) ¶ 8.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

The receiver includes an electrical pulse source, or pulse generator. The electrodes impart electrical pulses, generated by the pulse generator, directly by wire to the genioglossus muscle to stimulate the specific fibers to a point where the patient's tongue is moved anteriorly to maintain upper airway patency.

EX-1008 (Headley) ¶ 30.

210. The foregoing is reinforced when Headley is combined with Tran, which expressly discloses neuromuscular stimulation of the genioglossus muscle and hypoglossal nerve:

Bipolar hooked wires are inserted percutaneously into the tongue muscle, from under the chin at midline, and *used for neuromuscular stimulation.*

EX-1010 (Tran-II), p. 4287.

Bipolar wire electrodes were strategically placed *at the optimal stimulation site in the genioglossus [citing Tran-I].*

EX-1010 (Tran-II), p. 4288.

The hypoglossal nerve branches to the [genioglossus] muscle enter the tongue inferolaterally to innervate muscle fibers that are oriented transversely, longitudinally and radially in parasagittal fans. The posteriorly directed portion of the

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

parasagittal fan originates from the mandible and produces protrusion. Endplate bands innervate the midpoints of these fibers and extend to the midline [12]. Sanders et al using Sihler's stain have shown *motor endplates near the tongue base are innervated by a separate hypoglossal nerve branch (human genioglossus illustrated in Fig. 2). This suggests that a single site of stimulation located in the midline (near these endplates as illustrated in Fig. 3) would recruit selectively these motor units that will produce symmetrical protrusion of the tongue, thereby opening the airway.*

EX-1009 (Tran-I), p. 376.

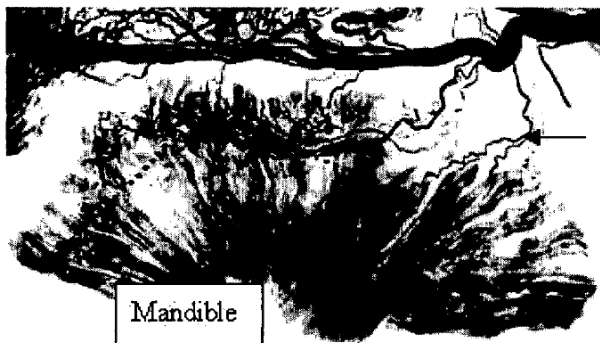


Fig. 2. The human genioglossus (GG), as shown in sagittal view. The single motor endplate band (red dotted line). A separate nerve branch innervates the motor endplates near the tongue base (arrow). Photo courtesy of Dr. Ira Sanders.



Fig. 3. Implantation site of a single BION in posterior midline of the genioglossus muscle with tantalum electrode (effective cathode) near the endplates (toward the tongue base).

EX-1009 (Tran-I), FIGS. 2-3.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

211. Further, a POSITA understood that the BION™ device disclosed by Tran could be implanted within a patient at a variety of locations, including adjacent or directly attached to nerves. In fact, the BION had been implanted in a clinical setting adjacent to the HGN and other nerves prior to March 19, 2015, as shown below.

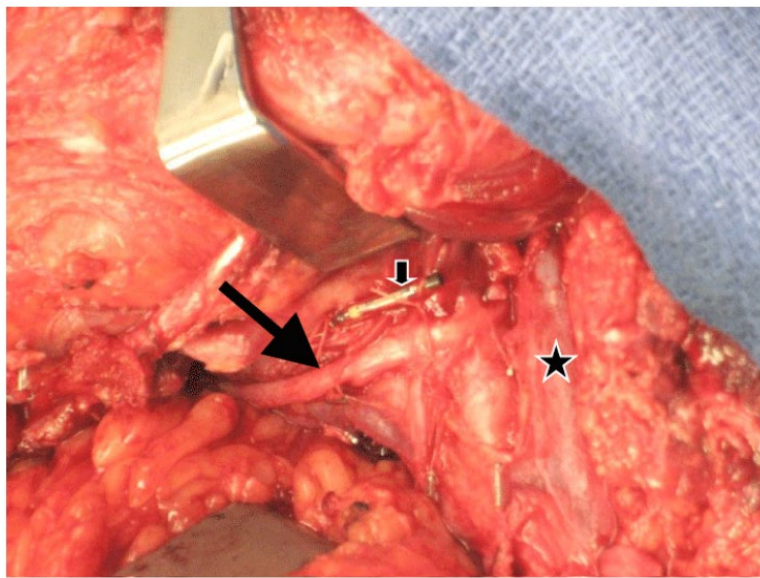


Figure 3: MS (small arrow) is placed above the left hypoglossal nerve (large arrow) during left modified radical neck dissection. Star indicates the origin of ansa cervicalis nerve.

EX-1039 (Sinha), p. 3.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

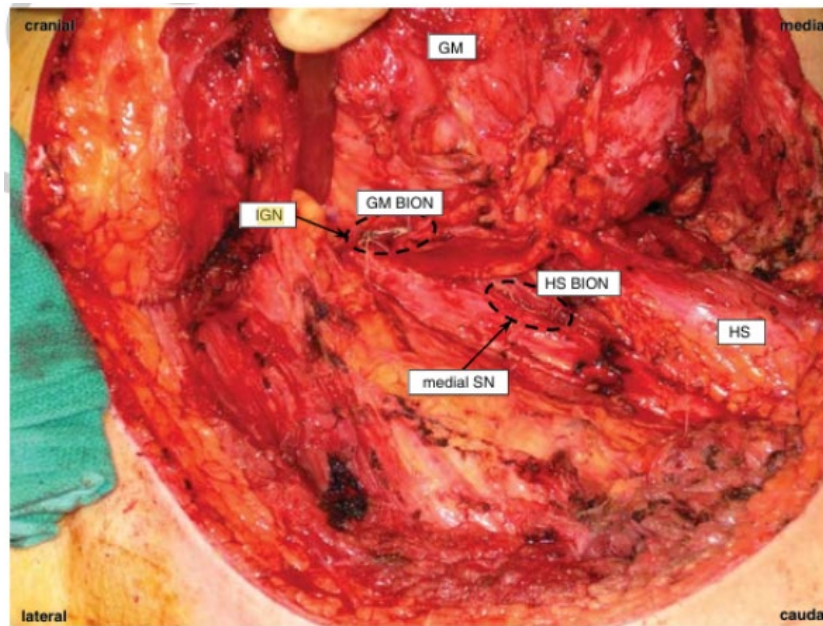


Fig. 2. Intraoperative BION placement.

EX-1040 (Kaplan), p. 348 (describing the implantation of the BIONs adjacent to the inferior gluteal nerve (“IGN”) and sciatic nerve (“SN”) for stimulating these nerves).

212. Thus, to the extent Headley does not expressly disclose engaging and stimulating an upper-airway-patency-related nerve, such as the hypoglossal nerve, Tran does. Further, moving the BION to another location, such as adjacent or attached to the HGN, would have been obvious to a POSITA, as it was known to implant the BION in such locations to achieve the desired result of stimulating one or more muscles by stimulating one or more nerves. EX-1039 (Sinha), p. 3; EX-1040 (Kaplan), p. 348.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

213. Accordingly, Headley discloses element [1.a1], either alone or in combination with Tran.

c. [1.a2] *according to a first stimulation therapy protocol not synchronized to actively-sensed respiratory information,*

214. Headley discloses that the receiver 116 and a stimulating electrode 110 [*non-cardiac stimulation element*] provides stimulation using an alternating on/off “intermittent” treatment [*first stimulation therapy protocol*].

In use, the device as described herein and/or the method as described herein provides for alternating on/off “intermittent” *treatment wherein the tissue is stimulated for a given period, and then the tissue is allowed to rest for a given period.*

EX-1008 (Headley) ¶ 10.

215. Although Headley discloses the use of *optional* sensors, such as sound-activation means and/or oxygen-sensing means, these sensors are not actively sensing respiration [*not synchronized to actively-sensed respiratory information*]. EX-1008 (Headley) ¶ 14. Instead, these sensors are detecting when a patient snores or the patient’s oxygen level.

In another preferred embodiment, the medical device further comprises alternatively sound-activation-means for allowing the

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

power unit to turn on when the sound of snoring is received from the patient thus allowing the device to be utilized only during times when the patient may actually experience the apneic episodes, and/or oxygen-sensing means and auto-start means for having the device turn on when the patient's oxygen concentration as measured by a transcutaneous receiver placed on the antenna over the patient's skin would detect an oxygen concentration of less than 96%.

EX-1008 (Headley) ¶ 14.

216. Further, these *optional* sensors are not used for purposes of synchronizing the first stimulation therapy protocol to the patient's respiratory cycle, but instead are used to initiate the first stimulation therapy protocol after sensing that the patient is first experiencing an apneic episode. EX-1008 (Headley) ¶ 14. Put another way, the at least one sensor disclosed by Headley is used to trigger therapy – not for synchronizing the therapy to the patient's respiratory cycle.

217. Accordingly, Headley discloses the limitations of claim element [1.a2].

218. Although not needed to demonstrate that the prior art references of Ground 2 disclose the limitations of claim element [1.a2], I note that Tran also discloses these limitations in a manner that is consistent with the Teachings of Headley. Specifically, Tran discloses the use of “repetitive intermittent electrical

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

stimulation” in which the “stimulation is repeated in continuous cycles at approximately the natural respiratory rhythm of the sleeping participant” to “recover and prevent or maintain airway patency.” EX-1010 (Tran-II), p. 4288. Tran expressly states that the repetitive intermittent electrical stimulation is applied “without synchronizing with breathing” thereby “obviating the need for a sensor to synchronize stimulation with breathing.” EX-1010 (Tran-II), pp. 4288-4289. Thus, the teachings of Headley could be combined with those of Tran, if needed, and the resultant device would provide the stimulation according to a first stimulation therapy protocol not synchronized to actively-sensed respiratory information.

d. [1.b] *wherein the first stimulation therapy protocol comprises a series of repeating stimulation cycles in which each stimulation cycle includes a stimulation period and a non-stimulation period,*

219. Headley discloses this claim element. Specifically, Headley discloses an alternating on/off “intermittent” treatment [*first stimulation therapy protocol*] that includes a period of stimulation [*stimulation period*] and a rest period in which the stimulation is turned off [*non-stimulation period*].

In use, the device as described herein and/or the method as described herein provides for alternating on/off “intermittent” *treatment wherein the tissue is stimulated for a given period,*

and then the tissue is allowed to rest for a given period. In one preferred embodiment, the device or method *applies stimulation* for 5 seconds, and then stimulation is turned off for 5 seconds. In another preferred embodiment, the *period of stimulation* ranges from 1 to 20 seconds, with *varying rest periods*. In another preferred embodiment, the *period of stimulation* is 20 seconds and the *rest period* is 5 seconds.

EX-1008 (Headley) ¶ 48.

220. Given the foregoing, a POSITA understood Headley as disclosing the limitations of claim element [1.b].

221. Although not needed to demonstrate that the prior art references of Ground 2 disclose the limitations of claim element [1.b], I note that Tran also discloses these limitations in a manner that is consistent with the Teachings of Headley. Specifically, Tran discloses repetitive intermittent electrical stimulation that includes an ON period [*stimulation period*] and an OFF period [*non-stimulation period*].

We hypothesized that electrical stimulation does not have to synchronize with inspiration to prevent OSA [4,5]. Instead, repetitive intermittent electrical stimulation could be used to recover or maintain airway patency. In this method, we applied a brief train of electrical pulses during an *ON period* followed by

no stimulation during an OFF period. This method of stimulation is repeated in continuous cycles at approximately the natural respiratory rhythm of the sleeping participant, obviating the need for a sensor to synchronize stimulation with breathing.

EX-1010 (Tran-II), p. 4288.

- e. ***[1.c] wherein each stimulation period includes continuous stimulation and has a minimum duration equal to or greater than an inspiratory reference of a reference respiratory cycle, wherein the inspiratory reference corresponds to a duration of an inspiratory phase of the reference respiratory cycle, and***

222. Headley in view of Tran discloses this claim element. Both Headley and Tran disclose that each stimulation period includes continuous stimulation, which is described in the '709 Patent as “a train of stimulation pulses which occur in a relatively short time frame,” such as “a finite number (e.g. 5, 10, etc.) of stimulation pulses per second.” EX-1001 4:37-43.

223. Headley discloses that the pulse generator is configured to vary the properties of the electrical pulses applied during the therapy.

The receiver includes an electrical pulse source, or pulse generator. ***The electrodes impart electrical pulses, generated by the pulse generator,*** directly by wire to the genioglossus muscle to stimulate the specific muscle fibers to a point where the

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

patient's tongue is moved anteriorly to maintain upper airway patency. *The pulse generator has an output that provides pulses having selectable properties of* mode, polarity, amplitude, current, pulse width, and *frequency*...The stimulator may be variably set to provide *direct current pulses* having an amplitude, a *frequency*, and a duration to provide a non-awakening stimulation directly by wire to the specific muscle fibers.

EX-1008 (Headley) ¶ 30.

224. Similarly, Tran discloses that the electrical stimulation may be applied at 20 pulses per second (PPS):

However, stimulation with parameters of 3.0 mA, 200 µsec pulse width, **20 PPS**, and duty cycle of 30% or more were well tolerated and seemed to be effective in preventing the development of hypopnea.

EX-1010 (Tran-II), p. 4289.

225. Headley and Tran further disclose that the stimulation period has a minimum duration equal to or greater than an inspiratory reference of a reference respiratory cycle. For example, Tran expressly discloses a respiratory rate of 5 seconds for a sleeping patient based on studying a patient while sleeping.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Two patients with documented severe OSA (>40 episodes/hr) were studied overnight. ***Baseline information such as respiratory rate and level of oxygen saturation was acquired during the first hour of sleep.*** Various duty cycles of gating of CPAP (30-50%) were studied at random during the night. For example, a 40% duty cycle ***in a 5 second respiration period*** means CPAP is applied for 3 sec and gated off for 2 sec.

EX-1009 (Tran-I), p. 377.

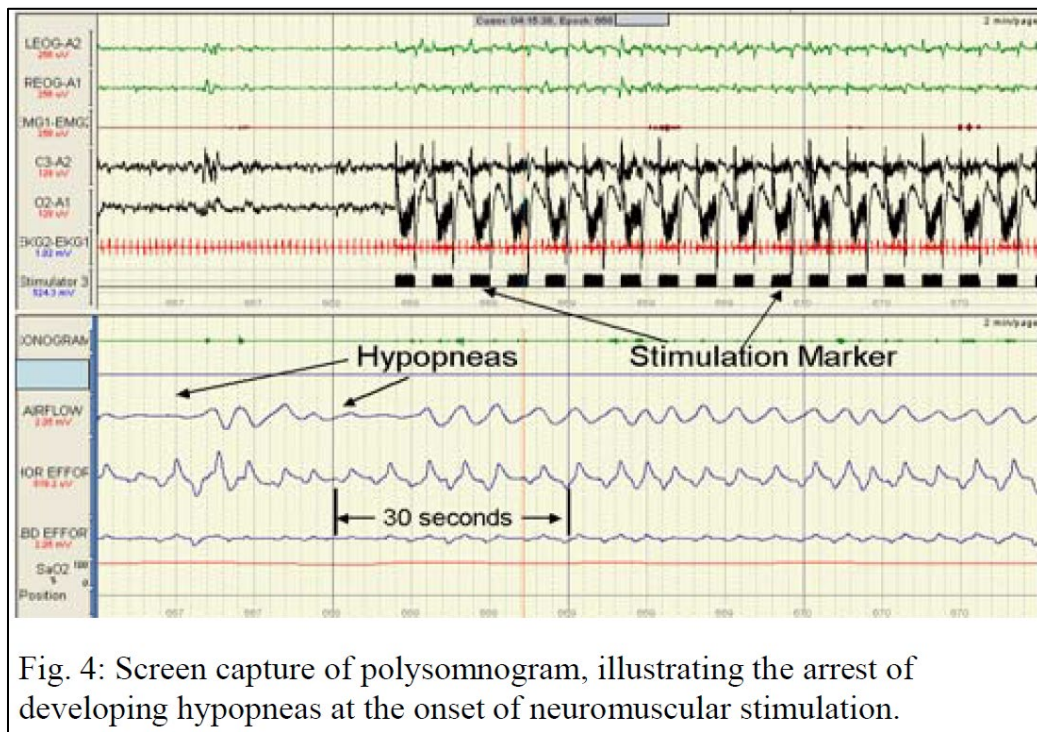
226. Tran further discloses providing the electrical stimulation based on the observed reference respiratory cycle of the patient.

In this method, we applied a brief train of electrical pulses during an ***ON period*** followed by ***no stimulation during an OFF period.*** ***This method of stimulation is repeated in continuous cycles at approximately the natural respiratory rhythm of the sleeping participant,*** obviating the need for a sensor to synchronize stimulation with breathing.

EX-1010 (Tran-II), p. 4288; *see also* EX-1009 (Tran-I), p.337.

227. FIG. 4 of Tran-II is a screen capture of a polysomnogram of a patient, which shows the patient's inspiratory phase to be approximately 2 seconds and the stimulation markers indicating an ON period [*stimulation period*] of approximately 2.5 seconds.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709



EX-1010 (Tran-II), FIG. 4.

228. Thus, Tran discloses that the ON period [*stimulation period*] has a minimum duration equal to or greater than the inspiratory phase of the patient's respiratory cycle [*reference respiratory cycle*]. Moreover, Headley expressly discloses periods of stimulation of up to 120 seconds. EX-1008 (Headley) ¶ 48 ("On periods may range, without limitations from 1 to 120 seconds, and off periods similarly."). One of ordinary skill in the art would have understood that a period of stimulation [*stimulation period*] of 120 seconds would vastly exceed the duration of any patient's inspiratory phase –

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

especially given the five-second respiratory phase duration disclosed by Tran. EX-1009 (Tran-I), p. 377. A POSITA would have been motivated to modify the teachings of Headley to provide stimulation for *a minimum duration equal to or greater than an inspiratory reference of a reference respiratory cycle, wherein the inspiratory reference corresponds to a duration of an inspiratory phase of the reference respiratory cycle* as taught by Tran for the reasons discussed herein and in X.A (Reasons to Combine Headley and Tran).

229. Accordingly, Headley in view of Tran discloses claim element [1.c].

- f. [1.d] *wherein the reference respiratory cycle comprises at least one of:
a historical patient-specific average respiratory cycle for stable respiration; and
a multi-patient average respiratory cycle for stable respiration, and*

230. Tran discloses observing a sleeping patient to determine the patient's respiratory rate [*historical patient-specific average respiratory cycle for stable respiration*] and using the respiratory rate to provide the electrical stimulation.

Two patients with documented severe OSA (>40 episodes/hr) were studied overnight. Baseline information such as respiratory rate and level of oxygen saturation was acquired during the first hour of sleep. Various duty cycles of gating of

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

CPAP (30-50%) were studied at random during the night. For example, a 40% duty cycle *in a 5 second respiration period* means CPAP is applied for 3 sec and gated off for 2 sec.

EX-1009 (Tran-I), p. 377.

In this method, we applied a brief train of electrical pulses during an ON period followed by no stimulation during an OFF period. *This method of stimulation is repeated in continuous cycles at approximately the natural respiratory rhythm of the sleeping participant*, obviating the need for a sensor to synchronize stimulation with breathing.

EX-1010 (Tran-II), p. 4288.

231. A POSITA would have been motivated to modify the teachings of Headley to provide the reference respiratory cycle using *a historical patient-specific average respiratory cycle for stable respiration stimulation* as taught by Tran at least for the reasons discussed above in X.A (Reasons to Combine Headley and Tran).
232. Accordingly, Headley in view of Tran discloses element [1.d].

- g. [1.e] *wherein each stimulation period of each respective stimulation cycle has a duration greater than a duration of the inspiratory reference of the reference respiratory cycle and the stimulation period is followed by the non-stimulation period of the respective stimulation cycle comprising a duration less than the duration of the stimulation period.*

233. Headley in view of Tran discloses this claim element. As detailed above with respect to claim element [1.c], Headley in view of Tran discloses that the period of stimulation/ON period [*stimulation period*] has a minimum duration that is greater than the inspiratory phase [*inspiratory reference*] of the patient's respiratory cycle [*reference respiratory cycle*]. X.B.1.e (Ground 2, claim element [1.c]).

234. Headley and Tran also disclose that the stimulation period is followed by the non-stimulation period, as detailed above with respect to claim element [1.b]. X.B.1.d (Ground 2, claim element [1.b]). Headley further discloses that a duration of the rest/off period [*non-stimulation period*] is less than a duration of the of the period of stimulation/on period [*stimulation period*], as Headley discloses duty cycles (on/off periods) ranging from 12:1 (60/5) to 1:12 (5/60).

In use, the device as described herein and/or the method as described herein provides for alternating on/off "intermittent" treatment wherein *the tissue is stimulated for a given period, and then the tissue is allowed to rest for a given period.* In one

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

preferred embodiment, the device or method applies stimulation for 5 seconds, and then stimulation is turned off for 5 seconds. In another preferred embodiment, the period of stimulation ranges from 1 to 20 seconds, with varying rest periods. In another preferred embodiment, ***the period of stimulation is 20 seconds and the rest period is 5 seconds***. In yet another preferred embodiment, the period is 60 seconds on with 60 seconds off. On periods may range without limitations from 1 to 120 seconds, and off periods similarly. ***On/off intermittent periods include*** from 5/5, ***20/5***, 10/10, 5/60, ***60/5***, 20/20, 30/30, 40/40, 50/50, 60/60, and so forth.

EX-1008 (Headley) ¶ 48.

235. Headley in view of Tran discloses claim element [1.e]. Accordingly, claim 1 is obvious from Headley in view of Tran.

2. **Claim 2**

- a. [2] ***The device of claim 1, wherein the non-cardiac stimulation element comprises an implantable electrode and a pulse generator electrically connected to the implantable electrode.***

236. Headley in view of Tran renders obvious claim 1, as discussed above in X.B.1 (Ground 2, claim 1). Headley further discloses claim 2, as Headley discloses a stimulating electrode 110 [*implantable electrode*] emanating from [*electrically connected to*] a receiver 116 [*pulse generator*].

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

The device itself consists of 4 parts. First is a power source 120 (Fig. 3). Second is an antenna 118 (Fig. 4). ***Third is a receiver 116 and fourth is the stimulating electrode 110 (Fig. 5).*** The power source provides the power for the device and is of small size so that it can be clipped to the upper nightwear of the patient being treated. This is connected to the antennae which deliver the radio frequency to the ***receiver which has been implanted in the neck of the patient with the stimulating electrodes emanating from the receiver*** and entering into specific muscle sites in the tongue of the patient.

EX-1008 (Headley) ¶ 29.

The receiver includes an ***electrical pulse source, or pulse generator. The electrodes impart electrical pulses, generated by the pulse generator,*** directly by wire to the genioglossus muscle to simulate the specific muscle fibers to a point where the patient's tongue is moved anteriorly to maintain upper airway patency. ***The pulse generator has an output that provides electrical pulses*** having selectable properties of mode, polarity, amplitude, current, pulse width, and frequency.

EX-1008 (Headley) ¶ 30.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

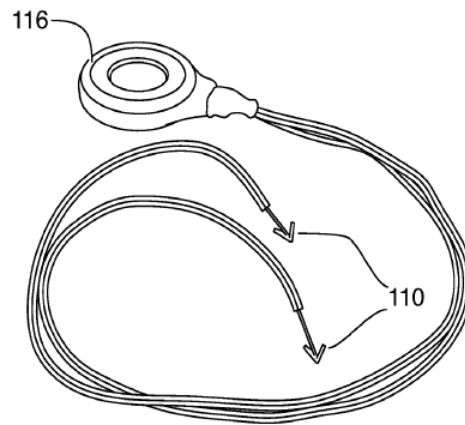


FIG. 5

EX-1008 (Headley), FIG. 5.

237. Thus, Headley expressly discloses the limitations of claim 2.

238. Although not needed to demonstrate that the prior art references of Ground 2 disclose the limitations of claim 2, I note that Tran also discloses these limitations in a manner that is consistent with the teachings of Headley. Specifically, as discussed above in X.A (Reasons to Combine Headley and Tran), a POSITA understood that the BION™ actually had been reduced to practice and could be used to treat OSA. X.A (Reasons to Combine Headley and Tran); *see also* EX-1039 (Sinha); EX-1040 (Kaplan). The BION™ [*non-cardiac stimulation element*] included an anodized sintered Ta electrode and an iridium electrode [*implantable electrode*] electrically connected to circuitry (e.g., copper coil, Schottky diode, ASIC) [*pulse generator*].

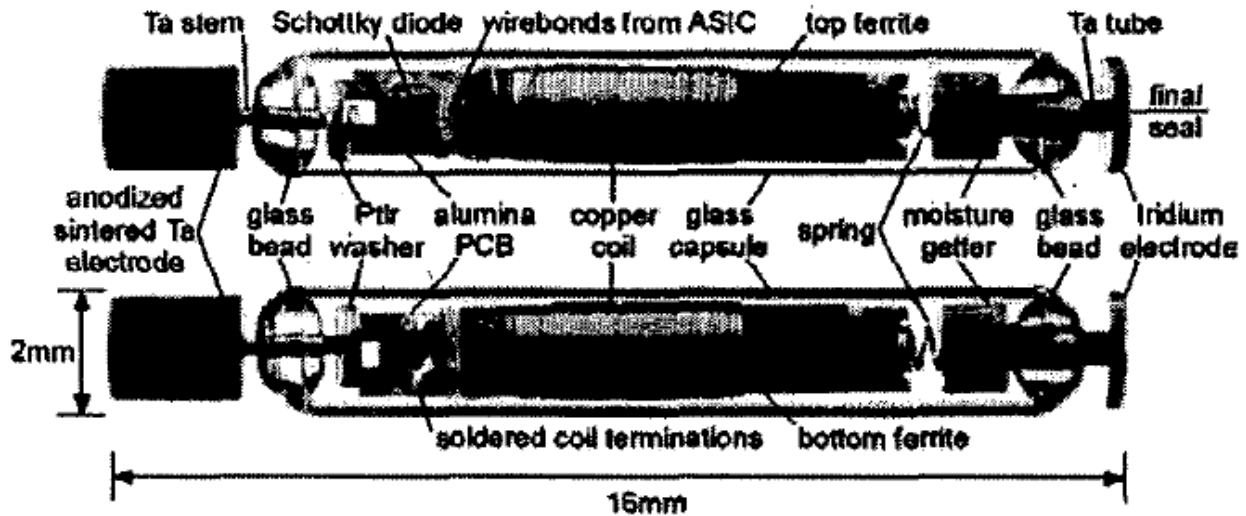


Fig. 1. The main components of BION implant.

EX-1009 (Tran-I), p. 375.

3. Claim 4

- a. [4] *The device of claim 1, wherein a total duration of stimulation via the first stimulation protocol during a treatment period is greater than 30 percent of the total duration of the treatment period.*

239. Headley in view of Tran renders obvious claim 1, as discussed above in X.B.1 (Ground 2, claim 1). Headley and Tran further disclose the limitations of claim 4, as Headley discloses a treatment protocol in which a duration of the period of stimulation/on period [*stimulation period*] may be equal to or greater than a duration of the rest/off period [*non-stimulation period*].

In use, the device as described herein and/or the method as described herein provides for alternating on/off “intermittent”

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

treatment wherein the tissue is stimulated for a given period, and then the tissue is allowed to rest for a given period. In one preferred embodiment, the device or method ***applies stimulation for 5 seconds, and then stimulation is turned off for 5 seconds.***

In another preferred embodiment, the period of stimulation ranges from 1 to 20 seconds, with varying rest periods. In another preferred embodiment, ***the period of stimulation is 20 seconds and the rest period is 5 seconds.*** In yet another preferred embodiment, ***the period is 60 seconds on with 60 seconds off.*** On periods may range without limitations from 1 to 120 seconds, and off periods similarly. ***On/off intermittent periods include*** from 5/5, 20/5, 10/10, 5/60, 60/5, 20/20, 30/30, 40/40, 50/50, 60/60, and so forth.

EX-1008 (Headley) ¶ 48.

240. Given Headley's express disclosure that the treatment includes alternating on/off periods, a POSITA would have understood that the total duration of stimulation applied during the treatment would correspond to the duty cycle (on/off periods). EX-1008 ¶48. As such, Headley discloses that the total period of stimulation/on period [*total duration of stimulation*] may range from about 8% (e.g., an on/off period of 5/60) to about 92% (e.g., an on/off period of 60/5).

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

On/off period of 5/60; total cycle length 65:

$$\frac{5}{65} \times 100\% = 7.69\%$$

On/off period of 60/5; total cycle length 65:

$$\frac{60}{65} \times 100\% = 92.3\%$$

241. To the extent Patent Owner asserts that Headley does not expressly disclose 30%, Tran does, as Tran expressly discloses that duty cycles of 30% or greater were well-tolerated and effective and a duty cycle of approximately 50% is shown in FIG. 4.

However, stimulation with parameters of 3.0 mA, 200 μ sec pulse width, 20 PPS, and duty cycle of 30% or more were well tolerated and seemed to be effective in preventing the development of hypopnea.

EX-1010 (Tran-II), p. 4289.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

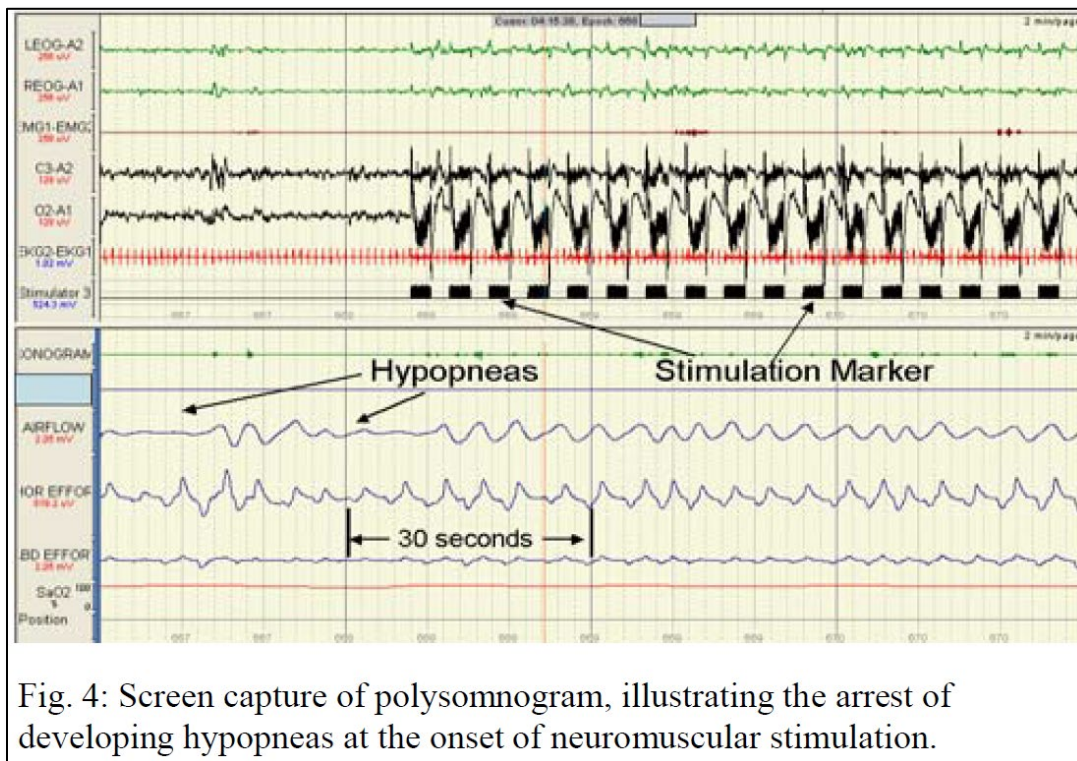


Fig. 4: Screen capture of polysomnogram, illustrating the arrest of developing hypopneas at the onset of neuromuscular stimulation.

EX-1010 (Tran-II), FIG. 4.

242. Here again, a POSITA would have understood that duty cycle of “30% or greater” as disclosed by Tran would correspond a total duration of stimulation via the first stimulation protocol during a treatment period to be greater than 30% of the total duration of the treatment period. EX-1010 (Tran-II), p. 4289, FIG. 4. A POSITA would be motivated to modify the teachings of Headley to include a stimulation period during a treatment period that is greater than 30 percent of the total duration of the treatment period as taught by Tran for the reasons discussed in X.A (Reasons to Combine Headley and Tran).

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

243. Further, as discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle, was routine in the art and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the '709 Patent does not identify any unexpected results resulting from providing a total duration of stimulation via the first stimulation protocol during a treatment period that is greater than 30 percent of the total duration of the treatment period as claimed. As such, not only do Headley and Tran disclose the limitations of claim 4, but the claim itself recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).
244. Accordingly, claim 4 is obvious from Headley in view of Tran.

4. Claim 5

- a. ***[5] The device of claim 1, wherein the duration of the stimulation period comprises at least 50 percent of a duration of the stimulation cycle.***
245. Headley in view of Tran renders obvious claim 1, as discussed above in X.B.1 (Ground 2, claim 1). Headley and Tran further disclose claim 5 for the reasons discussed above with respect to claim 4. X.B.3 (Ground 2, claim 4). Specifically, as discussed above, Headley discloses that the total period of

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

stimulation/on period [*total duration of stimulation*] may range from about 8% (e.g., an on/off period of 5/60) to about 92% (e.g., an on/off period of 60/5), and Tran discloses a 50% duty cycle. EX-1008 (Headley) ¶48; EX-1010 (Tran-II), p. 4289, FIG. 4.

246. Further, as discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle, was routine in the art and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the '709 Patent does not identify any unexpected results resulting from providing a stimulation period having a duration that comprises at least 50 percent of a duration of the stimulation cycle. As such, not only do Headley and Tran disclose the limitations of claim 5, but the claim itself recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).
247. Accordingly, claim 5 is obvious from Headley in view of Tran.

5. **Claim 6**

- a. [6] *The device of claim 1, wherein the duration of the stimulation period comprises at least 50 percent of a duration of the reference respiratory cycle.*

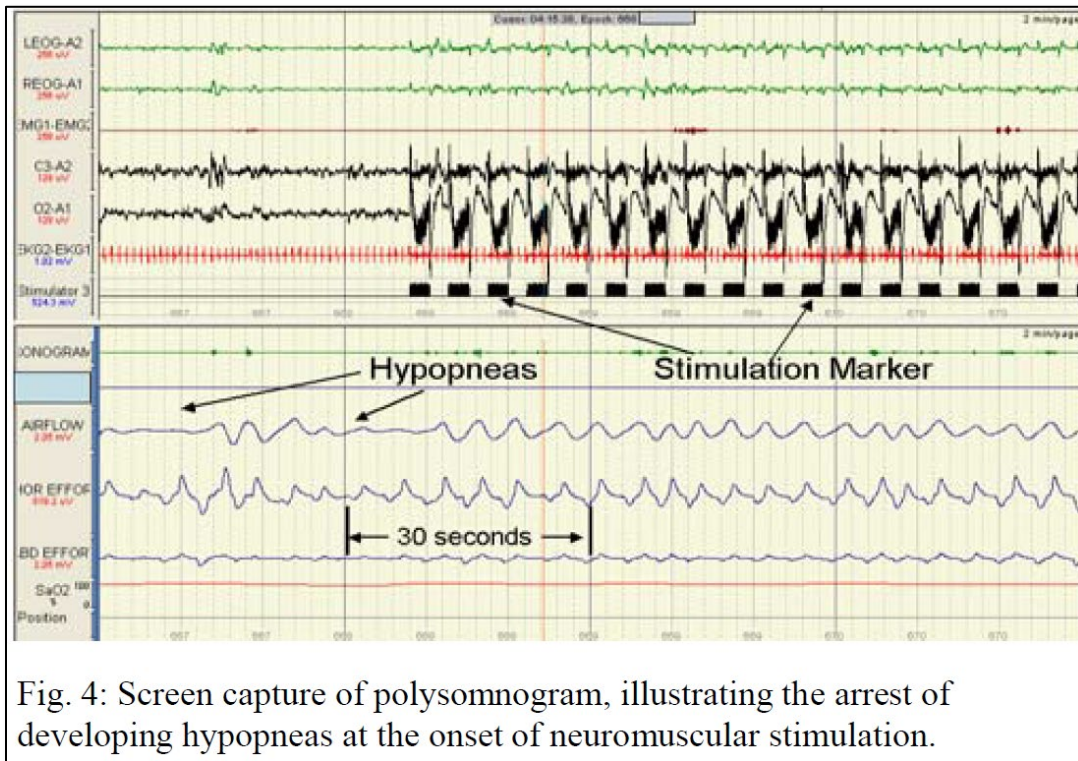
248. Headley in view of Tran renders obvious claim 1, as discussed above in X.B.1 (Ground 2, claim 1), and further disclose the limitations of claim 6. Tran discloses a respiratory rate of 5 seconds for a sleeping patient based on observing the patient during sleep.

Baseline information such as respiratory rate and level of oxygen saturation *was acquired during the first hour of sleep.* Various duty cycles of gating of CPAP (30-50%) were studied at random during the night. For example, a 40% duty cycle *in a 5 second respiration period* means CPAP is applied for 3 sec and gated off for 2 sec.

EX-1009 (Tran-I), p. 377.

249. FIG. 4 of Tran-II illustrates a treatment protocol with a duty cycle of approximately 50%, such that stimulation is applied [*stimulation period*] 50% of the patient's respiratory rate [*reference respiratory cycle*].

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709



EX-1010 (Tran-II), FIG. 4.

250. As detailed above with respect to claim 4, Headley discloses that the period of stimulation/on period [*stimulation period*] may range from 8% to (e.g., an on/off period of 5/60) to about 92% (e.g., an on/off period of 60/5) of a stimulation cycle. X.B.3 (Ground 2, claim 4); EX-1008 (Headley) ¶ 48 (“***On/off intermittent*** periods include from 5/5, 20/5, 10/10, 5/60, **60/5**, 20/20, 30/30, 40/40, 50/50, 60/60, and so forth.”). Thus, when combined with Tran for the reasons discussed above in X.A (Reasons to Combine Headley and Tran), a POSITA would have provided a stimulation cycle in which the

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

duration of the period of stimulation/on period [*stimulation period*] comprises at least 50% of a duration of the patient's respiratory rate [*reference respiratory cycle*].

251. As discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle, was routine in the art and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the '709 Patent does not identify any unexpected results resulting from providing a stimulation period that comprises at least 50 percent of a reference respiratory cycle. As such, not only do Headley and Tran disclose the limitations of claim 6, but the claim itself recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).
252. Accordingly, claim 6 is obvious from Headley in view of Tran.

6. **Claim 7**

- a. [7] *The device of claim 1, wherein the duration of each respective stimulation cycle is less than the duration of the reference respiratory cycle, and a duration of the stimulation period exceeds the duration of the non-stimulation period by a factor of at least 3.*

253. Headley in view of Tran renders obvious claim 1, as discussed above in X.B.1 (Ground 2, claim 1), and Headley further discloses claim 7. For example, Headley expressly discloses that a stimulation cycle may be as short as two seconds (e.g., one second on/one second off). EX-1008 (Headley) ¶ 48 (“On periods may range, without limitations from 1 to 120 seconds, and off periods similarly.”). A two second stimulation cycle is less than the reference respiratory cycle of five seconds disclosed by Tran.
254. Headley further discloses duty cycles in which the period of stimulation [*stimulation period*] is greater than the rest/off period [*non-stimulation period*] by 12 (e.g., 60 on/5 off), which is greater than 3. EX-1008 (Headley) ¶ 48 (“On/off intermittent periods include from 5/5, **20/5**, 10/10, 5/60, **60/5**, 20/20, 30/30, 40/40, 50/50, 60/60, and so forth.”).
255. Further, as discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle, was routine in the art and was a typical part of the titration process performed by a physician after

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

implantation of an OSA treatment device. I further note that the '709 Patent does not identify any unexpected results resulting from providing each respective stimulation cycle with a duration that is less than a duration of a reference respiratory cycle and in which a duration of the stimulation period exceeds a duration of the non-stimulation period by a factor of at least three. As such, not only do Headley and Tran disclose the limitations of claim 7, but the claim itself recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).

256. Accordingly, claim 7 is obvious from Headley, either alone or in combination with Tran.

7. **Claim 8**

a. [8] *The device of claim 1, wherein the duration of each respective stimulation cycle is greater than the duration of the reference respiratory cycle.*

257. Headley in view of Tran renders obvious claim 1, as discussed above in X.B.1 (Ground 2, claim 1). Headley and Tran further disclose claim 7, as Headley expressly discloses that the on/off intermittent periods [*stimulation cycle*] may be as long as 240 seconds (e.g., 120 seconds on/120 seconds off). EX-1008 (Headley) ¶ 48 (“On periods may range, without limitations from 1 to 120

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

seconds, and off periods similarly.”). A 240-second stimulation cycle, which is provided when both the on period and off period are 120 seconds, is greater than the reference respiratory cycle of five seconds disclosed by Tran. A six-second stimulation cycle, which also is in the range disclosed by Headley (i.e., three seconds on; three seconds off, which is within the range of 1-120 seconds for each of the on/off periods), also is greater than a five-second reference respiratory cycle disclosed by Tran.

258. As discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle and duration of a stimulation cycle, was routine in the art and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the '709 Patent does not identify any unexpected results resulting from providing each respective stimulation cycle with a duration greater than the duration of the reference respiratory cycle. As such, not only do Headley and Tran disclose the limitations of claim 8, but the claim itself recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).
259. Accordingly, Headley and Tran render obvious claim 8.

8. **Claim 9**

- a. [9] *The device of claim 8, wherein the stimulation period and the non-stimulation period are in a proportion of at least 1.5 to 1.*

260. Headley in view of Tran renders obvious claim 8, as discussed above in X.B.7 (Ground 2, claim 8), and Headley further discloses the limitations of claim 9. For example, Headley further discloses duty cycles in which the period of stimulation [*stimulation period*] and the rest/off period [*non-stimulation period*] are in a proportion of at least 1.5:1, as Headley expressly discloses proportions of 20:5 (i.e., 4:1) and 60/5 (i.e., 12:1). EX-1008 (Headley) ¶ 48 (“On/off intermittent periods include from 5/5, **20/5**, 10/10, 5/60, **60/5**, 20/20, 30/30, 40/40, 50/50, 60/60, and so forth.”).
261. As discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle, was routine in the art and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the ’709 Patent does not identify any unexpected results from providing a stimulation period and a non-stimulation period in a proportion of at least 1.5 to 1. As such, not only does Headley disclose the limitations of claim 9, but the claim itself

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).

262. Accordingly, claim 9 is obvious from Headley, either alone or in combination with Tran.

9. Claim 10

a. [10] The device of claim 8, wherein the duration of the stimulation cycle is less than a duration of two consecutive reference respiratory cycles.

263. Headley in view of Tran renders obvious claim 8, as discussed above in X.B.7 (Ground 2, claim 8). Headley and Tran further disclose claim 10, as Headley expressly discloses that an alternating on/off period [*stimulation cycle*] may range from 2 seconds to 240 seconds. Specifically, Headley discloses that “[o]n periods may range, without limitations from 1 to 120 seconds, and off periods similarly.” EX-1008 (Headley) ¶ 48. A POSITA understood that a one second ON period and a one second OFF period corresponds to a stimulation cycle length of two seconds and a 120 second ON period and 120 second OFF period corresponds to a stimulation cycle length of 240 seconds.

264. A six-second stimulation cycle, which is in the range disclosed by Headley (i.e., three seconds on/three seconds off), is greater than a five-second

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

reference respiratory cycle disclosed by Tran while being less than a duration of two consecutive five second respiratory cycles (i.e., ten seconds).

265. As discussed above in V.B (Technical Background, OSA Treatment), adjusting stimulation parameters, including duty cycle and duration of a stimulation cycle, was routine in the art and was a typical part of the titration process performed by a physician after implantation of an OSA treatment device. I further note that the '709 Patent does not identify any unexpected results from providing a stimulation cycle with a duration less than a duration of two consecutive respiratory cycles. As such, not only do Headley and Tran disclose the limitations of claim 10, but the claim itself recites nothing more than routine optimization (i.e., a duty cycle that provides the desired outcome of increasing airway patency while sleeping).

266. Accordingly, Headley and Tran render obvious claim 10.

10. Claim 12

**a. [12.a] *The device of claim 1, comprising:
a processor; and***

267. Headley in view of Tran renders obvious claim 1, as discussed above in X.B.1 (Ground 2, claim 1). Headley discloses that the pulse generator of the receiver includes a microprocessor [*processor*].

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Commercially available ***pulse generators provide pulses having many of the previously mentioned variables and may include microprocessors*** and electronics for signal processing and cooperation with apnea detection device.

EX-1008 (Headley) ¶ 30.

268. Accordingly, Headley discloses the limitations of claim element [12.a].

b. [12.b] a non-volatile computer readable medium storing instructions, executable on the processor, to implement the non-cardiac stimulation element and to perform the first stimulation therapy protocol.

269. A POSITA understood that a commercially available pulse generator included a non-volatile computer readable medium storing instructions, executable by the microprocessor [*processor*], to perform the alternating on/off “intermittent” treatment [*first stimulation therapy protocol*]. See V.A (Technical Background, Neuromuscular Stimulators) (citing Christopherson, Bolea, and others).

270. Headley further discloses that the controller could be programmed with the stimulation parameters, which a POSITA understood would be stored in a non-volatile computer readable medium.

Commercially available pulse generators provide pulses having many of the previously mentioned variables and may include

microprocessor and electronics for signal processing and cooperation with apnea detection devices. *The stimulator may be variably set to provide direct current pulses having an amplitude, a frequency, and a duration to provide a non-awakening stimulation* directly by wire to the specific muscle fibers.

EX-1008 (Headley) ¶ 30.

271. Accordingly, Headley discloses the limitations of claim element [12.b] and renders obvious claim 12, either alone or in combination with Tran.

11. Claim 13

- a. [13.a] *The device of claim 1, comprising:
a sensing element to at least periodically actively sense
respiratory information to obtain the actively-sensed
respiratory information unrelated to stimulation
synchronization,*

272. Headley in view of Tran renders obvious claim 1, as discussed above in X.B.1 (Ground 2, claim 1). Headley further discloses sound-activation-means and oxygen-sensing means [*sensing element*] to at least periodically sense the patient snoring and/or low oxygen levels [*actively sense respiratory information*].

In another preferred embodiment, the medical device further comprises alternatively sound-activation-means for allowing the

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

power unit to turn on when the sound of snoring is received from the patient thus allowing the device to be utilized only during times when the patient may actually experience the apneic episodes, and/or oxygen-sensing means and auto-start means for having the device turn on when the patient's oxygen concentration as measured by transcutaneous receiver placed on the antenna over the patient's skin would detect an oxygen concentration of less than 96%.

EX-1008 (Headley) ¶ 14.

An eighth application would be sound activated stimulation. This would allow the power unit to turn on when the sound of snoring is received from the patient. This would allow the device to be utilized only during times when the patient may actually experience the apneic episodes.

A ninth application would be to have the device turned on when the patient's oxygen concentration as measured by a transcutaneous receiver placed on the antenna over the patient's skin would detect an oxygen concentration of less than 96%.

EX-1008 (Headley) ¶¶ 44-45.

273. A POSITA understood that either of the sound or oxygen activation means disclosed by Headley would periodically actively sense respiratory

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

information (e.g., presence of snoring and/or oxygen level) but are both unrelated to simulation synchronization, as neither is used to detect a patient's inspiration period, expiration period, or overall respiratory rate. EX-1008 (Headley) ¶¶ 44-45.

274. Accordingly, Headley discloses the limitations of claim element [13.a].

- b. ***[13.b] wherein the non-cardiac stimulation element is activated for stimulation upon the sensing element identifying, via at least the actively-sensed respiratory information, obstructive sleep apnea behavior which meets or exceeds a severity threshold and wherein the non-cardiac stimulation element is deactivated upon the sensing element identifying, via at least the actively-sensed respiratory information, that the obstructive sleep apnea behavior is less than the severity threshold.***

275. Headley in view of Tran renders obvious this claim element. For example, a POSITA understood that the sound-activation-means [*sensing element*] disclosed by Headley would activate the pulse generator of the receiver and electrodes stimulation [*activate the non-cardiac stimulation element*] if the snoring sound [*actively-sensed respiratory information identifying OSA behavior*] was at or above a severity threshold.

In another preferred embodiment, the medical device further comprises alternatively sound-activation-means for allowing the power unit to turn on when the sound of snoring is received from

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

the patient thus allowing the device to be utilized only during times when the patient may actually experience the apneic episodes, and/or oxygen-sensing means and auto-start means for having the device turn on when the patient's oxygen concentration as measured by a transcutaneous receiver placed on the antenna over the patient's skin would detect an oxygen concentration of less than 96%.

EX-1008 (Headley) ¶ 14.

An eighth application would be sound activated stimulation. This would allow the power unit to turn on when the sound of snoring is received from the patient. This would allow the device to be *utilized only during times when the patient may actually experience the apneic episodes.*

A ninth application would be to have the device turned on when the patient's oxygen concentration as measured by a transcutaneous receiver placed on the antenna over the patient's skin would detect an oxygen concentration of less than 96%.

EX-1008 (Headley) ¶¶ 44-45.

276. This especially true given that Headley expressly discloses using a severity threshold (i.e., 96%) when discussing the oxygen sensing means. EX-1008 (Headley) ¶¶ 14, 45.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

277. A POSITA also understood the electrical stimulation applied by the pulse generator of the receiver and electrode [*non-cardiac stimulation element*] would be deactivated when the snoring or oxygen level [*actively-sensed respiratory information*] is less than the severity threshold, as Headley expressly discloses that these sensing means “allow[] the device to be utilized ***only during times when the patient may actually experience the apneic episodes***” and further discloses a threshold (i.e., 96%) above which the electrical stimulation need not be applied [*deactivation of non-cardiac stimulation element*]. EX-1008 (Headley) ¶¶ 14, 44. Further, it would make sense to deactivate the electrical stimulation when the snoring or oxygen level is below a severity threshold to reduce battery drain, which was a known consideration for implantable stimulators. EX-1011 (Christopherson) 25:30-42 (describing a suspension mode to conserve energy when respiration is not stable); EX-1024 (Christopherson ’543) 32:10-67 (describing power off and sleep modes to conserve energy); EX-1033 (Zaidi), p. 384 (discussing reduced power consumption as another benefit of eliminating sensing lead).
278. Headley discloses claim element [13.b]. Accordingly, claim 13 is obvious from Headley, either alone or in view of Tran.

12. Claim 15

- a. [15] *The device of claim 1, wherein the stimulation period and the non-stimulation period are in a proportion of at least 1.5 to 1.*

279. Headley in view of Tran renders obvious claim 1, as discussed above in X.B.1 (Ground 2, claim 1). Headley and Tran further disclose the limitations of claim 15 for the same reasons discussed in X.B.8 (Ground 2, claim 9) as the limitations of claims 9 and 15 are identical.

280. Accordingly, Headley and Tran render obvious claim 15.

XI. SECONDARY CONSIDERATIONS DO NOT REBUT THE PRIMA FACIE CASE OF OBVIOUSNESS

281. In my opinion, secondary considerations do not rebut the prima facie case of obviousness for at least two reasons.

282. *First*, I have not seen any evidence of any secondary considerations to date. As such, I do not believe any such secondary considerations exist. To the extent Patent Owner seeks to proffer evidence of any secondary considerations in this proceeding, I reserve the right to comment on such evidence.

283. *Second*, I do not believe that Patent Owner will be able to establish a nexus between any secondary considerations and the Challenged Claims. I have

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

been advised that a nexus does not exist where the alleged secondary considerations result from something other than what is both claimed and novel in the claims.

284. As I have explained above, there is nothing novel in the claims. Indeed, all claim elements are disclosed in the prior art. Thus, I do not see any basis for Patent Owner to assert that there is a nexus between any secondary considerations and the claims.

XII. CONCLUSION

285. My findings and opinions set forth in this Declaration are based on my work and examination to date. I may continue my examinations in view of additional documents or other factual evidence over the course of this proceeding that may necessitate supplementing and/or refining my opinions. I reserve the right to add to, alter, or delete any of my opinions and my Declaration upon discovery of additional information. I reserve the right to make any changes as necessary.

286. In signing this Declaration, I understand that this Declaration will be filed as evidence in a contested case 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 this case and that cross-examination will take

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

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 allowed for cross-examination. I declare that all statements made herein of my knowledge, all statements made on information and belief are believed to be true, and 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.

Dated: Dec. 17, 2025

A handwritten signature in blue ink, appearing to read "Gerald Loeb", is written over a horizontal line.

Dr. Gerald Loeb

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

APPENDIX A

CURRICULUM VITAE
Gerald E. Loeb, M.D.

Professional Address:

Alfred E. Mann Dept. of Biomedical Engineering
DRB-B11, Mail Code 1111
University of Southern California
1042 Downey Way
Los Angeles, CA 90089
Mobile telephone: 213-944-2283
Office tel: 213-821-5311
Office fax: 213-821-3897
email: gloeb@usc.edu
webpages: <http://bme.usc.edu/gloeb>, <http://mddf.usc.edu>
https://en.wikipedia.org/wiki/Gerald_E._Loeb

Education:

1965-1969 - B.A. The Johns Hopkins U. (Human Biology Major)
1968-1972 - M.D. The Johns Hopkins U. School of Medicine

Professional History:

2023- present Director of the Biomedical Engineering Innovation Space, University of Southern California
2008-present Professor of Pharmacy, University of Southern California (secondary appointment)
2007-present President, Biomed Concepts Inc. (consulting and prototyping in biomedical engineering)
2006-present Professor of Neurology, University of Southern California (secondary appointment)
1999-present Professor of Biomedical Engineering (primary appointment) and Director of the Medical Device Development Facility, University of Southern California
2021-2022 Founder and Chief Scientist (consulting), Chironics Ltd., UK (healthcare decision software)
2013-2015 Distinguished Scientist of the Strategic Advisory Committee, Chongqing Institute for Green and Intelligent Technology, Chinese Academy of Science (robotics)
2012-2020 Chief Scientist (consulting), General Stim Inc. (injectable neuromuscular stimulators)
2008-2024 Founding CEO and Director, SynTouch Inc. (biomimetic tactile sensors and haptics)
2003-2009 Deputy Director, NSF Engineering Research Center on Biomimetic MicroElectronic Systems

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

1999-2008 Director of Medical Device Development, Alfred E. Mann Institute for Biomedical Engineering at the University of Southern California

1994-1999 Chief Scientist (consulting), Advanced Bionics Corp., Sylmar, California

1991-1999 Director of Bio-Medical Engineering Unit and Professor of Physiology, Queen's University

1990-1999 Member, Medical Research Council Group in Sensory-Motor Neuroscience, Queen's University

1988-1991 Director of Special Projects, Biomedical Engineering Unit, and Professor of Physiology, Queen's University, Kingston, Ontario

1987-1988 Special Expert, Lab. of Neural Control, IRP, NINCDS, NIH

1986-1987 Chief, Neurokinesiology Section, Lab. of Neural Control, IRP, NINCDS, NIH (Sr. Surgeon, U.S. Public Health Service)

1985-1987 Adjunct Associate Professor of Bioengineering, U. Utah

1981-1990 President, Biomed Concepts, Inc. (consulting and prototyping in biomedical engineering)

1980-1981 Partner in Bak Electronics, Inc.(electrophysiological research instrumentation)

1979-1986 Permanent Sr. Investigator, Lab. of Neural Control, IRP, NINCDS, NIH

1979-1981 Guest Researcher, Depts. Otolaryngology and Physiology, UCSF School of Medicine

1974-1979 Medical Officer, Lab. of Neural Control, IRP, NINCDS, NIH

1973-1974 Research Associate, Lab. of Neural Control, IRP, NINCDS, NIH

1972-1973 Internship, Department of Surgery, Univ. of Arizona

1971-1972 Independent R&D of real-time scientific programming language for minicomputers

1971 Guest Research Associate, Univ. of Utah Artificial Eye Project

1967-1972 Research Assistant to Dr. William B. Marks, Dept of Biophysics, Johns Hopkins Univ.

1966-1967 Training in thin film microelectronics, Johns Hopkins Univ. Applied Physics Lab.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Awards and Honors:

Manville High School Hall of Fame, 2025
Top 200 Best Scientists in Engineering and Technology, 2022, Research.com
Tribute Award, 2022, Division of Biokinesiology & Physical Therapy, Univ. Southern California
Fellow of the National Academy of Inventors (NAI)
Technology Pioneer 2014 – World Economic Forum
Breakthrough Innovator Award 2013 – Popular Mechanics
Medical Device & Diagnostic Industry Magazine's 100 Notable People in the Medical Device Industry
Fellow of the American Institute for Medical and Biological Engineering (AIMBE)
Queen's National Scholar - Queen's University
International Exchange Fellowship to Bulgaria - National Academy of Sciences
Commendation Medal - U.S. Public Health Service
Seeing Eye, Inc. Fellowship, 1969-72

Research Interests:

Neuroprosthetics and neural control techniques
Sensorimotor control in mammals
Implantable medical devices
Haptics for robots

Research & Scholarly Activities:

Publications: 439 (excluding abstracts)

Google H-index: 111

Electronic reprints available through <http://bme.usc.edu/gloeb> and
<https://www.ncbi.nlm.nih.gov/myncbi/gerald.loeb.1/bibliography/public/>

Books: 1

Loeb, G.E. and Gans, C. *Electromyography for Experimentalists*. Univ. Chicago Press, 1986. (373 pp., 140 figs.)

Full-Length Original Research Reports in Refereed Journals: 188

Biomedical Engineering, Modeling and Methodology: 124

Bar-Cohen, Y., Silka, M.J., Hill, A.C., Shwayder, M., Pruetz, J.D., Severy-Rindenow, L., Peck, R., Kohan, S. and Loeb, G.E. A leadless pericardial pacemaker, *Heart Rhythm*, (in press), 2025.
Clark, G.T., Vistoso-Monreal, A.P., Veas, N.E. and Loeb, G.E. Artificial intelligence algorithm for real-time diagnostic assist in orofacial pain, *J. Amer. Dental Assoc.*, (in press), <https://doi.org/10.1016/j.adaj.2025.05.002>, 2025.
Oh, J., Loeb, G.E., Smith, B.A. The utility of calibrating wearable sensors before quantifying infant leg movements, *Sensors* 24(17):5736, doi: 10.3390/s24175736, 2024.
Loeb, G.E. Developing intelligent robots that grasp affordance, *Frontiers in Robotics and AI*, 9:951293, doi: 10.3389/frobt.2022.951293, 2022.

Declaration of Dr. Gerald Loeb in Support of Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Enander, J., Jones, A.M., Kirkland, M., Hurless, J., Jorntell, H. and Loeb, G.E. A model for self-organization of sensorimotor function: the spinal monosynaptic loop, *J. Neurophysiol.* 127(6):1460-1477, <https://doi.org/10.1152/jn.00242.2021>, 2022.
- Enander, J., Loeb, G.E. and Jorntell, H. A model for self-organization of sensorimotor function: spinal interneuronal integration, *J. Neurophysiol.* 127(6):1478-1495, <https://doi.org/10.1152/jn.00054.2022>, 2022.
- Loeb, G.E. and Richmond, F.J. Turning Neural Prosthetics into Viable Products, *Frontiers Robotics & AI* 8:754114, doi: 10.3389/frobt.2021.754114, 2021.
- Rongala, U.B., Enander, J.M.D., Kohler, M., Loeb, G.E. and Jorntell, H. A non-spiking neuron model with dynamic leak to avoid instability in recurrent networks. *Frontiers Comp. Neurosci.* 15:1-15, doi:10.3389/fncom.2021.656401, 2021.
- Loeb, G.E. A new approach to medical diagnostic decision support. *J. Biomedical Informatics* 116:, <https://doi.org/10.1016/j.jbi.2021.103723>, 2021.
- Mick, S., Segas, E., Dure, L., Halgand, C., Benois-Pineau, J., Loeb, G.E., Daniel, C., de Rugy, A. Shoulder kinematics plus contextual target information enable control of multiple distal joints of a simulated prosthetic arm and hand, *J. NeuroEngineering & Rehab.* 18:1-17, 2021.
- Hagen, D.A., Marjaninejad, A., Loeb, G.E. and Valero-Cuevas, F.J. InsideOut: A bio-inspired machine learning approach to estimating posture in robots driven by compliant tendons, *Front. Neurorobotics* 15(150), 2021, <https://www.frontiersin.org/articles/10.3389/fnbot.2021.679122>
- Nagamori, A., Laine, C.M., Loeb, G.E. and Valero-Cuevas, F.J. Force variability is mostly not motor noise: theoretical implications for motor control, *PLoS Comput Biol* 17(3): e1008707, 2021. <https://doi.org/10.1371/journal.pcbi.1008707>
- Eriksson, D., Loeb, G.E., Persson, C., Korin, C. Evaluating the use of a tactile sensor for measuring cartan compliance, *Nordic Pulp & Paper Research Journal* 35:362-369, doi: 10.1515/npprj-2019-0086, 2020.
- Loeb, G.E. Neural prosthetics: A review of empirical vs. systems engineering strategies, *Applied Bionics & Biomechanics*, vol. 2018, Article ID 1435030, 17 pages, 2018. <https://doi.org/10.1155/2018/1435030>.
- Bar-Cohen, Y., Silka, M.J., Hill, A.C., Pruetz, J.D., Chmait, R.H., Zhou, L., Rabin, S.M., Norekyan, V. and Loeb, G.E. Minimally invasive implantation of a micropacemaker into the pericardial space, *Circulation: Arrhythmia and Electrophysiology* 11:e006307. DOI: 10.1161/CIRCEP.118.006307, 2018.
- Trujillo-Priego, I.A., Lane, C.J., Vanderbilt, D.L., Deng, W., Loeb, G.E., Shida, J. and Smith, B.A. Development of a wearable sensor algorithm to detect the quantity and kinematic characteristics of infant arm movement bouts produced across a full day in the natural environment, *Technologies* 5(3):39-55, doi:10.3390/technologies5030039, 2017.
- Huang, X., Denprasert, P.M., Zhou, L., Vest, A.N., Kohan, S. and Loeb, G.E. Accelerated life-test methods and results for implantable electronic devices with adhesive encapsulation, *Biomed. Microdevices* 19:46, DOI 10.1007/s10544-017-0189-9, 2017. <http://rdcu.be/sYYR>
- Huang, X., Zheng, K., Kohan, S., Denprasert, P.M., Liao, L., Loeb, G.E. Neurostimulation strategy for stress urinary incontinence, *IEEE Trans. Neural Stim. Rehab. Engng.* DOI: 10.1109/TNSRE.2017.2679077, 2017.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Jalaleddini, K., Niu, C., Chakravarthi Raja, S., Sohn, W.J., Loeb, G.E., Sanger, T., Valero-Cuevas, F. Neuromorphic Meets Neuromechanics, Part II: The Role of Fusimotor Drive, *J. Neural Engineering* (on-line), 2017.
- Zhou, L., Bar-Cohen, Y., Peck, R.A., Chirikian, G.V., Harwin, B., Chmait, R.H., Pruetz, J.D., Silka, M.J. and Loeb, G.E. Analytical modeling for computing lead stress in a novel epicardial micropacemaker, *Cardiovascular Engineering & Technology*, DOI: 10.1007/s13239-017-0292-3, 2017.
- Vest, A.N., Zhou, L., Huang, X., Norekryan, V., Bar-Cohen, Y., Chmait, R.H. and Loeb, G.E. Design and testing of a transcutaneous RF recharging system for a fetal micropacemaker, *IEEE Trans. Biomed. Circuits and Systems*, DOI:10.1088/0967-3334/37/7/1172, 2016.
- Vest, A.N., Zhou, L., Bar-Cohen, Y. and Loeb, G.E. A novel method to estimate safety factor of capture by a fetal micropacemaker, *Physiological Measurement* 37(7):1172, 2016.
- Zhou, L., Vest, A.N., Peck, R.A., Sredal, J., Huang, X., Bar-Cohen, Y., Silka, M.J., Pruetz, J.D., Chmait, R. and Loeb, G.E. Minimally invasive implantable fetal micropacemaker: mechanical testing and technical refinements, *Med. & Biol. Engng. & Comput.* DOI: 10.1007/s11517-016-1470-4, 2016.
- Bar-Cohen, Y., Loeb, G.E., Pruetz, J., Silka, M.J., Guerra, C., Vest, A.N., Zhou, L. and Chmait, R.H. Preclinical Testing and Optimization of a Novel Fetal Micropacemaker, *Heart Rhythm* 12:1683-1690, 2015, doi: 10.1016/j.hrthm.2015.03.022
- Tsianos, G.A., Goodner, J. and Loeb, G.E. Useful Properties of Spinal Circuits for Learning and Performing Planar Reaches, *J. Neural Engineering* 11 056006 [doi:10.1088/1741-2560/11/5/056006](https://doi.org/10.1088/1741-2560/11/5/056006), 2014.
- Sinha, U.K., Villegas, B., Kuo, C., Richmond, F.J., Masood, R., Nelson, N.I. and Loeb, G.E. Safety of microstimulator during radiation therapy – a preliminary study on head and neck cancer patients. *Journal of Nuclear Medicine & Radiation Therapy*, 5:197, 2014, doi: 10.4172/2155-9619.1000197.
- Kaliki, R.R., Davoodi R. and Loeb, G.E. Evaluation of a noninvasive command scheme for upper-limb prostheses in a virtual reality reach and grasp task. *IEEE Trans. BME* 60:792-802, 2013.
- Loeb, G.E., Zhou, L., Zheng, K., Nicholson, A., Peck, R.A., Krishnan, A., Silka, M., Pruetz, J., Chmait, R. and Bar-Cohen, Y. Design and testing of a percutaneously implantable fetal pacemaker. *Annals Biomed. Engng.*, 41:17-27, DOI: 10.1007/s10439-012-0631-3, 2013.
- Roy, D., Wettels, N. and Loeb, G.E. Elastomeric skin selection for a fluid-filled artificial fingertip. *J. Applied Polymer Sci.*, 127.6:4624-4633, 2013.
- Li, Yao, Smith, L.H., Hargrove, L.J., Weber, D.J. and Loeb, G.E. Sparse optimal motor estimation (SOME) for extracting commands for prosthetic limbs. *IEEE Trans. Neural Systems and Rehabilitation Engineering*, 10.1109/TNSRE.2012.2218286, 2012.
- Loeb, G.E. Optimal Isn't Good Enough. *Biological Cybernetics*, 11:757-765, DOI 10.1007/s00422-012-0514-6, 2012.
- Hauschild, M., Mulliken, G.H., Fineman, I., Loeb, G.E. and Andersen, R.A. Cognitive signals for brain-machine-interfaces in posterior parietal cortex. *Proc. National Acad. Sci.* 109.42:17075-17090, 2012.
- De Rugy, A., Loeb, G.E., Carroll, T.J. Virtual biomechanics: a new method for online reconstruction of force from EMG recordings. *J. Neurophysiol.*, 108:3333-3341, 2012.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Tsianos, G.A., Rustin, C. and Loeb G.E. Mammalian muscle model for predicting force and energetics during physiological behaviors. *IEEE Trans. Neural Systems & Rehab. Engng.* 20:117-133, 2012.
- Davoodi, R. and Loeb G.E., Real-time animation software for customized training to use motor prosthetic systems, *IEEE Trans. Neural Systems and Rehabilitation Engineering*, 20:134-143, 2012.
- Davoodi, R. and Loeb, G.E., Development of a physics-based target shooting game to train amputee users of multijoint upper limb prostheses, *Presence: Teleoperators and Virtual Environments*, 21:85-95, 2012.
- Avraham, G., Nisky, I., Fernandes, H., Acuna, D., Kording, K., Loeb, G.E. and Karniel, A. "Towards perceiving robots as humans: Three handshake models face the Turing-like handshake test, *IEEE Trans. Haptics*, 5:196-207, 2012.
- Li, Y, Levine, W.S. and Loeb, G.E. A two-joint human posture control model with realistic neural delays, *IEEE Trans. Neural Systems and Rehabilitation Engineering*, 20:738-748, doi: 10.1109/TNSRE.2012.2199333
- Fishel, J.A. and Loeb, G.E. Bayesian exploration for intelligent identification of textures. *Frontiers in Neurorobotics*, 6:4, 2012 (doi: 10.3389/fnbot.2012.00004).
<http://journal.frontiersin.org/article/10.3389/fnbot.2012.00004/full#>
- Su, Zhe, Fishel, J.A., Yamamoto, T. and Loeb, G.E. Use of tactile feedback to control exploratory movements to characterize object compliance. *Frontiers in Neurorobotics*, 6:7, 2012 (doi: 10.3389/fnbot.2012.00007).
- Yamamoto, T., Wettels, N., Fishel, J.A., Lin, C.H., Loeb, G.E., "BioTac – 生体模倣型触覚センサ–", *日本ロボット学会誌 (Journal of the Robotics Society of Japan)*, 30(5):496-498, 2012.
- Kaplan, H.M. and Loeb, G.E. Preventing ischial pressure ulcers: I. Review of neuromuscular electrical stimulation. *Applied Bionics & Biomechanics* 8:323-331, 2011.
- Kaplan, H.M., Baker, L.L., Davoodi, R., Wong, N.T. and Loeb, G.E. Preventing ischial pressure ulcers: II. Biomechanics. *Applied Bionics & Biomechanics* 8:333-343, 2011.
- Kaplan, H.M., Baker, L.L., Rubayi, S. and Loeb, G.E. Preventing ischial pressure ulcers: III. Clinical pilot study of chronic neuromuscular electrical stimulation. *Applied Bionics & Biomechanics* 8:345-359, 2011.
- Loeb, G.E., Tsianos, G.A., Fishel, J.A., Wettels, N. and Schaal, S. Understanding haptics by evolving mechatronic systems, *Prog. Brain Res.* 192:129-144, 2011,
<http://www.ncbi.nlm.nih.gov/pubmed/21763523>
- Tsianos, G.A., Raphael, G. and Loeb, G.E. Modeling the potentiality of spinal-like circuitry for stabilization of a planar arm system. *Prog. Brain Res.* 194:203-213, 2011,
<http://www.ncbi.nlm.nih.gov/pubmed/21867805>
- Davoodi, R. and Loeb, G.E. MSMS software for VR simulations of neural prostheses and patient training and rehabilitation. *Stud. Health Technol. Inform.* 163:156-162, 2011,
<http://www.ncbi.nlm.nih.gov/pubmed/21335781>
- Zehner, M.J., Armiger, R.S., Burck, J.M., Moran, C., Kiely, J.B., Weeks, S.R., Tsao, J.W., Pasquina, P.F., Davoodi, R. Loeb, G.E. Using a virtual integration environment in treating phantom limb pain. *Medicine Meets Virtual Reality*, 18:730-736, 2011.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Raphael, G., Tsianos, G.A. and Loeb, G.E. Spinal-like regulator facilitates control of a two degree-of-freedom wrist. *J. Neuroscience* 30:9431-9444, 2010, <http://www.ncbi.nlm.nih.gov/pubmed/20631172>.
- Kaplan, H.M. and Loeb, G.E. Design and fabrication of an injection tool for neuromuscular microstimulators. *Annals of Biomedical Engineering*, 37(9):1858-1870, 2009.
- Wettels, N., Parnandi, A.R., Moon, J.-H., Loeb, G.E. and Sukhatme, G.S. Grip control using biomimetic tactile sensing systems. *IEEE/ASME Trans. Mechatronics*, 14(6):718-723, 2009.
- Mileusnic, M.P., and Loeb, G.E. Force estimation from ensembles of Golgi tendon organs. *Journal of Neural Engineering*, 6:1-15, 2009, <http://www.ncbi.nlm.nih.gov/pubmed/19367000>
- Zou, Q., Tan, Wei, Kim, E.-S. and Loeb, G.E. Single-axis and Tri-axis Piezoelectric Bimorph Accelerometer. *IEEE/ASME Journal of Microelectromechanical Systems*, 17(1):45-57, 2008.
- Kaliki, R.K., Davoodi, R. and Loeb, G.E. Prediction of elbow trajectory from shoulder angles using neural networks. *International Journal of Computational Intelligence & Applications* 2008:333-349, 2008.
- Song, D., Lan, N., Loeb, G.E., and Gordon, J. Model-based sensorimotor integration for multi-joint control: Development of a virtual arm model. *Annals of Biomedical Engineering* 36(6):1033-1048, 2008.
- Liao, K-C, Hogen-Esch, T., Richmond, F.J., Marcu, L.R, Clifton, W. and Loeb, G.E. Percutaneous Fiber-optic Sensor for Chronic Glucose Monitoring *in vivo*. *Biosensors & Bioelectronics*, 23(10):1458-1465, 2008.
- Wettels, N., Popovic, D., Santos, V.J., Johansson, R.S. and Loeb, G.E. Biomimetic tactile sensor array. *Advanced Robotics*. 22(8):829-849, 2008.
- Song, D., Raphael, G., Lan, N. and Loeb, G.E. Computationally efficient models of neuromuscular recruitment and mechanics. *J. Neural Eng.* 5:175-184, 2008.
- Kaliki, R.R., Davoodi, R. and Loeb, G.E. Prediction of distal arm posture in 3-D Space from shoulder movements for control of upper limb prostheses. *Proceedings of the IEEE*, 96(7):1217-1225, 2008.
- Cheng, E.J. and Loeb, G.E. On the use of musculoskeletal models to interpret motor control strategies from performance data. *Journal of Neural Engineering*, 5:232-253, 2008, <http://www.ncbi.nlm.nih.gov/pubmed/18506076>
- Loeb, G.E, Peck, R.A., Singh, J., Kim, Y., Deshpande, S., Baker, L.L., and Bryant, J.T. Mechanical Loading of Rigid Intramuscular Implants. *Biomedical Microdevices*, 9(6):901-910, 2007.
- Rodriguez, N., Weissberg, J., Loeb, G.E. Flexible Communication and Control Protocol for Injectable Neuromuscular Interfaces. *IEEE Transactions on Biomedical Circuits and Systems*, 1(1):19-27, March, 2007.
- Hauschild, M., Davoodi, R. and Loeb, G.E. A virtual reality environment for designing and fitting neural prosthetic limbs, *IEEE Trans. Neural Systems & Rehabilitation Engineering*, 15:9-15, 2007.
- Sachs, N.A. and Loeb, G.E. Development of a BIONic muscle spindle for prosthetic proprioception. *IEEE Trans. Biomedical Engineering*, 54(6):1031-1041, June, 2007.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Davoodi, R., Urata, C., Hauschild, M., Khachani, M. and Loeb, G.E. Model-based development of neural prostheses for movement. *IEEE Trans. Biomedical Engineering*, 54(11):1909-1918, 2007.
- Tan, Wei and Loeb, G.E. Feasibility of prosthetic posture sensing via injectable electronic modules. *IEEE Trans. Neural Systems & Rehab. Engng.*, 15(2):295-309, 2007.
- Popovic, D. and Loeb, G.E. Recruitment and comfort of BION implanted electrical stimulation: implications for FES applications. *IEEE Transactions on Neural Systems & Rehabilitation Engineering*. 15(4):577-586, 2007.
- Loeb, G.E., Richmond, F.J.R., and Baker, L.L. The BION devices: injectable interfaces with peripheral nerves and muscles. *Neurosurgical Focus*. 20:1-9, May, 2006.
- Loeb, G.E., Sing, J., Allen, J.G., Raphael, G., Buckley, P., Blanco, C., Richmond, F.J.R., and Salter, G.D.V. A document navigation system for the paperwork jungle. *Medical Device and Diagnostic Industry*. 28:110-119, August, 2006.
- Hwang, S.J., Kaplan, H., Loeb, G.E., Kim, H.S., and Kim, Y.H. Pressure distributions on the buttocks and thighs by electrical stimulation in the sitting posture. *Key Engineering Materials*. Vols. 321-323:984-987, 2006.
- Mileusnic, M.P., Brown, I.E., Lan, N. and Loeb, G.E. Mathematical models of proprioceptors: I. Control and transduction in the muscle spindle. *J. Neurophysiol.* 96:1772-1788, 2006.
- Mileusnic, M.P. and Loeb, G.E. Mathematical models of proprioceptors: II. Structure and function of the Golgi tendon organ. *J. Neurophysiol.* 96:1789-1802, 2006.
- Loeb, G.E. Galvani's delayed legacy: neuromuscular electrical stimulation. *Expert Review of Medical Devices*. 2(4):379-381, July, 2005.
- Loeb, G.E. Are cochlear implant patients suffering from perceptual dissonance? *Ear & Hearing* 26:435-450, 2005.
- Dupont, A.C., Bagg, S.D., Creasy, J.L., Romano, C. Romano, D., Richmond, F.J.R. and Loeb, G.E. First clinical experience with BION® implants for therapeutic electrical stimulation. *Neuromodulation* 7:38-47, 2004.
- Weber D.J., Stein R.B., Chan K.M., Loeb G.E., Richmond F.J., Rolf R., James K., Chong S.L., Thompson A.K., and Misiaszek J. Functional electrical stimulation using microstimulators to correct foot drop: a case study. *Canadian Journal of Physiology & Pharmacology*. 82:784-92, 2004.
- Davoodi R, Brown, I.E. and Loeb, G.E. Advanced modeling environment for developing and testing FES control systems. *Med Engng & Physics* 25:3-9, 2003.
- Loeb, G.E. and Richmond, F.J.R. Making Design Controls Useful for Research and Development. *Medical Device and Diagnostic Industry* 25(4):63-68, April, 2003.
<http://www.devicelink.com/mddi/archive/03/04/004.html>
- Loeb, G.E., Brown, I.E., Lan, N. and Davoodi, R. The importance of biomechanics. *Adv. Exper. Med. Biol.* 508: 481-487, 2002.
- Davoodi, R. and Loeb, G.E. A Software Tool for Faster Development of Complex Models of Musculoskeletal Systems and Sensorimotor Controllers in Simulink. *J. Appl. Biomech.* 18:357-365, 2002.
- Dupont, A.-C., Sauerbrei, E. E., Fenton, P. V., Shragge, P. C., Loeb, G. E. and Richmond, F. J. R. Real-Time Sonography to Estimate Muscle Thickness: Comparison with MRI and CT. *Journal of Clinical Ultrasound*, 23(4):230-236, 2001.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Loeb, G. E., Peck, R. A., Moore, W. H. and Hood, K. BION™ system for distributed neural prosthetic interfaces. *Medical Engineering and Physics*, 23:9-18, 2001.
- Cheng, E., Brown, I.E. and Loeb, G.E. Virtual Muscle: A computational approach to understanding the effects of muscle properties on motor control. *J. Neurosci. Methods*, 101:117-130, 2000.
- Singh, K., Richmond, F.J.R. and Loeb, G.E. Recruitment properties of intramuscular and nerve-trunk stimulating electrodes. *IEEE-Trans. Rehab. Engng.*, 8(3):276-285, 2000.
- Loeb, G.E, Brown, I.E and Cheng, E. A hierarchical foundation for models of sensorimotor control. *Exp. Brain Res.* 126: 1-18, 1999.
- Cameron, T., Richmond, F.J.R. and Loeb, G.E. Effects of regional stimulation using a miniature stimulator implanted in feline posterior biceps femoris. *IEEE Trans. Biomed. Engng.*, 45:1036-1043, 1998.
- Cameron, T., Liinamaa, T.L., Loeb, G.E. and Richmond, F.J.R. Long-term biocompatibility of a miniature stimulator implanted in feline hind limb muscles. *IEEE Trans. Biomed. Engng.*, 45:1024-1035, 1998.
- Wilson, B.S., Rebscher, S., Zeng, F.-G., Shannon, R.V., Loeb, G.E. and Lawson, D.T. Design for an inexpensive but effective cochlear implant. *Otolaryngol.-Head & Neck Surg.* 118:235-241, 1998.
- Cameron, T., Loeb, G.E., Peck, R.A., Schulman, J.H., Strojnik, P. and Troyk, P.R. Micromodular implants to provide electrical stimulation of paralyzed muscles and limbs. *IEEE Trans. Biomed. Engng.*, 44:781-790, 1997.
- Loeb, G.E. and Peck, R.A. Cuff electrodes for chronic stimulation and recording of peripheral nerve activity. *J. Neurosci. Meth.* 64:95-103, 1996.
- Ruddy, H.A. and Loeb, G.E. The influence of materials and geometry on fields produced by cochlear electrode arrays. *Med. & Biol. Engng. & Comput.* 33:793-801, 1995.
- Kessler, D.K., Loeb, G.E., Barker, M.S. Distribution of speech recognition results with the Clarion cochlear prosthesis. *Otol., Rhinol. & Laryngol. Suppl.* 166:283-285, 1995.
- Loeb, G.E. and Kessler, D.K. Speech recognition performance over time with the Clarion cochlear prosthesis. *Otol., Rhinol. & Laryngol. Suppl.* 166:290-292, 1995.
- Loeb, G.E., Peck, R.A. and Martyniuk, J. Toward the ultimate metal microelectrode. *J. Neurosci. Meth.* 63:175-183, 1995.
- Loeb, G.E., Peck, R.A. and Smith, D.W. Microminiature molding techniques for cochlear electrode arrays. *J. Neurosci. Meth.* 63:85-92, 1995
- Scott, S.H. and Loeb, G.E. The computation of position sense from spindles in mono-and multiarticular muscles. *J. Neurosci.* 14:7529-7540, 1994.
- Martyniuk, J., Corbett, S., and Loeb, G.E. Innovative Laser Systems for Ultraviolet Laser-Based Micromachining. *Med. Dev. & Diag. Industry*, October, 1994, pp. 110-121.
- Scott, S.H., Engstrom C.M. and Loeb, G.E. Morphometry of human thigh muscles. Determination of fascicle architecture from magnetic resonance imaging. *J. Anat.* 182:249-257, 1993.
- Levine, W.S. and Loeb, G.E. Neural control of limb movement. *IEEE Control Systems Magazine*, 12:38-46, 1992.
- He, Jiping, Levine, W.S. and Loeb, G.E. Feedback gains for correcting small perturbations to standing posture. *IEEE Trans on Automatic Control*, 36:322-332, 1991.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Loeb, G.E., Zamin, C.J., Schulman, J.H. and Troyk, P.R. Injectable microstimulator for functional electrical stimulation. *Med. & Biol. Engng. and Comput.* 29:NS13-NS19, 1991.
- Engstrom, C.M., Loeb, G.E., Reid, J.G., Forrest, W.J. and Avruch, L. Morphometry of the human thigh muscles. A comparison between anatomic sections and computer tomographic and magnetic resonance images. *J. Anat.* 176:139-156, 1991.
- DeFoa, J.L. and Loeb, G.E. Issues in cochlear prosthetics: An International survey of opinions. *Inter. J. Tech. Assessment in Health Care*, 7:403-410, 1991.
- Bak, M., Girvin, J.P., Hambrecht, F.T., Kufta, C.V., Loeb, G.E. and Schmidt, E.M. Visual sensations produced by intracortical microstimulation of the human occipital cortex. *Med. & Biol. Engng and Comput.* 28:257-259, 1990.
- Loeb, G.E., Levine, W.S. and He, J. Understanding sensorimotor feedback through optimal control. *Cold Spring Harbor Symp. Quant. Biol.* 55: 791-803, 1990.
- Loeb, G.E., He, Jiping and Levine, W.S. Spinal cord circuits: Are they mirrors of musculoskeletal mechanics? *J. Motor Behavior*, 21:473- 491, 1989.
- He, Jiping, Levine, W.S. and Loeb, G.E. Modeling and analysis of the neuromusculoskeletal control system of a cat hindlimb. Proceedings of the 3rd International Conference on Intelligent Control, pp. 407-513, Arlington, Va., August 1988.
- Loeb, G.E., Yee, W.J., Pratt, C.A., Chanaud, C.M. and Richmond, F.J.R. Cross-correlation of EMG reveals widespread synchronization of motor units during some slow movements in intact cats. *J. Neurosci. Meth.* 21:239-249, 1987.
- Chanaud, C.M., Pratt, C.A. and Loeb, G.E. A multiple-contact EMG recording array for mapping single muscle unit territories. *J. Neurosci. Meth.* 21:105-112, 1987.
- Hoffer, J.A. and Loeb, G.E. A technique for reversible fusimotor blockade during chronic recording from spindle afferents in walking cats. *Exp. Brain Res. Suppl.* 7:272-279, 1983.
- Loeb, G.E., White, M.W. and Merzenich, M.M. Spatial cross-correlation: A proposed mechanism for acoustic pitch perception. *Biol. Cybernetics* 47:149-163, 1983.
- Loeb, G.E., White, M.W. and Jenkins, W.M. Biophysical considerations in electrical stimulation of the auditory nervous system. *Ann. N.Y. Acad. Sci.* 405:123-136, 1983.
- Loeb, G.E., Byers, C.L., Rebscher, S.J., Casey, D.E., Fong, M.M., Schindler, R.A., Gray, R.F. and Merzenich, M.M. Design and fabrication of an experimental cochlear prosthesis. *Med. & Biol. Engng. & Comput.* 21:241-254, 1983.
- O'Donovan, M.J., Hoffer, J.A. and Loeb, G.E. Physiological characterization of motor unit properties in intact cats. *J. Neurosci. Meth.* 7:137-149, 1983.
- Hoffer, J.A., Loeb, G.E. and Pratt, C.A. Single unit conduction velocities from averaged nerve cuff electrode records in freely moving cats. *J. Neurosci. Meth.* 4:211-225, 1981.
- Chapin, J.K., Loeb, G.E. and Woodward, D.J. A simple technique for determination of footfall patterns of animals during treadmill locomotion. *J. Neurosci. Meth.* 2:97-102, 1980.
- Hoffer, J.A. and Loeb, G.E. Implantable electrical and mechanical interfaces with nerve and muscle. *Ann. Biomed. Eng.* 8:351-360, 1980.
- Bak, M.J. and Loeb, G.E. A pulsed integrator for EMG analysis. *Electroenceph. & Clin. Neurophysiol.* 47:738-741, 1979.
- Loeb, G.E., Bak, M.J. and Duysens, J. Long-term unit recording from somatosensory neurons in the spinal ganglia of the freely walking cat. *Science* 197:1192-1194, 1977.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Loeb, G.E., Bak, M.J., Salcman, M. and Schmidt, E.M. Parylene as a chronically stable, reproducible microelectrode insulator. *IEEE-BME* 24:121-128, 1977.
- Loeb, G.E., Marks, W.B. and Beatty, P.G. Analysis and microelectronic design of tubular electrode arrays for chronic, multiple single unit recording from captured nerve fibers. *Med. & Biol. Eng. & Comput.* 15:195-201, 1977.
- Loeb, G.E., Walker, A.E., Uematsu, S. and Konigsmark, B.W. Histological reaction to various conductive and dielectric films chronically implanted in the subdural space. *J. Biomed. Mater. Res.* 11:195-210, 1977.
- Marks, W.B. and Loeb, G.E. Action currents, internodal potentials, and extracellular records of myelinated mammalian nerve fibers derived from node potentials. *Biophys. J.* 16:655-668, 1976.
- Thomas, C.A., Jr., Springer, P.A., Loeb, G.E., Berwald-Netter, Y. and Okun, L.M. A miniature microelectrode array to monitor the bioelectric activity of cultured cells. *Exp. Cell Res.* 74:61-66, 1972.

Experimental Physiological Research: 65

- Contemori, S., Loeb, G.E., Corneil, B.D., Wallis, G. and Carroll, T.J. Express visuomotor responses reflect knowledge of both target locations and contextual rules during reaches of different amplitudes, *J Neurosci.* (early release <https://www.jneurosci.org/content/43/42/7041>), 2023.
- Divakar, R., Loeb, G.E., Corneil, B.D., Wallis, G. and Carroll, T.J. A complex reach direction rule that delays reaction time causes alternating excitation and inhibition in express muscle responses and corticospinal excitability, preprint DOI: 10.1101/2022.12.13.520353, 2022.
- Contemori, S., Loeb, G.E., Corneil, B.D., Wallis, G. and Carroll, T.J. Symbolic cues enhance express visuomotor responses in human arm muscles at the motor planning rather than the visuospatial processing stage, *J. Neurophysiol.* 128(3):494-510, doi.org/10.1152/jn.00136.2022, 2022.
- Contemori, S., Loeb, G.E., Corneil, B.D., Wallis, G. and Carroll, T.J. Trial-by-trial modulation of express visuomotor responses induced by symbolic or barely detectable cues. *J Neurophysiol* 126:1507–1523, 2021.
- Contemori, S., Loeb, G.E., Corneil, B.D., Wallis, G. and Carroll, T.J. The influence of temporal predictability on express visuomotor responses, *J. Neurophysiol.* 125(3):731-747, 2021.
- Loeb, G.E. Learning to use muscles, *J. Human Kinetics*, 76:9-33, DOI: 10.2478/hukin-2020-0084, 2021, <http://www.johk.pl/files/10078-76-2021-v76-2021-02.pdf>
- Shida-Tokeshi J, Lane CJ, Trujillo-Priego IA, Deng, W, Vanderbilt, DL, Loeb, GE, Smith, BA. Relationships between full-day arm movement characteristics and developmental status in infants with typical development as they learn to reach: An observational study, *Gates Open Res* 2:17, doi: 10.12688/gatesopenres.12813.2, 2018.
- Loeb, G.E. and Fishel, J.A. Bayesian Action&Perception: Representing the World in the Brain, *Frontiers in Neuroscience* 8:341, doi: 10.3389/fnins.2014.00341, 2014, <http://journal.frontiersin.org/Journal/10.3389/fnins.2014.00341/abstract>.
- De Rugy, A., Loeb, G.E., Carroll, T.J. Are muscle synergies useful for neural control? *Frontiers in Computational Neuroscience*, 7: 10.3389/fncom.2013.00019, 2013.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- De Rugy, A., Loeb, G.E., Carroll, T.J. Muscle coordination is habitual rather than optimal. *J. Neuroscience* 32:7384-7391, 2012.
- Dupont Salter, A.-C., Richmond, F.J.R. and Loeb, G.E. Prevention of muscle disuse atrophy by low-frequency electrical stimulation in rats. *IEEE Trans. Neural Sys. Rehab. Engng* 11: 218-226, 2003.
- Dupont Salter, A.-C., Richmond, F.J.R. and Loeb, G.E. Effects of muscle immobilization at different lengths on tetrodotoxin-induced disuse atrophy. *IEEE Trans. Neural Sys. Rehab. Engng* 11, 209-217, 2003.
- Loeb, G.E. Learning From the Spinal Cord. *J. Physiol. (London)* 533:111-117, 2001.
- Cornell, B.D., Olivier, E., Richmond, F.J.R., Loeb, G.E. and Munoz, D.P. Neck muscles in the rhesus monkey. II. Electromyographic patterns of activation underlying postures and movements. *J. Neurophysiol.* 86:1729-1749, 2001.
- Prochazka, A., Wolpaw, J.R., Clarac, F., Loeb, G.E. and Rothwell, J.C. What do reflex and voluntary mean? Modern views on an ancient debate. *Exp. Brain Res.* 130:417-432, 2000.
- Brown, I.E. and Loeb, G.E. Measured and modeled properties of mammalian skeletal muscle: III. The effects of stimulus frequency on stretch-induced force enhancement and shortening-induced force depression. *J. Muscle Res. Cell Motility*, 21:21-31, 2000.
- Brown, I.E. and Loeb, G.E. Measured and modeled properties of mammalian skeletal muscle: IV. The dynamics of activation and deactivation. *J. Muscle Res. Cell Motility*, 21:33-47, 2000.
- Loeb, G.E. Asymmetry of hindlimb muscle activity and cutaneous reflexes after tendon transfers in kittens. *J. Neurophysiol.* 82:3392-3405, 1999.
- Brown, I.E., Cheng, E.J. and Loeb, G.E. Measured and modeled properties of mammalian skeletal muscle: II. The effects of stimulus frequency on force-length and force-velocity relationships. *J. Muscle Res. Cell Motility* 20:627-643, 1999.
- Brown, I.E. and Loeb, G.E. Measured and modeled properties of mammalian skeletal muscle: I. The effects of post-activation potentiation on the time-course and velocity dependencies of force production. *J. Muscle Res. Cell Motility*, 20:443-456, 1999.
- Brown, I.E., Satoda, T., Richmond, F.J.R. and Loeb, G.E. Feline caudofemoralis muscle: Muscle fiber properties, architecture and motor innervation. *Exp. Brain Res.* 121:76-91, 1998.
- Brown, I.E., Kim, D.H. and Loeb, G.E. The effect of sarcomere length on triad location in intact feline caudofemoralis muscle fibers. *J. Muscle Res. Cell Motility*, 19:473-477, 1998.
- Brown, I.E. and Loeb, G.E. Post-activation potentiation - a clue for simplifying models of muscle dynamics. *Amer. Zool.* 38:743-754, 1998.
- Thomson, D.B., Loeb, G.E. and Richmond, F.J.R. Effect of neck posture on patterns of feline neck muscles: Compensatory head movements during horizontal whole-body rotation. *Exp. Brain Res.* 110:392-400, 1996.
- Scott, S.H., Brown, I.E. and Loeb, G.E. Mechanics of feline soleus: I. Effect of fascicle length and velocity on force output. *J. Muscle Research and Cell Motility* 17:205-218, 1996.
- Brown, I.E., Scott, S.H. and Loeb, G.E. Mechanics of feline soleus: II. Design and validation of a mathematical model. *J. Muscle Research and Cell Motility* 17:221-233, 1996.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Brown, I.E., Liinamaa, T.L. and Loeb, G.E. Relationships between range of motion, L_0 and passive force in five strap-like muscles of the feline hindlimb. *J. Morph.* 230:69-77, 1996.
- Scott, S.H. and Loeb, G.E. The mechanical properties of the aponeurosis and tendon of the cat soleus muscle during whole-muscle isometric contractions. *J. Morph.* 224:73-86, 1995.
- Thomson, D.B., Loeb, G.E. and Richmond, F.J.R. Effect of neck posture on the activation of feline neck muscles during voluntary head turns. *J. Neurophysiol.* 72:2004-2014, 1994.
- Young, R.P., Scott, S.H. and Loeb, G.E. The distal hindlimb musculature of the cat: Multiaxis moment arms at the ankle joint. *Exp. Brain Res.* 96:141-151, 1993.
- Loeb, G.E. The distal hindlimb musculature of the cat: Interanimal variability of locomotor activity and cutaneous reflexes. *Exp. Brain Res.* 96:125-140, 1993.
- Blaszczyk, J. and Loeb, G.E. Why cats pace on the treadmill. *Physiol. & Behav.* 53:501-507, 1993.
- Abrahams, V.C., Kori, A., Loeb, G.E., Richmond, F.J.R., Rose, P.K. and Kierstead, S.A. Facial input to neck motoneurons: Trigemino-cervical reflexes in the conscious and anaesthetised cat. *Exp. Brain Res.* 97:23-30, 1993.
- Young, R.P., Scott, S.H. and Loeb, G.E. An intrinsic mechanism to stabilize posture - joint-angle-dependent moment arms of the feline ankle muscles. *Neurosci. Lett.* 145:137-140, 1992.
- Scott, S.H., Thomson, D.B., Richmond, F.J.R. and Loeb, G.E. Neuromuscular organization of feline anterior sartorius: II. Intramuscular length changes and complex length-tension relationships during stimulation of individual nerve branches. *J. Morph.* 213:171-183, 1992.
- Richmond, F.J.R., Thomson, D.B. and Loeb, G.E. Electromyographic studies of neck muscles in the intact cat: I. Patterns of recruitment underlying posture and movement during natural behaviors. *Exp. Brain Res.* 88:41-58, 1992.
- Richmond F.J.R. and Loeb, G.E. Electromyographic studies of neck muscles in the intact cat: II. Reflexes evoked by muscle-nerve stimulation. *Exp. Brain Res.* 88:59-66, 1992.
- Heckman, C.J., Weytjens, J.L.F. and Loeb, G.E. Effect of velocity and mechanical history on the forces of motor units in the cat medial gastrocnemius muscle. *J. Neurophysiol.* 68:1503-1515, 1992.
- Pratt, C.A., Chanaud, C.M. and Loeb, G.E. Functionally complex muscles of the cat hindlimb. IV. Intramuscular distribution of movement command signals and cutaneous reflexes in broad bifunctional thigh muscles. *Experimental Brain Research*, 85:281-299, 1991.
- Pratt, C.A., and Loeb, G.E. Functionally complex muscles of the cat hindlimb. I. Patterns of activation across sartorius. *Experimental Brain Research*, 85:243-256, 1991.
- Gordon, D.C., Loeb, G.E. and Richmond, F.J.R. Distribution of motoneurons supplying cat sartorius and tensor fasciae latae, demonstrated by retrograde multiple-labelling methods. *J. Comp. Neurol.* 304:357-373, 1991.
- Chanaud, C.M., Pratt, C.A. and Loeb, G.E. Functionally complex muscles of the cat hindlimb. II. Mechanical and architectural heterogeneity within a parallel-fibered muscle. *Experimental Brain Research*, 85:257-270, 1991.
- Chanaud, C.M., Pratt, C.A. and Loeb, G.E. Functionally complex muscles of the cat hindlimb. V. The roles of histochemical fiber-type regionalization and mechanical heterogeneity in differential muscle activation. *Experimental Brain Research*, 85:300-313, 1991.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Duenas, S.H., Loeb, G.E. and Marks, W.B. Monosynaptic and dorsal root reflexes during locomotion in normal and thalamic cats. *J. Neurophysiol.*, 63:1467-1476, 1990.
- Krarup, C., Loeb, G.E. and Pezeshkpour, G.H. Conduction studies in peripheral cat nerve using implanted electrodes: III. The effects of prolonged constriction on the distal nerve segment. *Muscle and Nerve*, 12:915-928, 1989.
- Gans, C., Loeb, G.E. and de Vree, F. Architecture and consequent physiological properties of the semitendinosus muscle in domestic goats. *J. Morphology*, 199:287-297, 1989.
- Krarup, C., Loeb, G.E., and Pezeshkpour, G.H. Conduction studies in peripheral cat nerve using implanted electrodes: II. The effects of prolonged constriction on regeneration of crushed nerve fibers. *Muscle & Nerve*, 11:933-944, 1988.
- Krarup, C. and Loeb, G.E. Conduction studies in peripheral cat nerve using implanted electrodes: I. Methods and findings in controls. *Muscle & Nerve*, 11:922-932, 1988.
- Loeb, G.E., Pratt, C.A., Chanaud, C.M. and Richmond, F.J.R. Distribution and innervation of short, interdigitated muscle fibers in parallel-fibered muscles of the cat hindlimb. *J. Morph.* 191:1-15, 1987.
- Loeb, G.E., Marks, W.B. and Hoffer, J.A. Cat hindlimb motoneurons during locomotion: IV. Participation in cutaneous reflexes. *J. Neurophysiol.* 57:563-573, 1987.
- Hoffer, J.A., Sugano, N., Loeb, G.E., Marks, W.B., O'Donovan, M.J. and Pratt, C.A. Cat hindlimb motoneurons during locomotion: II. Normal activity patterns. *J. Neurophysiol.* 57:530-553, 1987.
- Hoffer, J.A., Loeb, G.E., Sugano, N., Marks, W.B., O'Donovan, M.J. and Pratt, C.A. Cat hindlimb motoneurons during locomotion: III. Functional segregation in sartorius. *J. Neurophysiol.* 57:554-562, 1987.
- Hoffer, J.A., Loeb, G.E., Marks, W.B., O'Donovan, M.J., Pratt, C.A. and Sugano, N. Cat hindlimb motoneurons during locomotion: I. Destination, axonal conduction velocity, and recruitment threshold. *J. Neurophysiol.* 57:510-529, 1987.
- Loeb, G.E., Hoffer, J.A. and Pratt, C.A. Activity of spindle afferents from cat anterior thigh muscles. I. Identification and patterns during normal locomotion. *J. Neurophysiol.* 54:549-564, 1985.
- Loeb, G.E., Hoffer, J.A. and Marks, W.B. Activity of spindle afferents from cat anterior thigh muscles. III. Effects of external stimuli. *J. Neurophysiol.* 54:578-591, 1985.
- Loeb, G.E. and Hoffer, J.A. The activity of spindle afferents from cat anterior thigh muscles. II. Effects of fusimotor blockade. *J. Neurophysiol.* 54:565-577, 1985.
- Abraham, L.D., Marks, W.B. and Loeb, G.E. The distal hindlimb musculature of the cat: Cutaneous reflexes during locomotion. *Exp. Brain Res.* 58:594-603, 1985.
- Abraham, L.D. and Loeb, G.E. The distal hindlimb musculature of the cat: Patterns of normal use. *Exp. Brain Res.* 58:580-593, 1985.
- Rindos, A.J., Loeb, G.E. and Levitan, H. Conduction velocity changes along lumbar primary afferents in cats. *Exp. Neurol.* 86:208-226, 1984.
- Hoffer, J.A., O'Donovan, M.J., Pratt, C.A. and Loeb, G.E. Discharge patterns in hindlimb motoneurons during normal cat locomotion. *Science* 213:466-468, 1981.
- Duysens, J., Loeb, G.E. and Weston, B.J. Crossed flexor reflex responses and their reversal in freely walking cats. *Brain Res.* 197:538-542, 1980.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Duysens, J. and Loeb, G.E. Modulation of ipsi- and contralateral reflex responses in unrestrained walking cats. *J. Neurophysiol.* 44:1024-1037, 1980.
- Loeb, G.E. and Duysens, J. Activity patterns in individual hindlimb primary and secondary muscle spindle afferents during normal movements in unrestrained cats. *J. Neurophysiol.* 42:420-440, 1979.
- Loeb, G.E., Bak, M.J. and Duysens, J. Long-term unit recording from somatosensory neurons in the spinal ganglia of the freely walking cat. *Science* 197:1192-1194, 1977.
- Loeb, G.E. Ventral root projections of myelinated dorsal root ganglion cells in the cat. *Brain Res.* 106:159-165, 1976.
- Loeb, G.E. Decreased conduction velocity in the proximal projections of myelinated dorsal root ganglion cells in the cat. *Brain Res.* 103:381-385, 1976.

Refereed Reviews and Proceedings: 143

- Loeb, G.E., “Did down-regulated instincts enable human gene-culture coevolution?”, *Evolutionary Anthropology*, (in press), DOI:10.1002/evan.70015, 2025.
- Vistoso Monreal, A., Veas, N., Loeb, G. and Clark, G., “Enhancing Diagnostic Accuracy in Orofacial Pain”, American Academy of Orofacial Pain’s 49th Scientific Meeting, Arlington, VA, May 4, 2025.
- Vistoso Monreal, A., ,”Veas, N., Loeb, G. and Clark, G. “Artificial intelligence based diagnostic support system for dental residents,” Proceedings of 18th Annual International Technology, Education and Development Conference, Valencia, Spain, Mar. 4-6, 2024.
- Clark, G., Monreal, A.V., Veas, N. and Loeb, G.E. “Highly structured data collection and a predictive diagnostic assist algorithm in orofacial pain and oral medicine”, in *Decision Support Systems and Tools*, Nguyen, ed., IntechOpen, London, ISBN 978-0-85466-125-1 (in press).
- Loeb, G.E. “Remembrance of things perceived: Adding thalamocortical function to artificial neural networks,” *Front. Integrative Neurosci.* 17:1108271, doi.org/10.3389/fnint.2023.1108271, 2023.
- Seminara, L., Dosen, S., Mastrogiovanni, F., Bianchi, M. Watt, S., Beckerle, P., Nanyakkara, T., Drewing, K., Moscatelli, A., Klatzky, R.L. and Loeb, G.E. “A hierarchical sensorimotor control framework for human-in-the-loop robotic hands”, *Science Robotics*, 8:eadd5434, 2023, DOI:[10.1126/scirobotics.add5434](https://doi.org/10.1126/scirobotics.add5434)
- Tsianos, G. A., & Loeb, G. E. Physiology and computational principles of muscle force generation. In *Encyclopedia of Computational Neuroscience* (pp. 2779-2795): Springer, 2022.
- Bar-Cohen, Y., Loeb, G.E., Silka, M.J., Pruetz, J.D. and Chmait, R.H. “The Fetal Pacemaker” in *Diagnosis and Management of Fetal Arrhythmias*, B. Cuneo, J.A. Drose & D.W. Benson, eds., Wolters Kluwer, 2021.
- Pruetz, J.D., Miller, J., Loeb, G.E., Silka, M., Bar-Cohen, Y., Chmait, R. “Prenatal diagnosis and management of congenital complete heart block”, *Birth Defects Research*, 111:380-388, 2019.
- Tsianos, G.A. and Loeb, G.E. “Muscle and limb mechanics,” *Comprehensive Physiology* 7:429-462, 2017.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Loeb, G.E. and Davoodi, R. "Musculoskeletal mechanics and modeling," Scholarpedia 11:12389, 2016, http://www.scholarpedia.org/article/Musculoskeletal_Mechanics_and_Modeling
- Su, Z., Kroemer, O., Loeb, G.E., Sukhatme, G.S. and Schaal, S. "Learning to switch between sensorimotor primitives using multimodal haptic signals," SAB2016, Aberystwyth, UK, Aug. 23-26, 2016.
- Su, Z., Kroemer, O., Loeb, G.E., Sukhatme, G.S. and Schaal, S. "Learning to switch between sensorimotor primitives using multimodal haptic signals," Robotics Science and Systems, R:SS 2016 Workshop on Bootstrapping Manipulation Skills, Ann Arbor, Michigan, June 18-22, 2016.
- Su, Z., Schaal, S. and Loeb, G.E. "Surface tilt perception with a biomimetic tactile sensor," IEEE RAS & EMBS International Conf. on Biomedical Robotics and Biomechatronics (BioRob 2016), Singapore, June 26-29, 2016.
- Su, Z., Hausman, K., Chebotar, Y., Molchanov, A., Loeb, G.E., Sukhatme, G. and Schaal, S. "Force estimation and slip detection/classification for grip control using a biomimetic tactile sensor," IEEE-RAS 15th International Conference on Humanoid Robots, 2015 (pp. 297-303), Seoul, Nov. 3-5, 2015.
- Su, Z., Hausman, K., Chebotar, Y., Molchanov, A., Loeb, G.E., Sukhatme, G.S. and Schaal, S. "Slip Classification Using Tangential and Torsional Skin Distortions on a Biomimetic Tactile Sensor," British Machine Vision Association, London, England, Dec. 9, 2015.
- Su, Z., Hausman, K., Chebotar, Y., Molchanov, A., Loeb, G.E., Sukhatme, G.S. and Schaal, S. "Slip Classification Using Tangential and Torsional Skin Distortions on a Biomimetic Tactile Sensor," IROS15, Hamburg, Germany, Sept. 28-Oct. 3, 2015.
- Loeb, G.E. and Tsianos, G.A. "Major remaining gaps in models of sensorimotor systems," Front. Comput. Neurosci. 9:, 2015, <http://dx.doi.org/10.3389/fncom.2015.00070>
- Loeb, G.E. and Mileusnic, M. "Proprioceptors and models of transduction," Scholarpedia 10(5):12390, 2015, http://www.scholarpedia.org/article/Proprioceptors_and_Models_of_Transduction
- Arian, M.S., Blaine, C.A., Loeb, G.E., Fishel, J.A., The BioTac as a tumor localization tool, IEEE Intl. Conf. on Haptic Interfaces for Virtual Environment and Teleoperator Systems (Haptics), 443-448, 2014.
- Tsianos, G.A. and Loeb, G.E. "Muscle physiology and modeling," Scholarpedia 8(10):12388, 2013, http://www.scholarpedia.org/article/Muscle_Physiology_and_Modeling
- Matulevich, B., Loeb, G.E. and Fishel, J.A. "Utility of contact detection reflexes in prosthetic hand control," IROS, Tokyo, Japan, Nov. 3-7, 2013.
- Reyes, A., Nayak, K.S., Loeb, G.E. and Valero-Cuevas, F.J. "Structural MRI identified precise location of intramuscular electrode recording site based on presence of micro-hematoma," IEEE-EMBC, San Diego, CA, Nov. 6-8, 2013.
- Wettels, N., Fishel, J.A. and Loeb, G.E. "Multimodal tactile sensor", in The Human Hand as an Inspiration for Robot Hand Development., Balasubramanian, R. and Santos, V.J., eds., Springer Tracts in Advanced Robotics, vol. 95, 2013.
- Xu, D., Loeb, G.E. and Fishel, J., "Tactile identification of objects using Bayesian exploration," IEEE-ICRA, Karlsruhe, Germany, May 6-10, 2013.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Richmond, F.J.R. and Loeb, G.E. Dissemination: Getting BCIs to the people who need them. Chapter 21 in *Brain-Computer Interfaces*, J.R. Wolpaw and E.W. Wolpaw, eds., Oxford University Press, New York, 2012.
- Nicholson, A., Chmait, R., Bar-Cohen, Y., Zheng, K. and Loeb, G.E. Percutaneously injectable fetal pacemaker: electronics, pacing thresholds and power budget. IEEE-EMBS Conference, Aug. 28 – Sept. 1, 2012, San Diego.
- Zhou, L., Chmait, R., Bar-Cohen, Y., Peck, R. and Loeb, G.E. Percutaneously injectable fetal pacemaker: electrodes, mechanical design and implantation. IEEE-EMBS Conference, Aug. 28 – Sept. 1, 2012, San Diego.
- Li, Y., Smith, L.H., Hargrove, L.J., Weber, D.J. and Loeb, G.E. Estimation of excitatory drive from sparse motoneuron sampling. IEEE-EMBS Conference, Aug. 28 – Sept. 1, 2012, San Diego.
- Sunwoo, J., Tsianos, G., Goodner, J. and Loeb, G.E. Improving the Dynamic Programming of a Spinal-Like Regulator by Using Preceding Results to Devise Efficient Search Strategies, BMES 2012, Oct. 24-27, 2012, Atlanta.
- Fishel, J.A., Loeb, G.E., “Sensing Tactile Microvibrations with the BioTac – Comparison with Human Sensitivity”, Proc. IEEE Intl Conf Biomed Robotics and Biomechatronics, p.1122-1127, 2012. (Best paper award).
- Loeb, G.E. Neuroprosthetic Interfaces – the Reality Behind Bionics and Cyborgs, in *Human Nature and Self-Design*, eds. Schleidgen, Jungert, Bauer & Sandow, mentis Verlag GmbH, Paderborn, Germany, 2011.
- Wettels, N. and Loeb, G.E. Haptic feature extraction from a biomimetic tactile sensor: force, contact location and curvature. IEEE-ROBIO, Phuket, Thailand, Dec. 7-11, 2011. Awarded C.M. Ho Best Paper in Biomimetics.
- Raphael, G, Tsianos, G. and Loeb, G.E. Spinal-like Regulator for Controlling Wrist Movements. 2009 Advances in Computational Motor Control (Symposium at the Society for Neuroscience Meeting. Chicago, Illinois, October 16, 2009.
- Wettels, N., Fishel, J.A., Su, Z., Lin, C.H. and Loeb, G.E. Multi-modal Synergistic Tactile Sensing. 9th IEEE-RAS International Conference on Humanoid Robots. Tactile Sensing in Humanoids – Tactile Sensors and Beyond Workshop. Paris, France, December 7-10, 2009.
- Lin, C.H., Erickson, T.W., Fishel, J.A., Wettels, N., and Loeb, G.E. Signal processing and fabrication of a biomimetic tactile sensor array with thermal, force and microvibration modalities, IEEE International Conference on Robotics and Biomimetics (ROBIO), 129-134. 2009..
- Song, D., Hendrickson, P., Marmarelis, V.Z., Aguayo, J., He, J., Loeb, G.E., Berger, T.W. Predicting EMG with Generalized Volterra Kernal Model. 30th Annual International IEEE EMBS Conference, April 16, 2008.
- Kaplan, H.M. Neuromuscular Electrical Stimulation for Pressure Ulcer Prevention, Doctoral Thesis. Los Angeles, CA: Dept of Biomedical Engineering, University of Southern California, Aug 2008.
- Kaplan, H.M., Baker, L.L., Rubayi, S., Loeb, G.E. NMES for pressure ulcer prevention: First clinical results. Proc 3rd National Spinal Cord Injury Conf & 16th Interurban Spinal Cord Injury Conf. Toronto, ON, Canada. Nov 2008.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Wettels, N., Smith, L.M., Santos, V.J. and Loeb, G.E. Deformable Skin Design to Enhance Response of a Biomimetic Tactile Sensor, Proc. IEEE Intl Conf Biomed Robotics and Biomechatronic (BioRob), December 7, 2008, Paris.
- Fishel, J.A., Santos, V.J. and Loeb, G.E. A Robust Micro-Vibration Sensor for Biomimetic Fingertips, Proc. IEEE Intl Conf Biomed Robotics and Biomechatronics (BioRob), December 7, 2008, Paris.
- Wettels, N., Popovic, D., Loeb, G.E. Biomimetic tactile sensor. *Proceedings of BioMed2007, 2nd Frontiers in Biomedical Devices Conference*, Irvine, California, June 7-8, 2007.
- Wettels, N., Popovic, D., Santos, V.J., Johansson, R.S., Loeb, G.E. Biomimetic tactile sensor for control of grip. International Conference on Rehabilitation Robotics 2007, Nordweijk an Zee, the Netherlands, June 12-15, 2007.
- Loeb, G.E. and Wills, J. General-Purpose Technology for a General-Purpose Nervous System. ISCAS Conference, New Orleans, LA, May 27-30, 2007.
- Raphael, G. and Loeb, G.E. How difficult is it to product realistic limb movements using realistic spinal circuitry? Conference on Neural Control of Movement (NCM), April 29-May 4, 2007.
- Kaplan, H.M., Baker, L.L., Loeb, G.E. BION™ Active Seating for pressure ulcer prevention: Clinical trial status. Poster Biomedical Engineering Soc Ann Conf. Los Angeles, CA, Sept 2007.
- Kaplan, H.M., Baker, L.L., Davoodi, R., Wong, T.T., Loeb, G.E. The skeletal biomechanics of pressure ulcer prevention by muscle activation. Proc 12th Ann Conf Intl Functional Electrical Stimulation Soc. Philadelphia, PA, Nov 2007.
- Kaliki, R.R., Davoodi, R., and Loeb, G.E. Prediction of distal arm posture from shoulder posture during three-dimensional reaching. 12th Annual Conference of the International Functional Electrical Stimulation Society (IFESS), Philadelphia, PA, November 10-14, 2007.
- Kaplan, H.M., Baker, L.L., Davoodi, R., Wong, N.T. and Loeb, G.E. The Skeletal Biomechanics of Pressure Ulcer Prevention by Muscle Activation. 12th Annual Conference of the International FES Society, Nagoya, Japan, November 18-21, 2007.
- Loeb, G.E. and Blanco, C. Biomimetic design of neural prostheses. *Textbook of Neural Repair and Rehabilitation*, Cambridge University Press, 2006, (587 – 601).
- Wolpaw, J.R., Loeb, G.E., Allison, B.Z., Donchin, E., do Nascimento, O.F., Heetderks, W.J., Nijboer, F., Shain, W.G. and Turner, J.N. BCI Meeting 2005—Workshop on Signals and Recording Methods. *IEEE Trans. Neural Syst. Rehabil. Eng.* 14(2): 138-141, 2006.
- Rodriguez, N., Weissberg, J., and Loeb, G.E. Configurable Communication Channels for Sensor/Actuator Networks. 4th International Conference on computing, communications and Control Technologies, (Orlando, Florida, July 20-23) 2006.
- Kaliki, R.R., Davoodi, R. and Loeb, G.E. The effects of training set on prediction of elbow trajectory from shoulder trajectory during reaching to targets. *Conf. Proc IEEE Eng Med Biol Soc*, 1:5483-6, 2006.
- Kaplan, H.M., Loeb, G.E., Baker, L.L., Davoodi, R. BION™ Active Seating for pressure ulcer prevention: Surface stimulation and finite element modeling for planning treatments. Proc 11th Ann Conf Intl Functional Electrical Stimulation Soc. Miyagi-Zao, Japan. Sept 2006.
- Kaplan, H.M., Loeb, G.E., Baker, L.L., Davoodi, R. BION™ Active Seating for pressure ulcer prevention: Surface stimulation and finite element modeling for planning treatments. Poster Biomedical Engineering Soc Ann Conf., Chicago, IL, Oct. 2006.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Davoodi, R. and G. E. Loeb (2006). Evolutionary methods for analysis of human movement. In: Computational Intelligence for Movement Sciences: Neural Networks and Other Emerging Techniques. R. Begg and M. Palaniswami, eds.. Hershey, PA, Idea Group Publishing: pp. 281-298, 2006.
- Liao, K.-C., Hogen-Esch, T., Richmond, F.J., Marcu, L. and Loeb, G.E. Design and Fabrication of Disposable, Percutaneous Chemical Sensors. *Proc. SPIE* 2005.
- Davoodi, R., Urata, C., and Loeb, G.E. Software for Musculoskeletal Modeling and Clinical Fitting of Neural Prostheses, *Proceedings of the International Society of Biomechanics' Symposium on Computer Simulation in Biomechanics*, (Cleveland, OH, July 28-30) 2005.
- Davoodi, R., Hauschild, M., and Loeb, G.E. Cooperative Control of Man-Machine FES System, *10th Annual Conference of International FES Society*, (Montreal, Canada, July) 2005.
- Loeb, G.E. & Tan, Wei. Biomimetic Posture Sensing and Feedback for Proprioception. *IEEE EMB 27th Annual International Conference* (Shanghai, China) 2005
- Davoodi, R., Urata, C., Todorov, E. and Loeb, G.E. Development of Clinician-Friendly Software for Musculoskeletal Modeling and Control. *Proc. IEEE-EMBS* 26: 438-441, 2004.
- Zou, Q., Tan, W., Kim, E.S., and Loeb, G.E., Highly Symmetric Tri-axis Piezoelectric Bimorph Accelerometer. *IEEE International Micro Electro Mechanical Systems Conference*, Maastricht, The Netherlands, January 25-29, 2004, pp. 197-200.
- Tan, W., Zou, Q, Kim, E.S., Loeb, G.E. Sensing Human Arm Posture with Implantable Sensors. *Proc. 26th Ann. Intl. Conference IEEE Engineering in Medicine and Biology Society*, (San Francisco, Sept 1-5) 2004.
- Zou, Q., Tan, W, Kim E.S., Singh, J. Loeb, G.E. Implantable Biaxial Piezoresistive Accelerometer for Sensorimotor Control. *Proc. 26th Ann. Intl. Conference IEEE Engineering in Medicine and Biology Society*, (San Francisco, Sept 1-5) 2004.
- Loeb, G.E., Richmond, F.J.R., Singh, J., Peck, R.A., Tan, W., Zou, Q, Sachs, N. RF-Powered BIONs for Stimulation and Sensing. *Proc. 26th Ann. Intl. Conference IEEE Engineering in Medicine and Biology Society*, (San Francisco, Sept. 1-5) 2004.
- Liao, K.-C., Richmond, F.J.,Hogen Esch, T.E., Marcu L., and Loeb, G.E. Sencil™ Project: Development of a Percutaneous Optical Biosensor. *Proc. 26th Ann. Intl. Conference IEEE Engineering in Medicine and Biology Society*, (San Francisco, Sept 1-5) 2004.
- Tran, W. H., Loeb, G.E., Richmond, F.J., Ahmed R., Clark, G.T., Haberman, P.B., First Subject Evaluated with Simulated BION™ Treatment in Posterior Genioglossus to Prevent Obstructive Sleep Apnea, *Proc. 26th Ann. Intl. Conference IEEE Engineering in Medicine and Biology Society*, (San Francisco, Sept 1-5) 2004.
- Weber, D.J., Stein, R.B., Chan, K.M., Loeb, G.E., Richmond, F.J.R., Rolf, R., James, K., Chong, S.L. BIONic WalkAide for correcting foot drop. *Proc. 26th Ann. Intl. Conf. IEEE Engineering in Medicine and Biology Society*, (San Francisco, September 1-5) 2004.
- Loeb, G.E., Tan, W., Sachs, N., Zou, Q. and Kim, E.S. A modular approach to sensing limb position in FES patients. *Proc. 9th Ann. Mtg. International Functional Electrical Stimulation Soc.*, Bournemouth, U.K., Sept. 6-9, 2004.
- Richmond, F.J.R., Baker, L.L., Winstein, C., Waters, R.L. and Loeb, G.E. A modular approach to retraining muscles after stroke. *Proc. 9th Ann. Mtg. International Functional Electrical Stimulation Soc.*, Bournemouth, U.K., Sept. 6-9, 2004.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Stein R.B., Weber, D.J., Chan, K.M., Loeb, G.E., Rolf, R., and Chong, S.L., Simulation of Peripheral Nerves with a Microstimulator: Experimental Results and Clinical Application to Correct Foot Drop, *Proc. 9th Ann Mtg International Functional Electrical Stimulation Society*, (Bournemouth, UK, Sept 6-9) 2004.
- Sachs, N.A., Nulud, P.L. Loeb, G.E. Virtual Visit?: Improving communication for those who need it most. *Proceedings of Medicine Meets Virtual Reality 11*, Newport Beach, California, January 22-25, 2003, IOS Press, Amsterdam.
- Zou, Q., Tan, W., Kim, E.U., Loeb, G.E. Implantable biomorph piezoelectric accelerometer for feedback control of functional neuromuscular stimulation. *Proc. 12th International Conference on Solid State Sensors, actuators and Microsystems*, Boston, June 8-12, 2003.
- Loeb, G.E., Davoodi, R., Mileusnic, M., Ananth, R., Inmann, A., Brown I.E. Strategic Development of Sensorimotor Prosthetic Technology. *Proc. 25rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Cancun, Mexico, September 17-21, 2003.
- Richmond, F.J.R., Dupont, A.-C., Tran, W.H., Stein, R.B., Romano, C., Loeb, G.E.. Tactical Application of Sensorimotor Prosthetic Technology. *Proc. 25rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Cancun, Mexico, September 17-21, 2003.
- Davoodi, R. and Loeb, G.E. A biomimetic strategy for control of FES reaching. *Proc. 25rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Cancun, Mexico, September 17-21, 2003.
- Tran, W.H., Loeb, G.E., Richmond, F.J.R., Dupont, A.C., Mahutte, K.C., Sassoon, C.S.H., Dickel, M.J. Development of asynchronous, intralingual electrical stimulation to treat obstructive sleep apnea. *Proc. 25rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Cancun, Mexico, September 17-21, 2003.
- Loeb, G.E. Neural prosthetics. In: *The Handbook of Brain Theory and Neural Networks*. (Ed) M.A. Arbib, MIT Press, Cambridge, Mass., 2nd ed., 2002.
- Loeb, G.E., Sensory systems prosthetics. In: *The Handbook of Brain Theory and Neural Networks*. (Ed) M.A. Arbib, MIT Press, Cambridge, Mass., 2nd ed., 2002.
- Loeb, G.E. and Lan, N. Motor prosthetics. In: *The Handbook of Brain Theory and Neural Networks*. (Ed) M.A. Arbib, MIT Press, Cambridge, Mass., 2nd ed., 2002.
- Dupont, A.C., Bagg, S.D., Creasy, J.L., Romano, C., Romano, D., Loeb, G.E. and Richmond, F.J.R. Clinical Trials of BION Injectable Neuromuscular Stimulators, RESNA, Reno, Nevada., 22-26 June, 2001
- Dupont, A.C., Bagg, S.D., Creasy, J.L., Romano, C., Romano, D., Loeb, G.E. and Richmond, F.J.R. Clinical Trials of BION Injectable Neuromuscular Stimulators, *IFESS 2001 Proceedings* 6:7-9, Cleveland, Ohio, 16-21 June, 2001
- Fornwalt III, H.C., Davoodi, R., Lan, N., Loeb, G.E. Kinematic Analysis of Reaching to Extract Command Signals for FES Control, *IFESS 2001 Proceedings* 6:256-258, Cleveland, Ohio, 16-21 June, 2001.
- Lan, N, Fornwalt, H.C., Mileusnic, M., Davoodi, R., Brown, I.E. and Loeb, G.E. Biomimetic Design of FES Control Systems, , *IFESS 2001 Proceedings* 6:303-305, Cleveland, Ohio, 16-21 June, 2001.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Davoodi, R. and Loeb, G.E. Conversion of SIMM to Simulink for faster development of musculoskeletal models, *IFESS 2001 Proceedings* 6:282-284, Cleveland, Ohio, 16-21 June, 2001.
- Singh, J., Peck, R.A. and Loeb, G.E. Development of BION™ Technology for Functional Electrical Stimulation: Hermetic Packaging, *Proc. 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Istanbul, Turkey, October 25-28, 2001.
- Troyk, P.R., Brown, I.E., Moore, W.H., Loeb, G.E. Development of BION™ Technology for Functional Electrical Stimulation: Bidirectional Telemetry, *Proc. 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Istanbul, Turkey, October 25-28, 2001.
- Kaplan, H.M., Loeb, G.E. Injectable Sources of Locally Controlled Electrical Fields to Facilitate Tissue Repair, *Proc. 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Istanbul, Turkey, October 25-28, 2001.
- Davoodi, R., Brown, I.E., Lan, N., Mileusnic, M., Loeb, G.E. An Integrated Package of Neuromusculoskeletal Modeling Tools in Simulink™, *Proc. 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Istanbul, Turkey, October 25-28, 2001.
- Richmond, F.J.R., Loeb, G.E., Dupont, A.C., Bagg, S.D., Creasy, J.L., Romano, C., Romano, D. Clinical Trials of BIONs™ for Therapeutic Electrical Stimulation, *Proc. 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Istanbul, Turkey, October 25-28, 2001.
- Fornwalt III, H.C., Davoodi, R., Lan, N., Loeb, G.E. Kinematic Analysis of Reaching to Extract Command Signals for FES Control, *Proc. 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Istanbul, Turkey, October 25-28, 2001.
- Loeb, G. E., Brown, I. E., Lan, N., Davoodi, R. The Importance of Biomechanics, *Proceedings of the International Union of Physiological Societies, Movement and Sensation*, Cairns, Australia, September 3-6, 2001, Kluwer Academic/Plenum Publishers, New York.
- Brown, I.E. and Loeb, G.E. A reductionist approach to creating and using neuromusculoskeletal models. Chapter in: *Neuro-Control of Posture and Movement*, (Eds.) J. Winters and P. Crago, Springer-Verlag, New York, 2000, pp 148-163.
- Loeb, G.E. and Ghez, C. The motor unit and muscle action. Chapter 34 in: *Principles of Neural Science*, 4th edition, (Eds.) E.R. Kandel, J.H. Schwartz and T.M. Jessell, Elsevier, New York, (2000).
- Richmond, F.J.R., Bagg, S.D., Olney, S.J., Dupont, A.C., Creasy, J. and Loeb, G.E. Clinical Trial of BIONs™ for Therapeutic Electrical Stimulation. *Proc 5th Annual Conference of the International Functional Electrical Stimulation Society*, Aalborg University, Denmark, 17-23 June 2000, pp. 95-97.
- Dupont, A.C., Loeb, G.E. and Richmond, F.J.R. Effects of Chronic Stimulation Patterns in an Animal Model of Disuse Atrophy. *Proc 5th Annual Conference of the International Functional Electrical Stimulation Society*, Aalborg University, Denmark, 17-23 June 2000, pp. 192-195
- Brown, I.E., Cheng, E., Lan, N., Davoodi, R. and Loeb, G.E. A Comprehensive Model of Muscle Force Generation Under Dynamic Physiological Conditions. *Proc 5th Annual*

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Conference of the International Functional Electrical Stimulation Society*, Aalborg University, Denmark, 17-23 June 2000, pp. 417-420.
- Loeb, G.E. and Richmond, F.J.R. BION? Implants for Therapeutic and Functional Electrical Stimulation, Chapter in: *Neural Prosthesis for Restoration of Sensory and Motor Function*, (Eds.) J.K. Chapin and K.A. Moxon, CRC Press, Boca Raton, 2000, pp 75-99.
- Loeb, G.E., Richmond, F.J.R., Moore, W.H. and Peck, R.A. Design and fabrication of hermetic microelectronic implants. *Proc. IEEE Microtechnology Conference*, Lyon, France, October 12-14, 2000.
- Loeb, G.E. Relating Muscle Activity to Movement in Animals. Chapter in: *Modern Techniques in Neuroscience Research*, (Eds.) U. Windhorst and H. Johansson, Springer-Verlag, 1999, pp 777-786.
- Loeb, G.E. What might the brain know about muscles, limbs and spinal circuits? *Progress in Brain Research*, 123:405-409, 1999.
- Loeb, G.E. and Richmond, F.J.R. FES or TES: How to start an industry? Proceedings of the 4th Annual Conference of the International Functional Electrical Stimulation Society, Sendai, Japan, pp. 169-172, 1999.
- Loeb, G.E. Auditory Prostheses. Chapter in: *Textbook in Stereotactic and Functional Neurosurgery*, (Eds.) P.L. Gildenberg and R.R. Tasker, McGraw-Hill, New York, NY., 1998, pp. 2005-2008.
- Loeb, G.E., Richmond, F.J.R., Olney, S., Cameron, T., Dupont, A.C., Hood, K., Peck, R.A., Troyk, P.R. and Schulman, J.H. Bionic neurons for functional and therapeutic electrical stimulation. *Proc. IEEE-EMBS* 20:2305-2309, 1998.
- Loeb, G.E. A brief overview of bioelectric measurement. In: *Concepts and Techniques in Dielectric Measurements: Is the medium carrying the message?*, (Eds.) A.-R. LeBlanc and J. Billette, Editions de l'Ecole Polytechnique de Montreal, 1997, pp. 1-7.
- Loeb, G.E. Speech-processing strategies designed for children. *Otolaryngol. Head & Neck Surg.*, 117:170, 1997.
- Troyk, P.R., Schwan, M.A.K., DeMichele, G.A., Loeb, G.E., Schulman, J., and Strojnik, P. Microtelemetry techniques for implantable smart sensors. In: *Proc. SPIE 1996 Symposium on Smart Structures and Materials*, Feb. 26-29, 1996, San Diego, abst. #2718-55.
- Loeb, G.E. Neural Prosthetics. Chapter 217 in: *The Practice of Neurosurgery*. (Eds.) G.T. Tindall, P.R. Cooper and D.L. Barrow, Williams & Wilkens, Baltimore, Maryland, 1996, pp. 3287-3300.
- Hoffer, J.A., Stein, R.B., Haugland, M.K., Sinkjaer, T., Durfee, W.K., Schwartz, A.B., Loeb, G.E. and Kantor, C. Neural signals for command control and feedback in functional neuromuscular stimulation: A review. *J. Rehab. Res. & Devel.* 33:145-157, 1996.
- Loeb, G.E. An information highway to the auditory nerve. *Seminars in Hearing* 17:309-316, 1996.
- Loeb, G.E. Neural Prosthetics. In: *The Handbook of Brain Theory and Neural Networks*. (Ed) M.A. Arbib, MIT Press, Cambridge, Mass., 1995, pp. 768-772.
- Loeb, G.E., Faltys, M. and Voelkel, A. Flexible continuous interleaved sampling (FCIS) - A new era for Multi-Strategy CLARION research. IIIrd International Congress on Cochlear Implant, Paris, April 27-29, 1995, p. 157.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Loeb, G.E. and Richmond, F.J.R. Architectural Features of Multiarticular Muscles. *Human Movement Science* 13:545-556 (1994).
- van der Puije, P.D., Shelley, R., Loeb, G.E. A self-spiralling thin-film nerve cuff electrode. *Proc. 19th Canadian Medical and Biological Engineering Conference*, Ottawa, Ontario, May 12-15, 1993.
- Loeb, G.E. Neural prosthetic interfaces between neural and electronic computing. In: *Neurobionics*. (Eds.) H.-W. Bothe, M. Samii and K. Eckmiller, Elsevier, Amsterdam, 1993.
- Loeb, G.E. and Hood, K. New technologies for functional neuromuscular stimulation. In: *Electrophysiological Kinesiology. Proc. 9th International Congress of ISEK, Florence, Italy, June 29-July 2, 1992*. (Ed.) A. Pedotti, IOS Press, Amsterdam, 1993, pp. 35-41.
- Loeb, G.E. and Schulman, J.H. The transfer of technology from the laboratory to the real world. In: *Neural Prostheses: Replacing Motor Function After Disease or Disability*. (Eds.) R.B. Stein, P.H. Peckham, Oxford University Press, New York, 1992, pp. 329-341.
- Richmond, F.J.R., Gordon, D.C. and Loeb, G.E. Heterogeneous structure and function among intervertebral muscles. In: *The Head-Neck Sensory Motor System*. (Eds.) A. Berthoz, W. Graf, P.P. Vidal, Oxford University Press, New York, 1992, pp. 141-147.
- Loeb, G.E. and Richmond, F.J.R. Architectural features of muscles with more than one action. *Proc. 8th European Soc. Biomech.*, Rome, Italy, June 1992, pp. 245-247.
- Loeb, G.E., Peck, R.A., Troyk, P.R., Schwan, M., Schulman, J.H. and Strojnik, P.. Micromodular implants for neural prosthetics. *Proc. 18th Canadian Medical and Biological Engineering Conference*, Toronto, Ontario, June 8-11, 1992, pp. 40-41.
- Loeb, G.E. Cochlear Prosthetics. *Annual Review of Neurosciences*, 13:357-371, 1990.
- Loeb, G.E. The functional organization of muscles, motor units, and tasks. In: *The Segmental Motor System* (Eds.) M.D. Binder and L.M. Mendell, Oxford Univ. Press, New York, 1990, pp. 23-35.
- Loeb, G.E. and Levine, W.S. Linking musculoskeletal mechanics to sensorimotor neurophysiology. In: *Multiple Muscle Systems: Biomechanics and Movement Organization*. (Eds.) J.M. Winters, S.L-Y. Woo, Springer, New York, 1990, pp. 165-181.
- Loeb, G.E., Zamin, C.J., Schulman, J.H. and Troyk, P.R. An injectable microstimulator for functional electrical stimulation. *Proc. North Sea Conf. Biomed. Eng.* 90, Antwerp, November 19-22, 1990.
- Loeb, G.E. Neural prosthetic strategies for young patients. In: *Cochlear Implants in Young Children* (Eds.) E. Owens and D. Kessler, College-Hill Press, San Diego, 1989, pp. 137-152.
- Loeb, G.E. Neural prosthetic interfaces with the nervous system. *Trends in Neurosciences*, 12:195-201, 1989.
- Loeb, G.E. Neural control of locomotion. *Bioscience*, 39:800-804, 1989.
- Loeb, G.E. Whatever happened to the visual prosthesis? In: *Artificial Organs* (Eds.) J.D. Andrade et al., VCH Publishers, Inc., New York, 1987, pp. 457-466.
- Loeb, G.E., Hoffer, J.A., Sugano, N., Marks, W.B., O'Donovan, M.J. and Pratt, C.A. Activity patterns of identified alpha motoneurons to cat anterior thigh muscles during normal walking and flexor reflexes. In: *Motor Control* (Eds.) G.N. Gantchev, B. Dimitrov and P. Gatev, Plenum, New York, 1987, pp. 159-164.
- Loeb, G.E. Hard lessons in motor control from the mammalian spinal cord. *Trends in Neurosciences* 10:108-113, 1987.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Loeb, G.E. Restoring motor function through electrical stimulation. *MS Quart. Rep.* 6:47-50, 1987.
- Loeb, G.E. Spinal programs for locomotion. *Prog. Brain Res.* 64:273-287, 1986.
- Loeb, G.E. Neural control and prosthetics: Interfaces with the nervous system. Keynote address, *J. Am. Osteopathic Assoc.* 86:594-5, 1986.
- Howell, J.N., Binder, M.D., Nichols, T.R. and Loeb, G.E. Muscle spindles golgi tendon organs and the neural control of skeletal muscle. *J. Am. Osteopathic Assoc.* 86:599-602, 1986.
- Loeb, G.E. Kinematic factors in the generation and role of sensory feedback during locomotion. In: *Neurobiology of Vertebrate Locomotion* (Eds.) S. Grillner et al., Macmillan, London, 1986, pp. 547-562.
- Loeb, G.E. Single and multichannel cochlear prostheses: Rationale, strategies, and potential. In: *Cochlear Implants*, (Ed.) R.A. Schindler and M.M. Merzenich, Raven Press, New York, 1985, pp. 17-28.
- Loeb, G.E. What the cat's hindlimb tells the cat's spinal cord. In: *Proc. of Internat. Symp.: Feedback and Motor Control in Invertebrates and Vertebrates.* (Eds.) W.J.P. Barnes and M.H. Gladden. Croom Helm Ltd., London, 1985, pp. 174-186.
- Loeb, G.E. Motoneurone task groups - coping with kinematic heterogeneity. *J. Exp. Biol.* 115:137-146, 1985.
- Loeb, G.E. The control and response of mammalian muscle spindles during normally executed motor tasks. *Exerc. & Sports Sci. Rev.* 12:157-204, 1984.
- Merzenich, M.M., Rebscher, S.J., Loeb, G.E., Byers, C.L. and Schindler, R.A. The U.C.S.F. cochlear implant project - state of development. *Adv. Audiol.* 2:119-144, 1984.
- Loeb, G.E. The biocompatibility of electrically active implants. In: *Mechanisms of Hearing.* Proc. of I.U.P.S. Satellite Symposium, Monash University, Australia, 1983.
- Loeb, G.E., McHardy, J., Kelliher, E.M. and Brummer S.B. Neural Prosthesis. In: *Biocompatibility in Clinical Practice*, Vol. II. (Ed.) D.F. Williams, CRC Press, Inc., Boca Raton, 1982, pp. 123-149.
- Loeb, G.E. and Hoffer, J.A. Muscle spindle function during normal and perturbed locomotion in cats. In: *Muscle Receptors and Movement*, (Ed.) A. Taylor and A. Prochazka, MacMillan, London, 1981, pp 219-228.
- Loeb, G.E. Somatosensory unit input to the spinal cord during normal walking. *Can. J. Physiol & Pharm.* 59:627-635, 1981.
- Loeb, G.E., Walmsley, B. and Duysens, J. Obtaining proprioceptive information from natural limbs: Implantable transducers vs. somatosensory neuron recordings. In: *Physical Sensors for Biomedical Applications.* Proc. of Workshop on Solid State Physical Sensors for Biomedical Application, (Eds.) M.R. Neuman et al., CRC Press, Inc., Boca Raton, 1980.
- Hoffer, J.A. and Loeb, G.E. Implantable electrical and mechanical interfaces with nerve and muscle. *Ann. Biomed Engng.* 8:351-360, 1980.

Miscellaneous Short Papers: 28

- Seminara, L., Dosen, S., Berselli, G., Loeb, G.E., Pirozzi, S., Klatzky, R., Caiani, S.Z. and Zhu, M., Special Issue Editorial, *IEEE Trans. Haptics*, 2025.
- Loeb, G.E. Why do we have muscle spindles? Crosstalk50 commentary, *J. Physiol.*, 2021.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Andersen, R.A., Schieber, M.H., Thakor, N. and Loeb, G.E. Natural and accelerated recovery from brain damage: experimental and theoretical approaches. *IEEE Pulse* 3(2):61-65, 2012.
- Karniel, A., Peer, A., Donchin, O., Mussa-ivaldi, F.A. and Loeb, G.E. Haptic human-robot interaction. *IEEE Trans. Haptics* 5:193-195, 2012.
- Loeb, G.E. Taking Control of Prosthetic Arms. *JAMA* 301(6):670-671, Feb. 11, 2009.
- Loeb, G.E. and Davoodi, R. The functional reanimation of paralyzed limbs. *IEEE EMB Mag.* 24:45-51, 2005.
- Loeb, G.E. and Wilson, B.S. Cochlear prosthesis. In *Encyclopedia of Neuroscience*, 3rd edition, (Eds.) G. Adelman and B.H. Smith, 2004.
- Loeb, G.E. Motor control. In *Encyclopedia of Neuroscience*, 3rd edition, (Eds.) G. Adelman and B.H. Smith, 2004.
- Loeb, G.E., Overcomplete Musculature or Underspecified Tasks? *Motor Control*, 4:81-83, 2000.
- Loeb, G.E. What is a Reflex? Commentary in: *Neuro-Control of Posture and Movement*, (Eds.) J. Winters and P. Crago, 2000, pp 251-252.
- Loeb, G.E. From Idea to Product. Commentary in: *Neuro-Control of Posture and Movement*, (Eds.) J. Winters and P. Crago, 2000, p 570.
- Loeb, G.E. Cochlear Prosthesis. In: *Encyclopedia of Neuroscience*, (Eds.) G. Adelman and B.H. Smith, Elsevier, New York, 1999, pp. 415-416.
- Loeb, G.E. What might the brain know about muscles, limbs and spinal circuits? *Progr. in Brain Res.* 123:405-409, 1999.
- Loeb, G.E., Brown, I.E. and Scott, S.H. Directional Motor Control. *Trends in Neurosci.* 19:137-138, 1996.
- Loeb, G.E. What can we expect from models of motor control? *Behav. & Brain Sci.*, 18(4):767-768, 1995.
- Kessler, D.K., Loeb, G.E. and Osberger, M.J. Cochlear implants: it's time to rethink? Letter to Editor, *Am. J. Otol.*, 16(3):399-402, 1995
- Loeb, G.E. Past the equilibrium point. *Behav. & Brain Sci.*, 15:774-775, 1992
- Loeb, G.E. Strategies for the control of studies of voluntary movement with one degree of freedom. *Behav. & Brain Sci.*, 12:227, 1989.
- Loeb, G.E. and Richmond, F.J.R. Motor partitioning: Epiphenomena masquerading as control theory. *Behav. & Brain Sci.*, 12:660-661, 1989.
- Loeb, G.E. Auditory Prosthesis. In: *Encyclopedia of Neuroscience*, G. Adelman, Ed., Birkhauser Boston, Inc., Cambridge, Mass., 1987, pp. 88-89.
- Loeb, G.E. Motor Control. In: *Encyclopedia of Neuroscience*, G. Adelman, Ed., Birkhauser Boston, Inc., Cambridge, Mass., 1987, pp. 690-692.
- Loeb, G.E. Exploring the limits of servocontrol. *Behav. & Brain Sci.* 9:613-614, 1986.
- Loeb, G.E. and Marks, W.B. Optimal control principles for sensory transducers. In: *Proc. Internat. Sympos.: The Muscle Spindle*. (Eds.) I.A. Boyd and M.H. Gladden. MacMillan Ltd., London, 1985, pp. 409-415.
- Loeb, G.E. The functional replacement of the ear. *Scientific American* 252:104-111, 1985.
- Loeb, G.E. Finding common ground between robotics and physiology. *Trends Neurosci.* 6:203-204, 1983.
- Loeb, G.E. Intentional non-consonant tuning. *Piano Technicians Journal.* 24:#8:17-19, 1981.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Loeb, G.E. and Marks, W.B. Epistemology and heuristics in neural network research. *Behav. & Brain Sci.* 3:556-557, 1980.
- Duysens, J. and Loeb, G.E. Precortical processing of somatosensory information. *Behav. & Brain Sci.* 1:149-150, 1978.
- Loeb, G.E. A study of electrical stimulation of the visual system to determine feasibility of a sensory prosthesis - Biomaterials studies. *Quarterly Reports of NIH Contract #70-2277*, 6/70 - 6/71, The Johns Hopkins University.

Patented Inventions: 78 issued (others pending)

- Faltys, M.A., Martin, R.C., Scottee, S.E. and Loeb, G.E. Nerve cuff with pocket for leadless stimulator, US Patent #12,251,558, Mar. 18, 2025.
- Loeb, G.E., Botticelli, P.A., Groves, D.E., Ilis, A.K., Borzage, M.T., Fishel, J.A. and Newell, K. Method and system for assisting the selection of materials or products according to haptic properties, US Patent #12,033,201, July 9, 2024.
- Bar-Cohen, Y., Loeb, G.E. Sheath for maintaining position in a body cavity, US Patent #11,433,222B2, Sept. 6, 2022.
- Bar-Cohen, Y., Loeb, G.E., Zhou, L. and Yun, X. Implanted electrical lead for pacemaker, US Patent #11,376,424, July 5, 2022.
- Bar-Cohen, Y., Loeb, G.E., Zhou, L., Peck, R. and Nutt, S. Epicardial lead design, US Patent #11,020,588, June 1, 2021.
- Faltys, M.A., Martin, R.C., Scott, S.E. and Loeb, G.E. Nerve cuff with pocket for leadless stimulator, US Patent #10,716,936, July 21, 2020.
- Loeb, G.E. and Fishel, J.A. Method and system for identifying diagnostic and therapeutic options for medical conditions using electronic health records, US Patent #10,559,377, February 11, 2020.
- Loeb, G.E. and Fishel, J.A. Method and system for identifying diagnostic and therapeutic options for medical conditions using electronic health records, US Patent #10,340,040, July 2, 2019.
- Faltys, M.A., Martin, R.C., Scott, S.E. and Loeb, G.E. Nerve cuff with pocket for leadless stimulator, US Patent #10,220,203, March 5, 2019.
- Faltys, M.A., Martin, R.C., Scott, S.E. and Loeb, G.E. Nerve cuff with pocket for leadless stimulator, US Patent #9,700,716, July 11, 2017.
- Fishel, J.A. and Loeb, G.E. Living object investigation and diagnosis using a database of probabilities pertaining to ranges of results, US Patent #9,690,906, June 27, 2017.
- Fishel, J.A. and Loeb, G.E. Object investigation and classification, US Patent #9,477,909, October 25, 2016.
- Bar-Cohen, Y., Loeb, G.E., Silka, M. and Chmait, R. Minimally invasive epicardial pacemaker, US Patent #9,393,407, July 19, 2016.
- Faltys, M.A., Martin, R.C., Scott, S.E. and Loeb, G.E. Nerve cuff with pocket for leadless stimulator, US Patent #9,174,041, November 3, 2015.
- Fishel, J.A., Loeb, G.E., Peck, R.A., Lin, C.H., Matulevich, B. and Pandit, V. Compliant tactile sensor with fluid-filled, sponge-like material, US Patent #9,080,918, July 14, 2015.
- Woods, C.M., Peterson, D.K.L., Meadows, P.M. and Loeb, G.E. System for normalizing amplitude programming of a tissue stimulator, US Patent #9,050,473, June 9, 2015.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Faltys, M.A., Martin, R.C., Scott, S.E. and Loeb, G.E. Nerve cuff with pocket for leadless stimulator, US Patent #8,886,339, November 11, 2014.
- Woods, C.M., Peterson, D.K.L., Meadows, P.M. and Loeb, G.E. System and method for displaying stimulation field generated by electrode array, US Patent #8,805,524, August 12, 2014.
- Woods, C.M., Peterson, D.K.L., Meadows, P.M. and Loeb, G.E. System and method for displaying stimulation field generated by electrode array, US Patent #8,401,658, March 19, 2013.
- Loeb, G.E., Wettels, N., Fishel, J., Lin, C.H., Santos, V.J. and Peck, R. Enhancements to improve the function of a biomimetic tactile sensor, US Patent #8,272,278, September 25, 2012.
- Woods, C.M., Peterson, D.K.L., Meadows, P.M. and Loeb, G.E. Implantable pulse generator having current steering means. U.S. Patent #8,265,762, September 11, 2012.
- Loeb, G.E., Fishel, J., Wettels, N., Santos, V.J. and Peck, R. Measurement of sliding friction-induced vibrations for biomimetic tactile sensing. U.S. Patent #8,181,540, May 22, 2012.
- Woods, C.M., Peterson, D.K.L., Meadows, P. and Loeb, G.E. System and method for displaying stimulation field generated by electrode array. U.S. Patent #8,121,701, February 21, 2012.
- Loeb, G.E. and Tan, W. Method and apparatus for detecting object orientation and position. U.S. Patent #7,970,477, June 28, 2011.
- Woods, C. M., Peterson, D.K.L., Meadows, P. and Loeb, G.E. Implantable pulse generator having current steering means, U.S. Patent #7,930,030, April 19, 2011.
- Loeb, G.E. Cochlear Implant Fitting. U.S. Patent #7,885,714, February 8, 2011.
- Johansson, R.S., Loeb, G.E., Wettels, N., Popovic, D., Santos, V.J. Biomimetic tactile sensor for control of grip. U.S. Patent #7,878,075, February 1, 2011.
- Loeb, G.E. and Johansson, R. Biomimetic tactile sensor. U.S. Patent #7,658,119, February 9, 2010.
- Loeb, G.E., Weissberg, J., Rodriguez, N. Flexible communication and control protocol for a wireless sensor and microstimulator network. U.S. Patent #7,593,776, September 22, 2009.
- Woods, C. M., Peterson, D. K. L, Meadows, P. M., Loeb, G. E. Implantable pulse generator having current steering means, U.S. Patent # 7,555,346, June 30, 2009.
- Loeb, Gerald E. Identification of target site for implantation of a microstimulator. U.S. Patent #7,555,347, June 30, 2009.
- Gordon, D.C. and Loeb, G.E. Treatments for snoring using injectable neuromuscular stimulators. U.S. Patent #7,277,749, October 2, 2007.
- Loeb, G.E., George, T. Internal Biochemical Sensing Device, U.S. Patent #7,096,053, August 22, 2006.
- Loeb, G.E. Method and apparatus to identify small variations of biomolecules, U.S. Patent #6,887,667, May 3, 2005.
- Loeb, G.E., Richmond, F.J.R. Method and apparatus to treat disorders of gastrointestinal peristalsis, U.S. Patent #6,895,279, May 17, 2005.
- Woods, Carla M., Peterson, David K. L, Meadows, Paul M., Loeb, Gerald E. Implantable generator having current steering means, U.S. Patent # 6,909,917, June 21, 2005.
- Richmond, Frances J.R., Loeb, Gerald E., Gordon, Tessa. System and method for providing recovery from muscle denervation, U.S. Patent #6,937,904, August 30, 2005.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Mann, Carla M., Whitehurst, Todd K., McGivern, James P., Loeb, Gerald E., Richmond, Frances J.R. Implantable stimulator methods for treatment of incontinence and pain, U.S. Patent #6,941,171, September 6, 2005.
- Loeb, G.E., Richmond, F.J.R., Mann, C.M., Faltys, M.A., Whitehurst, T.K., McGivern, J.P. Implantable stimulator system and method for treatment of incontinence and pain, U.S. Patent #6,735,474, May 11, 2004.
- Woods, C.M., Peterson, D.K.L., Meadows, P.M. and Loeb, G.E. Fitting process for a neural stimulation system. U.S. Patent #6,609,032, Aug. 19, 2003.
- Loeb, G.E. Method and apparatus for control of bowel function. U.S. Patent #6,658,297 B2, Dec. 2, 2003.
- Loeb, G.E. and Richmond, F.J.R. Method and apparatus for conditioning muscles during sleep. U.S. Patent #6,658,301 B2, Dec. 2, 2003.
- Richmond, F.J.R. and Loeb, G.E. Method of treating obstructive sleep apnea using implantable electrodes, U.S. Patent #6,345,202, February 5, 2002.
- Mann, C.M., Peterson, D.K.L., Meadows, P.M. and Loeb, G.E. Directional programming for implantable electrode arrays, U.S. Patent #6,393,325, May 21, 2002.
- Loeb, G.E. and Richmond, F.J.R. Implantable microstimulator system for producing repeatable patterns of electrical stimulation, U.S. Patent #6,175,764, Jan. 16, 2001.
- Loeb, G.E. and Richmond, F.J.R. Implantable microstimulator system for prevention of disorders, U. S. Patent #6,181,965, Jan. 30, 2001
- Loeb, G.E. and Richmond, F.J.R. Method of reducing the incidence of medical complications using implantable microstimulators, U.S. Patent #6,185,455, Feb. 6, 2001.
- Loeb, G.E. and Richmond, F.J.R. System for implanting a microstimulator, U. S. Patent #6,214,032, Apr. 10, 2001.
- Faltys, M.A., Loeb, G.E., Palmer, L.P., Voelkel, A.W., Wolfe, J.H. and Karunasiri, R.T. Multichannel cochlear prosthesis with flexible control of stimulus waveforms, U.S. Patent #6,219,580, April 17, 2001.
- Munoz, D., Loeb, G.E., Hampton, K., and Ten Hove, M. Method and apparatus for detecting eye movement. U.S. Patent #6,231,187, May 15, 2001.
- Loeb, G.E. and Richmond, F.J.R. Implantable microstimulator and systems employing the same, U.S. Patent #6,051,017, April 18, 2000.
- Mann, C.M. and Loeb G.E. Directional programming for implantable electrode arrays, U.S. Patent #6,052,624, April 18, 2000.
- Richmond, F.J.R. and Loeb, G.E. Method for conditioning pelvic musculature using an implanted microstimulator, U.S. Patent #6,061,596, May 9, 2000.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

- Loeb, G. E. Cochlear electrode array employing dielectric members, U.S. Patent #6,112,124, August 29, 2000.
- Faltys, M.A. and Loeb, G.E. Self-adjusting cochlear implant system and method for fitting same. U.S. Patent #6,157,861, December 5, 2000.
- Loeb, G.E., Schulman, J.H. and Richmond, F.J.R. Implantable Electrode Arrays, U.S. Patent #5,957,958, Sept. 28, 1999.
- Loeb, G.E. and Faltys, M.A. Multichannel cochlear prosthesis with flexible control of stimulus waveforms, U.S. Patent #6,002,966, Dec. 14, 1999.
- Zhang, C., Portillo, F., Zeng, F.-G., Shannon, R. V., Loeb, G. E. Low-Cost, Four-Channel Cochlear Implant, U. S. Patent #5,749,912, May 12, 1998.
- Loeb, G.E. Cochlear electrode array employing tantalum metal, U.S. Patent #5,833,714, Nov. 10, 1998.
- Loeb, G.E. and Ruddy, H. Edge-effect electrodes for inducing spatially controlled distributions of electrical potentials in volume conductive media, U.S. Patent #5,649,970, July 22, 1997.
- Troyk, P.R., Heetderks, W., Schwan, M. and Loeb, G.E. Suspended carrier modulation of high-Q transmitters. U.S. Patent #5,697,076, Dec. 9, 1997.
- Loeb, G.E. and Faltys, M.A. Multichannel cochlear prosthesis with flexible control of stimulus waveforms, U.S. Patent #5,601,617, Feb. 11, 1997; Canadian Patent #2,218,846, Mar. 3, 2007.
- Loeb, G.E. and Schulman, J.H. Implantable multichannel stimulator, U.S. Patent #5,571,148, Nov. 5, 1996.
- Loeb, G.E., Young, R.A. and Hood, K. Monitoring system and interface apparatus therefor, U.S. Patent #5,551,016, August 27, 1996
- Corbett, S.S., Martyniuk, J., Loeb, G.E., Mewes, K., Skiens, W.E., Stobie, J.J., Beck, D.A. Implantable microelectrode, U.S. Patent #5,515,848, May 14, 1996.
- Martyniuk, J., Corbett, S.S., Loeb, G.E., Mewes, K., Skiens, W.E., Stobic, J. J. and Beck, D. A. Method of Making Implantable Microelectrode, U. S. Patent #5,524,338, June 11, 1996.
- Loeb, G.E. and Schulman, J.H. Implantable multichannel stimulator, U.S. Patent #5,571,148, Nov. 5, 1996.
- Shannon, R.V., Loeb, G.E. and Zeng, F-G. Four-channel cochlear implant with a passive, nonhermetically sealed implant, U.S. Patent #5,549,658, Aug. 27, 1996.
- Schulman, J.H., Loeb, G.E., Gord, J.C. and Strojnik, P. Structure and method of manufacture of an implantable microstimulator, U.S. Patent #5,405,367. April 11, 1995.
- Peck, R.A. and Loeb, G.E. Reverse Crimp Connector, U.S. Patent #5,430,254, July 4, 1995.
- Loeb, G.E. Implantable device having an electrolytic storage electrode, U.S. Patent #5,312,439. May 17, 1994.
- Schulman, J.H., Loeb, G.E., Gord, J.C. and Strojnik, P. Implantable microstimulator, U.S. Patent #5,324,316. June 28, 1994.
- Schulman, J.H., Loeb, G.E., Gord, J.C. and Strojnik, P. Implantable microstimulator, U.S. Patent #5,193,539. March 18, 1993.
- Schulman, J.H., Loeb, G.E., Gord, J.C. and Strojnik, P. Structure and method of manufacture of an implantable microstimulator, U.S. Patent #5,193,540. March 18, 1993.
- Taylor, V., Koturov, D., Bradin, J. and Loeb, G.E. Syringe-implantable identification transponder, U.S. Patent #5,211,129. May 19, 1993.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Byers, C.L., Loeb, G.E., Merzenich, M.M. and Rebscher, S.J. Intracochlear electrode array, U.S. Patent #4,819,647, April 11, 1989.
Byers, C.L., Loeb, G.E., Merzenich, M.M. and Rebscher, S.J. Method for making an intracochlear electrode array, U.S. Patent #4,686,765, Aug. 18, 1987.
Loeb, G.E. Surgically implantable electrode for nerve bundles, U.S. Patent #4,590,946, May 27, 1986.

Abstracts (previous ten years only):

Contemori, S., Loeb, G.E., Corneil, B.D., Wallis, G. and Carroll, T.J. “Subcortical control of human reaching?” Neural Control of Movement, Dubrovnik, Croatia, April 15-19, 2024.
Vistoso Monreal, A., Veas, N., Loeb, G. and Clark, G. “Bayesian Exploration: a new clinical decision-support tool,” AMIA 2024 Clinical Informatics Conference, May 21-23, Minneapolis, 2024.
Vistoso Monreal, A., Veas, N., Loeb, G. and Clark, G. “Artificial intelligence based diagnostic support system for dental residents,” 18th Annual International Technology, Education and Development Conference, Valencia, Spain, Mar. 4-6, 2024.
Divakar, R., Loeb, G.E., Corneil, B.D., Wallis, G. and Carroll, T.J. “Initial corticospinal responsiveness following visual target presentation during reaching reflects target direction rather than reach direction,” Soc. For Neuroscience, Chicago, 2021.
Nagamori, A., Laine, C.M., Loeb, G.E. and Valero-Cuevas, F.J. “Force variability is not motor noise,” Neural Control of Movement, April 20-22, 2021.
Enander, J.M.D., Loeb, G.E. and Jorntell, H. “A model for the self-organization of spinal circuitry through learning,” Neural Control of Movement, April 20-22, 2021.
Contemori, S., Loeb, G.E., Corneil, B. Wallis, G. and Carroll, T. “Express visuomotor responses are modulated by cognitive expectations,” Motor Learning & Motor Control, 2020.
Enander, J., Jones, A., Kirkland, M., Hurless, J., Jorntell, H., Loeb, G.E., “A model for self-organizing spinal cord circuitry through learning,” Society for Neuroscience, Chicago, 2019.
Nagamori, A., Laine, C.M., Loeb, G.E. and Valero-Cuevas F.J., “Can motor noise account for force variability,” Society for Neuroscience, San Diego, 2018.
Loeb, G.E. and Fishel, J.A., “Decision support for cost-effective diagnosis and treatment by inverting Bayesian probability,” AIMed 2016, Dec. 14, 2016, Dana Point, CA.
Huang, X-C., Zheng, K.-H., Kohan, S., Denprasert, P.M., Liao, L-M., Loeb, G.E., “Development and testing of NuStim system for stress urinary incontinence treatment,” Society for Neuroscience, Nov. 15, 2016.
Barradas, V.R., Niu, C.M., Sanger, T.D., Loeb, G.E. and Valero-Cuevas, F.J. “Adjustment of gamma motor neuron firing rates in neuromorphic hardware elicits physiological behavior while controlling a cadaveric human finger under kinematic constraints,” Neural Control of Movement, April 20-24, 2015, Charleston, SC.
Sunwoo, J., Goodner, J.R. and Loeb, G.E. “Dimensionality reduction of the spinal-like regulator model improves motor learning,” Society for Neuroscience, Nov. 11, 2013, San Diego, CA.
Li, Y., Loeb, G.E., Sunwoo, J. and Cerne, T. “Are high dimensional spinal neural circuits configured to facilitate rapid learning?” SIAM, July 9, 2013, San Diego, CA.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Tsianos, G.A., Loeb, G.E. and Goodner, J. “A realistic model of spinal circuitry facilitates control of center-out reaching movements”. Abst. 275.03, Society for Neuroscience, Oct. 14, 2012, New Orleans.

Goodner, J., Tsianos, G.E., Lie, Y. and Loeb, G.E. “BioSearch: A physiologically plausible learning model for the sensorimotor system”. Abst. 275.22, Society for Neuroscience, Oct. 14, 2012, New Orleans.

Guest Lectures (previous 25 years only):

International Conference on Medical Device Safety, Amsterdam, Netherlands, “From Concept to Design: Managing Safety Risks in Breakthrough Devices,” April 24-25, 2025.

Neurorehabilitation Seminar, University of Southern California, “The Stuff between Cortex and Muscles,” Feb. 29, 2025.

International Regulatory Science Forum 2024, Mahidol University, Bangkok, Thailand, “Design Considerations for Digital Health Devices,” Mar. 13, 2024.

Queen’s University, Kingston, Canada, “Learning to Use Muscles,” Oct. 19, 2023.

Asia Pacific Economic Cooperation, “Essential Principles of Medical Device Safety and Performance,” Oct. 12, 2023.

Göteborg University, Sweden, “The Stuff between Cortex and Muscles,” June 5, 2023.

Caltech Medical Engineering Program, Pasadena, CA, “From Haptic Robots to Bayesian Exploration to Differential Diagnosis,” Oct. 3, 2023.

SysInt 2022, Genoa, Italy, “Self-Organizing Middleware for Haptically Enabled Robots,” Sept. 8, 2022.

Lund University, Sweden, “Self-Organizing Middleware for Haptically Enabled Robots,” Sept. 5, 2022.

National Center for Adaptive Neurotechnologies, Stratton VA Medical Center, Albany, NY, “Animals and Machines that Learn,” May 25, 2021.

INTUITIVE EU Innovative Training Network, Lund, Sweden, “Intelligent Machines that Grasp Affordance,” May 4, 2021.

Horizons Lecture, Kimberly-Clark Corporation, “Intelligent Machines that Grasp Affordance,” April 14, 2021.

Asia-Pacific Economic Cooperation, Medical Devices 2021, “Case Studies in Classification, Safety, Performance and Risk,” April 6-8, 2021.

Taiwan-U.S. Joint Medical Device Forum, Tainan, “Developing an Invasive Device,” Feb. 4, 2021.

Caltech Medical Engineering Program, Pasadena, CA, “Bayesian Exploration for Intelligent Haptics and Medical Diagnosis,” Oct. 8, 2020.

EuroHaptics THUMB Workshop, Leiden, Netherlands, “Haptic Intelligence,” Sept. 6, 2020.

Salk Institute for Biological Studies, La Jolla, CA, “Learning to Use Muscles,” Mar. 24, 2020.

USC Division of Biokinesiology and Physical Therapy, Los Angeles, CA, “Learning to Use Muscles,” Feb. 28, 2020.

Caltech Medical Engineering Program, Pasadena, CA, “From Haptic Robots to Bayesian Exploration to Differential Diagnosis,” Oct. 31, 2019.

Tsinghua University, Beijing, China, “Medical Device Development,” Oct. 25, 2019.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

6th International Autumn School on Movement Science, Humboldt-Universität zu Berlin, “Learning to Use Muscles,” Oct. 7, 2019.

AI for Good, Geneva, Switzerland, “Decision support for cost-effective diagnosis and treatment by inverting Bayesian probability,” May 29, 2019.

Caltech Medical Engineering Program, Pasadena, CA, “From Haptic Robots to Bayesian Exploration to Differential Diagnosis,” Oct. 11, 2018.

China Pharmaceutical University, Nanjing, China, “Intellectual Property Rights,” July 18, 2018.

Frequently Unasked Questions in Neuroscience, Alicante, Spain, “How do all the parts fit together?” May 21-23, 2018.

Dexterous Anthropomorphic Robot Effectors, Pittsburgh, PA, “Bio-Inspired Robotic Design,” April 29-30, 2018.

Regulatory Science, University of Addis Ababa, Ethiopia, “Design Controls and Risk Analysis for Medical Devices,” April 23-26, 2018.

USC Jimmy Iovine and Andre Young Academy, Los Angeles, CA, “Neural Prosthetic Technology,” Mar. 26, 2018.

Winter Conference on Brain Research, Whistler, Canada, “Understanding Human Haptics by Building Robotic Systems,” Jan. 17, 2018.

Shanghai FDA, China, “Challenges for Development and Clinical Trials of Electroceuticals,” October 27 & 30, 2017.

Progress in Motor Control XI 2017, Miami, FL, “Optimal Isn’t Good Enough,” July 19-22, 2017.

IIT-Madras, India, “Neural Prosthetics – Case Studies in Regulation,” April 5, 2017.

Bearg Lecture in Brain Science, Carnegie Mellon University, “Understanding Human Haptics by Building Robotic Systems,” March 8, 2017.

China Pharmaceutical University, Nanjing, “Using Electrons as a Locally Delivered Excitatory Neuromodulator,” Nov. 24, 2016.

IEEE Humanoids 2016 Workshop on Tactile Sensing for Manipulation, Cancun, “Machine Touch for Dexterous Robotic and Prosthetic Hands,” Nov. 15, 2016.

Barrels XXIX, Los Angeles, CA, “Understanding human haptics by building robotic systems,” Nov. 10, 2016.

Motor Control 2016 – Bridging Motor Control and Biomechanics, Wisla, Poland, “Useful properties of spinal circuits for learning and performing sensorimotor tasks,” Sept. 14, 2016.

ISEK XXI Pre-Congress Workshop, Chicago, IL, “Insight into neural mechanisms of afferent pathways learned from neural recordings, mathematical modeling and real-time neuromorphic simulations,” July 5, 2016.

Biomechanics & Neural Control of Movement, Engineering Foundation Conference, Deer Creek, Ohio, “20 Years from Now,” June 17, 2016.

Automotive Interiors Expo, Stuttgart, Germany, “Quantifying human touch and feel – without humans,” June 1, 2016.

University of Lund, Sweden, “Representing the World in the Brain: Reverse Biomimetic Design from Haptic Robots,” Sept. 7, 2015.

Rehabilitation Institute of Chicago, “Machine Touch for Dexterous Robotic and Prosthetic Hands,” May 8, 2015.

Google DeepMind, London, U.K., “Representing the World in the Brain: Reverse Biomimetic Design from Haptic Robots,” April 13, 2015.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

National Science Foundation Workshop on Robotic Locomotion and Manipulation, Arlington, VA, “Machine Touch for Dexterous Robotic and Prosthetic Hands,” April 2, 2015.

McGill University, Montreal, Canada, “Representing the World in the Brain: Reverse Biomimetic Design from Haptic Robots,” Mar. 18, 2015.

Annual Sensorimotor Control Conference, University of Queensland, Brisbane, Australia, Keynote Address, “Representing the World in the Brain: Reverse Biomimetic Design from Haptic Robots,” Feb. 21, 2015.

University of California at Riverside Distinguished Speaker, “Machine Touch for Dexterous Robotic and Prosthetic Hands,” Oct. 29, 2014.

RoboBusiness Conference, Boston, MA, “The Future of Machine Touch,” Oct. 16, 2014.

American Society of Mechanical Engineers, Los Angeles Chapter, “Machine Touch for Dexterous Robotic and Prosthetic Hands,” April 17, 2014.

Aquitaine Institute for Cognitive and Integrative Neuroscience, Bordeaux, France, “Understanding Haptics by Building Computational and Physical Models,” April 1, 2014.

CNRS-AIST Joint Robotics Laboratory, Montpellier, France, “Machine Touch for Dexterous Robotic and Prosthetic Hands,” March 31, 2014.

University of Paris Marie Curie, “Biomimetic Strategies for Machine Touch,” March 27, 2014.

L’Oreal, Paris, “Biomimetic Strategies for Machine Touch,” March 26, 2014.

DARPA Sensorimotor Prosthetics Workshop, Scottsdale, AZ, “Biomimetic Strategies for Dexterity,” February 13, 2014.

Chongqing Institute for Green and Intelligent Technology (CIGIT), Chongqing, China, “Biomimetic Design for Robotic Systems,” Sept. 26, 2013.

Peking University, Beijing, China, “Innovative Device Development in China: An American’s Perspectives,” Sept. 21, 2013.

Korean Advanced Institute for Science and Technology (KAIST), Seoul, “Biomimetic Technology for Haptically Enabled Robots,” Dec. 3, 2012.

Medtronic Korea, Seoul, “New Opportunities in Neural Prosthetic Technologies,” Dec. 4, 2012.

Medical Scientist Training Program, University of California at Irvine, keynote speaker, “Feeding the Medical-Industrial Complex,” Oct. 6, 2012.

ITRI, Taiwan, “Understanding Haptics by Evolving Mechatronic Systems,” Feb. 14, 2012.

International Workshop on Bio-Inspired Systems and Prosthetic Devices (BioPro 2012), Taichung, Taiwan, “Biomimetic Tactile Sensors for Prosthetic Hands and Personal Assistive Robots,” Feb. 13, 2012.

Drexel University, Philadelphia, “Understanding Haptics by Evolving Mechatronic Systems,” June 22, 2012.

Chongqing Institute of Green and Intelligent Technology (CIGIT), Chinese Academy of Sciences, Chungqing, China, “Biomimetic Technology for Haptically Enabled Robots,” June 19, 2012.

Adept Technology, Pleasanton, CA, “Understanding Haptics by Evolving Mechatronic Systems,” Feb. 8, 2012.

3rd Military Medical School, Chongqing, China, “Clinical Applications of BION Injectible Neuromuscular Stimulators,” June 18, 2012.

West China Hospital, Chengdu, China, “Challenges and Opportunities in Neural Prosthetic Interfaces,” Nov. 30, 2011.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Suzhou Institute of Biomedical Engineering (SIBET), Chinese Academy of Sciences, Suzhou, China, “Challenges and Opportunities in Neural Prosthetic Interfaces,” Sept. 22, 2011.

Summer School on Impedance, STIFF EC Project, Frauenchiemsee, Germany, “What Roboticists Need to Know About NeuroMusculoSkeletal Systems,” July 25, 2011.

Shanghai Medical College of Fudan University, Shanghai, China, “Challenges and Opportunities in Neural Prosthetic Interfaces,” Dec. 1, 2011.

Shaanxi Qinming, Xian, China, “BION Injectable Neuromuscular Stimulators: Technology and Clinical Applications,” Sept. 23, 2011.

Multimodal & Sensorimotor Bionics Workshop, Munich, Germany, “Biomimetic Strategies for Dexterous Robots and Prosthetic Limbs,” July 27, 2011.

Life Science Park, Shanghai, China, “Regulation and Management of Medical Device Design,” Sept. 19, 2011.

IEEE-EMBS Distinguished Lecturer Event, San Fernando Valley, CA, “Biomimetic Strategies for Dexterous Robots and Prosthetic Limbs,” May 17, 2011.

HRL Laboratories, Malibu, CA, “Practical, Multi-modal Tactile Sensing,” Nov. 10, 2011.

Computational Motor Control Workshop, Beer Sheva, Israel, “Understanding Haptics by Evolving Mechatronic Systems,” June 15, 2011.

Chongqing Institute of Green and Intelligent Technology (CIGIT), Chinese Academy of Sciences, Chongqing, China, “Tactile Sensing for Dexterous Robots and Prosthetic Limbs,” Dec. 6, 2011.

Chinese Pharmaceutical University, Nanjing, China, “Regulation and Management of Medical Device Design,” Dec. 4, 2011.

Ben Gurion University, President’s Distinguished Guest, Beer Sheva, Israel, “Spinal Circuitry Makes Motor Control Easy to Do but Hard to Understand,” June 13, 2011.

University of Southern California, Los Angeles, CA, “Biomimetic Tactile Sensing for Prosthetic and Robotic Hands,” Nov. 8, 2010.

Transformational Technologies Conference, Rancho Los Amigos National Rehabilitation Center, Downey, CA, “Multimodal Biomimetic Tactile Sensors for Prosthetic Limbs”, Sept. 2, 2010.

Telluride Neuromorphic Cognition Engineering Workshop, Telluride, CO, “Brain Machine Interfaces”, June 28-30, 2010.

Neural Control of Movement Annual Conference, Naples, FL, “Biomimetic Tactile Sensors” and “Spinal-Like Regulators”, April 20-25, 2010.

ISSCC 2010, San Francisco, evening session on Bionic Systems, “System design challenges in a very complex system indeed,” Feb. 9, 2010.

IEEE-EMBS, Thousand Oaks, CA, “Biomimetic Strategies for Dexterous Robots and Prosthetic Limbs”, Sept. 29, 2010.

EPFL, Lausanne, Switzerland, “Biomimetic Haptics for Robots”, Aug. 30, 2010.

Computational Motor Control Workshop, Beer Sheva, Israel, “Spinal-like regulator simplifies control of multiple degree-of-freedom limbs,” June 16, 2010.

Caltech, Pasadena, CA, “What Does the Brain Control”, Oct. 18, 2010.

Brain Machine Interfaces, Ystad Saltsjobad, Sweden, “What Does the Brain Control?”, Aug. 28, 2010.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

17th Joint Symposium on Neural Computation, Los Angeles, CA, “What Does the Brain Control?”, May 22, 2010.

XXXIX Neurohike Meeting, Jasper, Canada, “Taking care of business,” Sept. 26, 2009.

Workshop on Multi-Scale Muscle Mechanics, Woods Hole, MA, “Things that bother a mammalian neurophysiologist about muscle,” Sept. 19, 2009.

Robotics Science and Systems, Workshop on Understanding the Human Hand for Advancing Robotic Manipulation, Seattle, “Robust Biomimetic Tactile Sensing and Grip Control,” June 28, 2009.

NSF-CMMI Workshop on Neuromechanical Engineering, Arlington, VA, “Exploiting Neural and Muscular Trophisms for Rehabilitation,” Sept. 14, 2009.

Neurosurgery Grand Rounds, USC, “Opportunities & Challenges for Prosthetic Sensorimotor Interfaces,” May 4, 2009.

International Workshop on Neuromorphic Systems and Neural Prostheses, Taiwan, “Bio-Inspired Strategies for Dexterous Robots and Prosthetic Limbs,” May 21, 2009.

Human Nature and Self Design, Tuebingen, Germany, “Neuroimplants and Beyond,” Aug. 1, 2009.

First International Academic Conference of Acupuncture and Moxibustion Instrumentation, Shanghai, China, “The Art and Science of Neural Stimulation,” Dec. 11, 2009.

University of Utah, Salt Lake City, UT, “Making the Deaf Hear and the Blind See – Some Challenges Along the Way,” Nov. 10, 2008.

Korean Institute for Science and Technology, Seoul, Korea, “Prosthetic Interfaces with the Nervous System,” April 25, 2008.

International Symposium on Functional Electrical Stimulation, Taipei, Taiwan, “Opportunities and Challenges for the Use of Neuromuscular Electrical Stimulation in Rehabilitation Medicine” (keynote), “BIONic Interfaces to Reanimate Paralyzed Limbs,” April 26-27, 2008.

Fourth China International Life Science Summit, Hangzhou, China, “Trends and Opportunities in Medical Devices,” Sept. 22, 2008.

Erasmus University, Rotterdam, Netherlands, “Making the Deaf Hear, the Blind See and the Lame Walk,” May 5, 2008.

Engineering Neuroscience & Health, USC, “The Spinal Cord Makes Sensorimotor Control Easy to Do but Difficult to Understand,” Sept. 29, 2008.

DLR Inst. Robotics and Mechatronics, Wessling, Germany, “Biomimetic Interfaces for Mechatronic Limbs,” May 7, 2008.

Advanced Neural Microsystems, ISCAS-2008, Seattle, WA, “General Purpose Technology for a General Purpose Nervous System,” May 19, 2008.

Neurorehabilitation Grand Rounds, Rancho Los Amigos National Rehabilitation Center, Downey, CA, “BIONic Interfaces for Neuromuscular rehabilitation,” Oct. 25, 2007.

IEEE International Solid-State Circuits Conference, San Francisco, CA, “BIONic Neuromuscular Interfaces,” Feb. 13, 2007.

4th World Congress of the International Society of Physical and Rehabilitation Medicine, Seoul, Korea, “The Many Interfaces Required for Functional Reanimation of Limbs,” June 12, 2007.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

35th Annual Conference of Indian Association for Physical Medicine and Rehabilitation, Patna, India, “BION Injectable Neuromuscular Stimulators: Technology and Clinical Applications,” Jan. 20, 2007.

US-China Workshop on Neural Interface Technologies, Kunming, China, “Injectable Muscle Stimulators and Sensors for Motor Function,” July 9-11, 2006.

University of California at Irvine Engineering Symposium on Prosperity thru Technology, May 15, 2006.

Simon Fraser University, Vancouver, Canada, “Reanimating Limb = Technology + Neurophysiology,” Sept. 25, 2006.

Second Computational Motor Control Workshop, Ben-Gurion University of the Negev, Beer-Sheva, Israel, “Biomimetic Integration of Sensorimotor Neural Prostheses,” June 7, 2006.

State of the Science Workshop on Functional Restoration for the Stroke Survivor, “Practice”, keynote speaker, La Jolla, CA, March 7, 2006.

Neural Interfaces Workshop, National Institutes of Health, Bethesda, MD, “BIONic Neuromuscular Interfaces,” Aug. 21-23, 2006.

Johns Hopkins University Center for Hearing and Balance, Baltimore, MD, “Reanimating Limbs = Technology + Neurophysiology,” Aug. 23, 2006.

International Symposium on Biomedical Engineering, Taipei, Taiwan, “BION Injectable Neuromuscular Interfaces to Reanimate Paralyzed Limbs” (keynote), Dec. 15, 2006

Global Digital Healthcare, Cambridge Healthtech Institute, Baltimore, MD, “Neural Prostheses: Crossing the Last Meter in Personal Telecommunications,” Oct. 10-11, 2006.

Alberta Motor Control, Kananaskis, Canada, “Mathematical Models of Proprioceptors,” “Prosthetic Proprioception,” Sept. 23-24, 2006

University of Southern California, Los Angeles, CA, “Design and Fabrication of Disposable, Percutaneous Chemical Sensors”, Jan. 31, 2005

SoCalBio Investor Conference, Los Angeles, CA, “The Sencil™: Indwelling Percutaneous Optical Fibers with Nanoengineered Chemical Sensors”, Mar. 23, 2005.

Rutgers University, New Brunswick, NJ, “Biomimetic Reanimation of Paralyzed Limbs”, Nov. 21, 2005.

First International Conference on Neural Interface and Control, Wuhan, China, “FES and BION™ Development”, May 27, 2005.

Biotechnology Club, University of Southern California, “The Development of Medical Devices: Research, Construction and Distribution”, Mar. 30, 2005.

Design of Medical Devices Conference, University of Minnesota, Minneapolis, “Modular Injectable Interfaces with the Body”, April 13, 2005.

University of California at Santa Cruz, “Making the Deaf Hear, the Blind See and the Lame Walk”, June 8, 2004.

Univ. of Indonesia, Jakarta, “Treatment of Hearing Loss: Technology Meets Economics”, Dec. 15, 2004

SoCalBio Medical Technology Showcase, Los Angeles, “Implantable Glucose Sensor”, June 16, 2004.

Rehabilitation Institute of Chicago, IL, “Making the Deaf Hear, the Blind See and the Lame Walk”, Mar. 10, 2004.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Nano and Microtechnology Symposium, California Institute for Quantitative Biomedical Research, “BIONic Reanimation of Paralyzed Limbs”, April 17, 2004

Multidisciplinary Research Colloquium in Gerontology, USC, “Making the Deaf Hear, the Blind See and the Lame Walk”, Jan. 22, 2004.

Humanoids 2004, Santa Monica, CA, “Biomimetic Sensorimotor Control for Paralyzed Patients and Robots”, Nov. 12, 2004.

Dept. Aerospace & Mechanical Engineering, University of Southern California, “Neural Prosthetic Reanimation of Paralyzed Limbs,” Sept. 29, 2004.

Cornell University, Ithaca, NY, “Neural Prosthetic Reanimation of Paralyzed Limbs”, Nov. 23, 2004.

Canadian Physiological Society, British Columbia, Canada, “Biomimetic Prosthetic Proprioception”, Jan. 28-Feb. 1, 2004.

Brandeis University, Boston, MA, “Neural Prosthetic Reanimation of Paralyzed Limbs”, Nov. 22, 2004.

Bionics and Prosthetics - 2003 Whitney Symposium, GE Global Research, Schenectady, NY, “BIONics”, Mar. 8-9, 2004.

BioNEMS Symposium, Los Angeles, CA, “Survival Strategies for Millimeter Scale Injectable Stimulators”, May 22, 2004.

Spinal Cord Conference, Keynote Speaker for Ernest Bors Symposium, Long Beach, CA, “BIONic Therapy for Paralyzed Legs”, June 5, 2004.

Strategic Partnering Opportunities Conference, Southern California Biomedical Council, “The BION Project”, March 12, 2003.

Neurology/Neurosurgery Grand Rounds, University of Southern California, “Strategies for Neuromuscular Stimulation”, Feb. 25, 2003.

Biomedical Engineering Seminar, USC, Los Angeles, CA, “Modular Injectable Interfaces with the Body – A New Direction for Medical Devices & Diagnostics?”, Sept. 16, 2003.

AARP Workshop, Los Angeles, CA, “The Emerging Reality of Neural Prosthetics”, June 16, 2003.

Spinal Cord Conference and Training, Long Beach, CA, “BIONs – History and Potential”, June 5, 2003.

Science & Technology Series, Johns Hopkins U. Center for Talented Youth, “Neural Prosthetics – Making the Deaf Hear, the Blind See, and the Lame Walk”, Nov. 16, 2003.

USC School of Pharmacy Winter Retreat, Ojai, CA, “Embedded Electronics in our Bodies, our Homes and our Lives”, Jan. 19, 2002.

USC School of Engineering, 2002 Technology Equity Conference, San Diego, CA, “Alfred Mann Institute for Biomedical Engineering – An Experiment in Technology Transfer” and “BION Implants to Reanimate Paralyzed Muscles”, Sept. 24, 2002.

University of Chicago, IL, “Reanimating Paralyzed Limbs – Coping with Spatially Distributed, Multimodal Systems”, Oct. 23, 2002.

UCLA Biomedical Engineering Student Association, Los Angeles, CA, “BIONic Reanimation of Paralyzed Muscles and Limbs”, Mar. 8, 2002

Society for Neuroscience Symposium on Computational Motor Control, Orlando, FL, “Model-Based Analysis of Sensorimotor Control Strategies”, Nov. 2, 2002.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Llewellyn-Thomas Lecture, Institute of Biomaterials & Biomedical Engineering, Toronto, Canada, “Prosthetic Interfaces with the Nervous System”, June 6, 2002.

Christopher Reeve Paralysis Foundation, Research Consortium Associates Meeting, Irvine, CA, “Learning From the Spinal Cord,” May 18, 2002.

Catholic University of America, Washington, DC, “We Made the Deaf Hear....Now What?”, October 8, 2002.

Association of Pacific Rim Universities, Los Angeles, CA, “AMI-USC: An Experiment in Biomedical Technology Transfer”, May 30, 2002.

VA/NIH Prosthetics Roundtable, Bethesda, MD, “BIONic Interfaces for Rehabilitation and Repair,” June 25, 2001.

University of Minnesota, Minneapolis, MN, “Neural Prosthetic Interfaces Between Electronics and Neurons: Making the Deaf Hear, the Blind See and the Lame Walk”, Nov. 26, 2001.

Neurosurgical Grand Rounds, Massachusetts General Hospital, Boston, MA, “Making the Deaf Hear, the Blind See and the Lame Walk”, June 21, 2001.

Neural Prosthesis Workshop, NIH, Bethesda, MD, “Clinical Experience with Microstimulators,” Oct. 19, 2001.

Neural Information and Coding Workshop 2001, Big Sky, Montana, “Useful Effects from Lousy Signals: How to Build a Clinically Successful Neural Prosthesis”, March 20, 2001.

MIT Leg Lab, Cambridge, MA, “BIONic Implants for Distributed Neural Prosthetic Interfaces”, June 20, 2001.

Long Beach VA Medical Center and UC Irvine, CA, “BION Injectable Muscle Stimulators: Current Clinical Trials and Potential Application to Sleep Apnea”, Sept. 26, 2001.

Jet Propulsion Lab, Pasadena, CA, “BIONic Implants for Distributed Neural Prosthetic Interfaces”, June 28, 2001.

International Symposium on Movement and Sensation, Cairns, Australia, principal speaker, “The Importance of Biomechanics,” Sept. 6, 2001.

Industrial Technology Research Institute (ITRI), Taipei, Taiwan, “The Field of Neural Prosthetics” and “BION Technology and Biomimetic Control Strategies to Reanimate Paralyzed Limbs”, Dec. 17, 2001.

Hospital for Special Care, New Haven, CT, “BIONs – Injectable Electrical Stimulators for Paralyzed Muscles”, June 13, 2001.

CI2001, Los Angeles, CA, “Managing Extreme Versatility – CLARION II Implant Architecture”, March 3, 2001.

Cal Tech, Visual Research Lab Seminar, “Command and Control: Does our reach exceed our grasp?”, Nov. 5, 2001.

Cal Tech, Pasadena, CA, Sloan Seminar, “Making the Deaf Hear, the Blind See and the Lame Walk”, Nov. 5, 2001.

5th SIAM Conference on Control and its Applications, San Diego, CA, “Get Real: Biological and Neural Prosthetic Control of Muscles and Limbs”, July 12, 2001.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Symposium on Spinal Cord Function and Rehabilitation, sponsored by J. Physiol. In honor of Prof. Jankowska, New Orleans, LA, “Learning *From* the Spinal Cord”, 11/2000.
Rehabilitation Medicine Rounds, Veterans Administration Hospital, Los Angeles, “BIONic Implants for Therapeutic Electrical Stimulation,” 3/00.
NIPS*2000 Workshop on Algorithms, Technologies and Neural Representations for Neuroprosthetics and Neurorobotics, Breckenridge, CO, “Primitives or Primitive: Forgetting Knowledge about the Spinal Cord”, 12/2000.
Marquette University, Milwaukee, WI, “Bionic Man: Myth, Reality and Progress,” 3/2000.
IEEE USC Student Chapter, Los Angeles, CA, “Electronic Interfaces with the Brain”, 10/2000.
Engineering the Future of Medicine Symposium, A.E. Mann Institute for Biomedical Engineering, University of Southern California, “A Brief History of Neural Prosthetics,” 2/2000.
7th Joint Symposium on Neural Computation, Los Angeles, CA, Keynote speaker: “Dialogs with the Nervous System,” 5/2000.
1st Annual International IEEE EMBS Special Topic Conference on Microtechnology in Medicine and Biology, Lyon, France, “Design and Fabrication of Hermetic Microelectronic Implants”, 10/2000.
National Institute of Mental Health, Neural Prosthetics Conference, Washington, DC, “We Made the Deaf Hear. Now What?” 8/99.
IVth International Symposium on the Head/Neck System, Tokyo, “Is the Neck a Leg?”, 8/99.
Institute of Movement Science, University College London, England, “How Might the Brain Represent Muscles, Limbs and Spinal Circuits?” 3/99.
Institute of Electronic Systems, Aalborg University, Aalborg, Denmark, “Bionic Neurons for Electrical Stimulation of Paralyzed Muscles: Technology and Biology,” 3/99.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Administrative

Professional Memberships:

American Institute for Medical and Biological Engineering (AIMBE)
Institute of Electrical and Electronics Engineers (IEEE, senior member)
Society for Neuroscience
Biomedical Engineering Society (BMES)
Phi Beta Kappa

Advisory Posts (previous 20 years only):

Editorial Boards: Associate Editor, *IEEE Trans. Neural Systems and Rehabilitation Engineering* (2002-4); *J. Neurophysiol.* (1987-90); *Exercise & Sports Science Reviews* (1985-1995); *Exp. Brain. Res.* (1992-2008); Honorary Editorial Board of *Applied Bionics and Biomechanics*, (2003-present), Editorial Advisory Panel, *Expert Review of Medical Devices* (2004-present); Advisory Board, *IEEE Transactions on Neural Systems & Rehabilitation Engineering* (2005-present); Editorial Board, *Open Biomedical Engineering Journal* (2007-present); Editorial Board, *Tech Briefs* (2017-present), Advisory Council, *Research Directions: Bioelectronics* (2022-present),

Frequent Referee: *Nature*, *J. Neuroscience*, *J. Neurophysiology*, *Exp. Brain Res.*, *J. Physiol.*, *IEEE-BME*, *IEEE-TNRE*, *J. Neurosci. Methods*, *Med. & Biol. Engng. & Comput.*, *J. Biomech.*, *Ann. Biomed. Engng.*, *Muscle & Nerve*, *J. Neural Engng.*, *PLoS Computational Biology*, *Frontiers* (various)

Ad hoc Study Section member: US NIH, US NSF, MRC Canada, NSERC Canada

Steering Committee, Consortium for Technology & Innovation in Pediatrics (CTIP)

Advisory Board, STEM Academy of Hollywood

Advisory Board, Chongqing Institute for Green and Intelligent Technology, Chinese Academy of Science

Faculty Advisor, MEDesign Club, University of Southern California

Lead Mentor, Career Advancement and Development in Rehabilitation Research (CADDRE) Program, USC Division of Biokinesiology and Physical Therapy

Academic Committees (USC only)

2022-: Health Innovation Advisory Committee, Iovine & Young Academy

2022: Joint APT/EFC Merit Review Subcommittee

2021-23; 2010-12: Appointments, Promotions & Tenure Committee, Viterbi School of Engineering

2020-24: Strategic Vision Committee, Biomedical Engineering Dept.

2020-2021: RTPC Faculty Review Committee, Biomedical Engineering Dept.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

2019-2021: Engineering Faculty Council, Chairman Research Committee, Senate Alternate
2016-18, 2020: Faculty Merit Review Committee, Biomedical Engineering Dept.
2016-17: Senate Task Force on Innovation
2015-: Faculty Advisor, USC MEDesign Club and teams
2014-2021: Viterbi Research Committee
2014-2020: Neural Engineering Faculty Recruitment Committee
2014-16: Advisory Board for Body Engineering Los Angeles GK-12
2012-15: Ph.D. Admissions Committee, Biomedical Engineering; chair 2014-15
2012-13: Curriculum Committee, Neuroscience Graduate Program
2012-13: Ph.D. Admissions Committee, Neuroscience Graduate Program
2011-17: Space Utilization Committee, Biomedical Engineering Dept.
2011-12: Advisory Committee for Global Initiatives, Viterbi School of Engineering
2005-7: University Research Committee for the Academic Senate
2005-: Board of Advisors, Regulatory Science Program
2004-5: Committee on Nanotechnology, Viterbi School of Engineering
2004-10: Faculty Advisory Committee to the Distance Education Network
2004: Task Force on Restructuring of the Independent Health Professions
2004-10: USC Health Faculty Collaborative
2003-4: Provost's Strategic Planning Committee
2002-7: University Committee on Academic Review
2002-3: MS Program Review Committee, School of Engineering
2002: Internal Review Committee, Dept. of Electrical Engineering
2001-3: Board of Advisors, National Network for Technology Education and Commercialization (NSF funded)
2001-2: Research Committee for the School of Engineering
2001-2: Board of Advisors, Technology Commercialization Alliance
2000-3: Research Committee of the Academic Senate; chair 2001-3
2000-2: Appointments, Promotion and Tenure Committee for the School of Engineering
1999-2008: Steering Committee, Institute for Health in an Aging Population

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Scientific Meeting Organization:

Organizing Committee, Computational Motor Control Workshop, Beer Sheva, Israel, 6/2010, 6/2011.

Workshop Organizer, Winter Conference on Brain Research, 1/1985, 1/2007.

Track Chairman, Neural Engineering Committee, Biomedical Engineering Society, 1/2007.

Track Chair, Neural Engineering, BioMedical Engineering Society Annual Meeting, 9/2007.

Track Chair, Neural Prosthetics and Rehabilitation, IEEE-EMBS, Shanghai, 9/2005.

Organizer, Symposium Series "Engineering the Future of Medicine", A.E. Mann Institute:

- ☐ "Can we make the blind see?" Feb., 19, 2000
- ☐ "Putting the brain in command" July 8, 2000
- ☐ "Breaching barriers to drug entry" Mar. 31, 2001
- ☐ "Electric power in vivo" Feb. 28, 2004

Program Committee, 1st Annual International IEEE EMBS Special Topic Conference on Microtechnology in Medicine and Biology, Lyon, France, 10/2000.

Meeting Organizer, "Musculoskeletal Modeling Workshop", sponsored by A.E. Mann Institute for Biomedical Engineering, Morro Bay, CA, 8/2000

Session Organizer, NCM2000 Satellite on Computational Models, Key West, FL, 4/2000.

Organizing Committee, Conference for Research in Action and Perception, Kingston, ON, 6/98.

Program Committee, Neural Prostheses - Motor Systems V Conference, Burnaby, BC, 8/97.

Focus Group Leader, 1997 Conference on Implantable Auditory Prostheses, Pacific Grove, Ca, 8/97.

Scientific Panel Organizer, Neural Control of Movement Meeting, Cancun, Mexico, 4/97.

Program Committee, Engineering Foundation Conference on Biomechanics & Neural Control of Movement IX, Deer Creek, Ohio, 6/96.

Panel Organizer, "Linking Neural Control to Movement: Insights from Biomechanics," Neural Control of Movement, Marco Island, Florida, 4/93.

Scientific Committee, North Sea Conference - Biomedical Engineering 90, Antwerp, Belgium.

Cochairman, Engineering Foundation Conference on Biomechanics & Control, Henniker, NH, 7/87.

Panel Organizer, "Neural Prosthetic Electrode Arrays: The Perennial Promise of Microelectronics," Materials Research Society, 12/85.

Panel Organizer, 16th Annual Neural Prosthesis Workshop, NINCDS, 11/85.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Steering Committee, Engineering Foundation Conference on Neural Prostheses, Henniker, NH, 8/85.

Steering Committee, Engineering Foundation Conference on Biomechanics & Neural Control of Movement, Henniker, NH, 7/85.

Teaching

Program Development:

Founding Director, USC Master of Science in Medical Device and Diagnostic Engineering (2000-2010, 2023-present)

Founding Director, USC BME Innovation Space (2023-present)

Post-doctoral Fellowship Supervision and Funding Source:

K.E. Aktogan (2011- 2012), Government of Turkey
Yao Li (2010- 2013), DARPA
V.J. Santos (2007- 2008), AMI-USC
N. Rodriguez (2005-2007), AMI-USC
A. Inmann (2002-2003), AMI-USC
R. Davoodi (1999-2001), AMI-USC
Wan Jiang (1997-98), MRC Canada Grant
H. Ruddy (1991-1993), Network of Centres of Excellence/NIH Program-Project Grant
R.P. Young (1990-1992), NIH Grant
J. Weytjens (1986-1988), Fulbright Scholar
C.J. Heckman (1986-1988), PHS NRSA
J. Blaszczyk (1985-1987), Fogarty International Fellowship
S.J. Duenas (1984-86), Fogarty International Fellowship
S. Spector (1984-86), PHS NRSA
C.A. Pratt (1979-80), PHS NRSA
J. Duysens (1977-78), Fogarty International Fellowship

Ph.D. Thesis Adviser:

X. Huang (2017), Dept. of Biomedical Engineering, USC
L. Zhou (2016), Dept. of Biomedical Engineering, USC
A. Nicholson-Vest (2015), Dept. of Biomedical Engineering, USC
G. A. Tsianos (2012), Dept. of Biomedical Engineering, USC
J. A. Fishel (2012), Dept. of Biomedical Engineering, USC
N.A. Wettels (2011), Dept. of Biomedical Engineering, USC
M. Hauschild (2010), Dept. of Biomedical Engineering, USC
R. Kaliki (2009), Dept. of Biomedical Engineering, USC
G. Raphael (2009), Dept. of Biomedical Engineering, USC
Dan Song (2008) Dept. of Biomedical Engineering, USC
H. M. Kaplan (2008), Dept. of Biomedical Engineering, USC
K.C. Liao (2006) Dept. of Biomedical Engineering, USC

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

W. Tan (2006), Dept. of Biomedical Engineering, USC
M. P. Mileusnic (2005), Dept. of Biomedical Engineering, USC
A.C. Dupont (2001), Dept. Physiology, Queen's Univ.
I.E. Brown (1998), Dept. Physiology, Queen's Univ.
T. Cameron (1996), Dept. Physiology, Queen's Univ.
S.H. Scott (1993), Dept. Physiology, Queen's Univ.
A.J. Rindos (1988), Dept. Elect. Engineering, Univ. Maryland
C.M. Chanaud (1988), Dept. Zoology, Univ. Maryland

M.Sc. Thesis Adviser:

J.E. Arguelles-Morales (2013), Dept. of Biomedical Engineering, USC
M. Lai-Chuck-Choo (2012), Dept. of Biomedical Engineering, USC
Zhe Su (2012), Dept. of Biomedical Engineering, USC
C.S. Lin (2011), Dept. of Biomedical Engineering, USC
J. Goodner (2011), Dept. of Biomedical Engineering, USC
N. Sachs (2006), Dept. of Biomedical Engineering, USC
H.C. Fornwalt (2005), Dept. of Biomedical Engineering, USC
M. Rodriguez (2005), Dept. of Biomedical Engineering, USC
D. M. Kleiman (2003), Dept. of Biomedical Engineering, USC
J. Singh (2002), Dept. of Biomedical Engineering, USC
E. Cheng (1999), Dept. Physiology, Queen's Univ.
I.E. Brown (1995), Dept. Physiology, Queen's Univ.
C. Engstrom (1990), Dept. of Anatomy, Queen's Univ.
A.J. Rindos (1982), Dept. Zoology, Univ. Maryland

Doctoral Thesis Committees:

Nikolas Barrera (in progress) Alfred Mann Dept. of Biomedical Engineering, USC
Brianna Thielen (in progress) Alfred Mann Dept. of Biomedical Engineering, USC
Colleen Watson (2024) Doctoral Program in Regulatory Science, USC
Romina Mir (in progress) Alfred Mann Dept. of Biomedical Engineering, USC
Jaehoon Lee (in progress) Ming Hsieh Dept. of Electrical Engineering, USC
Ravinder Singh (in progress) Neuroscience Graduate Program
Yannick Darmon (2023) Dept. of Biokinesiology, USC
Suraj Chakravarthi Raja (in progress) Dept. of Electrical Engineering - Systems, USC
Rechu Divakar (external assessor, 2024) Human Movement & Nutrition Sci., U. Queensland, Australia
Samuele Contemori (external assessor, 2023) Human Movement & Nutrition Sci., U. Queensland, Australia
Andres Camarena (chair, 2023) Neuroscience Graduate Program, USC
Andrew Petersen (in progress) Dept. of Biomedical Engineering, USC
Amanda Rios (2023) Neuroscience Graduate Program, USC

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Susan Bissmeyer (2022), Dept. of Biomedical Engineering, USC
Ali Marjaninejad (2020) Dept. of Biomedical Engineering, USC
Akira Nagamori (2020) Dept. of Biomedical Engineering, USC
Daniel Hagen (2020), Dept. of Biomedical Engineering, USC
Ahuva Weltman (2019), Dept. of Biomedical Engineering, USC
John Hartigan (2017), Doctoral Program in Regulatory Science, USC
Darin Oppenheimer (2017), Doctoral Program in Regulatory Science, USC
Anton Spanne (external reviewer, 2015), University of Lund, Sweden
Shanie Liyanagamage (2016), Dept. of Biomedical Engineering, USC
Zhe Su (2019), Dept. of Biomedical Engineering, USC
Emily Lawrence (2017), Dept. of Biomedical Engineering, USC
Joseph Crew (2016), Dept. of Biomedical Engineering, USC
Alexander Reyes (2015), Dept. of Biomedical Engineering, USC
Cesar Medina (2015), Doctoral Program in Regulatory Science, USC
Kobby Dankwah (2015), Doctoral Program in Regulatory Science, USC
Taranjit Singh (2012), Doctoral Program in Regulatory Science, USC
Tony Chan (2012), Doctoral Program in Regulatory Science, USC
Susan Bains (2012), Doctoral Program in Regulatory Science, USC
Duane Mauzey (2012), Doctoral Program in Regulatory Science, USC
Bardia Fallah Behabadi (2012), Dept. of Biomedical Engineering, USC
Arthi Srinivasan (2012), Dept. of Biomedical Engineering, USC
Navya Davuluri (2011), Dept. of Biomedical Engineering, USC
Michael Jamieson (2011), Doctoral Program in Regulatory Science, USC
Monika Jadi (2010), Dept. of Biomedical Engineering, USC
Alan Horsager (2009), Dept. of Biomedical Engineering, USC
N. Sachs (2007), Dept. of Biomedical Engineering, USC
Joe Fu-Jiou Lo, Ph.D. (2007), Dept. of Biomedical Engineering, USC
J Henry Lin (2007), Dept. of Pathology, USC
J. Y. Hwang (2006), Dept. of Biomedical Engineering, USC
Eric Ortega, Ph.D. (2006), Dept. of Biomedical Engineering, USC
Chunhong Zhou, Ph.D. (2005), Dept. of Biomedical Engineering, USC
Juji Harimoto, Ph.D. (2003), Dept. of Biomedical Engineering, USC
Javier Jo, Ph.D.(2003), Dept. of Biomedical Engineering, USC
Deniz Baskent, Ph.D. (2003), Dept. of Biomedical Engineering, USC

Course Development:

Physiological Instrumentation, PHGY 484/884, Queen's Univ.
Applied Electrophysiology, seminar and laboratory, BME 620L, USC
Development and Regulation of Medical Products, BME 415/416L, USC
Advanced Overview of Neuroscience (core course, organizer for Sensorimotor System) NEUR 525, USC

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Guest Lecturer, USC courses:

BME 201 Biomedical Engineering Practice
BME 414 Rehabilitation Engineering
BME 501 Advanced Topics in Biomedical Systems
BME 504 Neuromuscular Systems
BAEP 551 Introduction to New Ventures
RSCI 601 Biomedical Commerce
RSCI 604 Regulation in Asia
RSCI 605 Management of Human Resources
RSCI 608 Regulation in Europe and the Americas
RXRS 416 Medical Products: From Idea to Market
MPTX 511 Introduction to Medical Product Regulation
MPTX 515 Quality Systems and Standards
NEUR 532 Systems and Behavioral Neurobiology
NEUR 524 Advanced Overview of Neuroscience

Special Course Faculty:

Quality Systems for Medical Products, Addis Ababa University, Ethiopia, 2017
National Center for Adaptive Neurotechnologies, Summer Course, Albany, NY, 2016,
2017, 2019
Workshop on Neuromorphic Engineering, Telluride, CO, 2010.
UCLA Dept. of Biomedical Engineering, BME260 Neuroengineering, guest lecturer
2000-2002
USC School of Pharmacy Short Course, Clearing Roadblocks in the New-Product Path,
2000.
Queen's University, PHGY 801 - Beyond Academia: Using Biomedical Science in
Business and Government, 1996 - 1999.
Advanced Bionics Corp., Continuing Education in Medical Devices, 1994 - 1999.
Cold Spring Harbor Course on Computational Neurobiology, 1985, 1986, and 1988.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Research Support

Current External Grants and Contracts (academic only):

5P50FD004896-03 Espinoza (Director), Loeb (Steering Committee) 09/16/2018-09/15/2023

US Food & Drug Administration

Southern California Center for Technology and Innovation in Pediatrics (CTIP)

The goal is to facilitate the development, production and distribution of pediatric medical devices by identifying companies working in the space and providing advice, networking, and direct and indirect financial support on the road to commercialization.

Minimally Invasive Micropacemakers Bar-Cohen (PI), Loeb (coPI) 09/01/2020-12/31/2023

Children's Hospital of Los Angeles

Development and preclinical animal testing of a cardiac pacemaker suitable for small pediatric patients and others for whom a conventional endovascular pacemaker is contra-indicated.

Subcortical Control of Human Reaching Carroll (PI), Loeb (coPI) 01/01/2024-12/31/2028

DP240101968, Discovery Project, Australian Research Council

Experiments in human subjects to identify circuits and mechanisms for control of rapid arm movements.

Recently Completed Grants and Contracts (academic only):

Tectal Circuits Involved in Rapid Reaching Behavior Carroll (PI), Loeb (coPI)

01/01/2017-12/31/2021

DP170101500, Australian Research Council

Experiments in normal human subjects to identify circuits and mechanisms for control of rapid arm movements

Predictive Haptic Coding Devices in Next Generation Interfaces Jorntell (PI), Loeb (coPI)

#829186, EU H2020 FETOpen project

1/1/2019-12/31/2021

Experiments on and models of somatosensory neural signal processing

DP170101500 Carroll (PI), Loeb (co-PI) 01/01/2017-12/31/2019

Australian Research Council Discovery Projects

A Common Sub-Cortical System for Human Eye and Limb Control

Multi-investigator project to test hypotheses regarding the role of the midbrain tectum in control of rapid reaching and gaze shifts to targets in extrapersonal space.

R01 AR-052345 Valero-Cuevas (PI), Loeb (Co-PI) 2014-2018

Structure and Function of the Fingers' Tendinous Apparatus

Creates neuromorphic circuitry to replicate the function of the spinal cord controlling afferented muscles that produce finger function.

5P50FD004896-02 Bar-Cohen (PI), Loeb (co-PI) 09/16/2013-08/31/2018

US Food & Drug Administration

Pediatric Medical Device Consortium

EX-1003

NYXOAH, INC. ET AL. V. INSPIRE MEDICAL SYSTEMS, INC.

Page 241

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

The goal is the creation of a multi-disciplinary network at USC, CHLA and other academic medical centers and businesses to foster development of promising new medical devices specifically for pediatric applications.

Development of an Epicardial Micropacemaker Bar-Cohen (PI), Loeb (co-PI) 09/01/2016-06/30/2018

L.K. Whittier Foundation

Translational Research Project

Supports development and preclinical testing of a novel cardiac pacemaker and minimally invasive implantation system suitable for infants and others who are not candidates for conventional endovascular pacemaker leads.

1 R01 HD075135-01 Bar-Cohen (PI), Loeb (co-PI) 12/01/2012 – 11/30/2017

National Institutes of Health

Preclinical Development of a Fetal Micropacemaker

Funds the design, fabrication and chronic animal studies of a minimally invasive cardiac pacemaker that can be injected into the chest of a fetus in utero to treat complete heart block with hydrops fetalis.

Development of a Common Platform for Unifying Humanoids Research

This grant fund the development of anthropomorphic robots and their controllers for a consortium of US labs; my group is development the tactile sensors and reflex control loops.

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Contract Administration:

Project Officer, #N01-NS-7-2366, Stanford Univ., Development of a Multichannel Electrode for an Auditory Prosthesis, 1976-79.

Project Officer, #N01-NS-7-2364, University of California at San Francisco, Development of a Multichannel Electrode for an Auditory Prosthesis, 1976-79

Project Officer, #N01-NS-3-2348, Univ. of Maryland, Kinesiological Modeling of the Cat Hindlimb, 1982-1986 and #N01-NS-6-Z300, 1986-89.

Principal Investigator, NIH Contracts #N01-NS-9-2327, #N01-NS-2-2322, #N01-NS-5-2325 to A.E. Mann Foundation, Micro-stimulator for Functional Neuromuscular Stimulation, 1989-98.

Consulting (partial listing)

Fish & Richardson P.C. (2025-present)
IntuiCell AB, Lund, Sweden, Advisory Board, (2022-present)
Nalu Medical Inc., Carlsbad, CA (2021-2022)
Urovant Sciences Inc., Irvine, CA (2020)
Neuromuscular Dynamics, LLC, Glendale, CA, Advisory Board (2019-present)
ANA Avatar XPRIZE, Advisory Board (2018-2023)
General Stim Inc., Los Angeles and Hangzhou, China (2014-2022)
MicroNuronix, Los Angeles and Hangzhou, China (2012-2014)
Sheppard Mullin Richter & Hampton LLP (2012-2016)
Nurotron, Hangzhou, China (2011-2013)
Purdue University (2011-2013)
Rehabilitation Institute of Chicago (2010-2013)
Setpoint Medical, Boston, MA (2009-2012)
Kardium Corp., Vancouver, Canada (2006-2008)
Connolly Bove Lodge & Hutz LLP, Los Angeles (2008-2012)
Shanghai Medical Cochlear Corp., Shanghai, China (2007- 2010)
Victhom Human Bionics, Saint-Augustin-de-Desmaures, Canada (2008-2010)
Bioness Inc., Valencia, CA (2006-2008)
Advanced Neuromodulation Systems, Plano, Texas (2001)
Advanced Bionics Corp., Sylmar, California (1993-1999)
A.E. Mann Foundation, Sylmar, California (1987-1999)
PI Medical, Portland, Oregon (1992-1996)
Advanced Surface Technology, Billerica, Massachusetts (1991-1993)
Trovan Ltd., Luxembourg (1988-1992)
Jet Process Corp., New Haven, Connecticut (1991-1992)
Biophor Corp., Billerica, Massachusetts (1991-1992)
Mentor Technologies, Inc., Rockville, Maryland (1987-1990)
Ionic Atlanta, Atlanta, Georgia (1988-1990)
Abiomed Inc., Danvers, Massachusetts (1989-1990)
Taymar Inc., Westminster, Colorado (1987-1988)

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

Travenol Laboratories, Deerfield, Illinois (1986-1987)
Microprobes for Life Science, Clarksburg, Maryland (1984-1987)
University of California, Dept. of Urology, San Francisco, California (1984-1986)
Intermedics, Freeport, Texas (1985-1986)
Identification Devices, Inc., Boulder, Colorado (1985-1986)
Gentronix, Inc., Rockville, Maryland (1984-1986)
Collier's Encyclopedia, Macmillan Publishers, New York (1986)
BTS, Inc., Greenbelt, Maryland (1985-1986)
Storz Instrument Company, St. Louis, Missouri (1983-1985)
Biostim, Inc., Princeton, New Jersey (1983-1985)
Bak Electronics, Inc., Rockville, Maryland (1979-1984)
Parco Scientific Company, Vienna, Ohio (1981-1983)

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

AUTOBIOGRAPHICAL SKETCH

I received both my bachelors and medical degrees from The Johns Hopkins University through their accelerated/combined program 1965-1972. While an undergraduate and medical student, I worked on several projects involving microelectronic fabrication of electrode arrays for neurophysiological research and neural prosthetics, including service as principal investigator on a biomaterials development contract from NIH to Johns Hopkins and as a guest researcher at the University of Utah Artificial Eye Project. I trained for one year as a resident in the Department of Surgery, University of Arizona, and I am a licensed physician in the State of California.



From 1973 to 1987, I was a medical officer and Section Chief in the USPHS in the Laboratory of Neural Control, National Institute of Neurological and Communicative Disorders and Stroke, National Institutes of Health, Bethesda, Maryland. In 1983, I received the Commendation Medal of the U.S. Public Health Service. I was responsible for planning and conducting a wide range of studies concerning the sensorimotor control of locomotion, electrophysiological studies of peripheral nerve conduction, and development of novel research techniques for neurokinesiological studies. In particular, my research group developed a variety of implantable electrodes and transducers that permit detailed study of single neuron and whole muscle activity during natural behavior in intact animals. I directed a collaborative project with the University of Maryland to develop a comprehensive musculoskeletal model of the cat hindlimb.

In addition to pursuing basic research, I have been involved in a variety of biomedical engineering projects in various capacities, including a guest appointment at University of California at San Francisco, adjunct associate professor at University of Utah, and president of Biomed Concepts, Inc., a consulting and prototype development business with several current projects (www.BiomedConceptsGroup.com). During the period 1979-1981, I commuted regularly to UCSF, where I was responsible for recruiting and leading the engineering team that developed the forerunner of the CLARION® cochlear implant, which now provides functional speech perception for hundreds of thousands of profoundly deaf patients. From 1988-1998 I led an inter-institutional team (Queen's University, Mann Foundation, and Illinois Institute of Technology) that developed a new class of implantable electronic devices (BION®) for a wide range of applications involving therapeutic and functional electrical stimulation of weak and paralyzed muscles. I led a joint venture with a Chinese company to commercialize a new version of this technology to treat urinary stress incontinence. From 1994-1999 I was Chief Scientist for Advanced Bionics Corp. (Sylmar, California), working on commercialization and further development of the CLARION and BION systems. In 2008, my students and I formed SynTouch Inc., which developed and sold BioTac® biomimetic tactile sensors and haptic instrumentation (www.SynTouchInc.com) and was designated a Technology Pioneer by the World Economic Forum.

I have authored or coauthored over 400 publications (excluding abstracts), including a book on electromyography (in press since 1986), 65 full-length physiological research reports in refereed journals and 123 full-length biomedical engineering papers in refereed journals. I have

Declaration of Dr. Gerald Loeb in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 10,898,709

served on the editorial boards of 8 journals and regularly referee for several others. I hold 79 issued US patents (others pending) and I am a Fellow of the National Academy of Inventors.

My research strategy is to understand how the nervous system solves problems in sensorimotor control and perception so that we can apply biomimetic strategies to the design of robotic and prosthetic systems. My students and I strive to combine the basic research, clinical medicine, applied engineering and industrial relations that are required for such "high-tech" endeavors to succeed.