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Spinal cord modulation for inhibiting pain via short pulse width waveforms, and associated systems and methods

Abstract

Short pulse width spinal cord modulation for inhibiting pain with reduced side effects and associated systems and methods are disclosed. In particular embodiments, modulation signal has pulse widths in the range of from about 10 microseconds to about 50 microseconds may be applied to the patient's spinal cord region to address chronic pain without using paresthesia or tingling to mask or cover the patient's sensation of pain. In other embodiments, modulation in accordance with similar parameters can be applied to other spinal or peripheral locations to address other indications.

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Exhibit 32 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-32) Deposition of Kaoru Lee Adair—May 10, 2017, Entire Document Sought to be Sealed, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 1 page. cited by applicant

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Exhibit 39 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-39) Boston Scientific—Precision Spinal Cord Stimulator System with MultiWave Technology Clinician Manual,, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 68 pages. cited by applicant

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Exhibit 41 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-41) Rebuttal Expert Report of Richard T. Mihran, Ph.D. dated Feb. 14, 2018, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 23 pages. cited by applicant

Exhibit 42 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-42) Redacted Version of Document Sought to be Sealed—Videotaped Deposition of Nevro Corp. with designated corporate representative Jim Cassidy on May 17, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 5 pages. cited by applicant

Exhibit 43 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-43) Entire Document Sought to be Sealed—Deposition of Kaoru Lee Adair taken on May 10, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 1 page. cited by applicant

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Exhibit 45 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-45) Entire Document Sought to be Sealed—Deposition of Kaoru Lee Adair taken on May 10, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston*

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Exhibit 46 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-46) Entire Document Sought to be Sealed—Deposition of Kaoru Lee Adair taken on May 10, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 1 page. cited by applicant

Exhibit 47 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-47) Entire Document Sought to be Sealed—Deposition of Kaoru Lee Adair taken on May 10, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 1 page. cited by applicant

Exhibit 48 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-48) Defendant's Identification of 40 Prior Art Grounds for Invalidity dated Dec. 22, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 4 pages. cited by applicant

Exhibit 49 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-49) Defendant's Second Amended Preliminary Invalidity Contentions dated Aug. 10, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 47 pages. cited by applicant

Exhibit 50 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-50) Declaration of Rafael Carbunaru in Support of Boston Scientific's Invalidity Contentions dated Mar. 17, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 6 pages. cited by applicant

Exhibit 51 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-51) Declaration of Kaoru Lee Adair in Support of Boston Scientific's Motion to Dismiss Nevro's Declaratory Judgment Claims dated Dec. 27, 2016, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 5 pages. cited by applicant

Exhibit 52 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-52) Expert Report of Richard T. Mihran, Ph.D., regarding Invalidity of U.S. Pat. No. 8,712,533; U.S. Pat. No. 9,327,125; U.S. Pat. No. 8,359,102; U.S. Pat. No. 9,480,842; U.S. Pat. No. 9,333,357; U.S. Pat. No. 8,792,988; and U.S. Pat. No. 8,768,472 dated Jan. 18, 2018, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 78 pages. cited by applicant

Exhibit 53 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-53) Redacted Version of Document Sought to be Sealed—Rebuttal Expert Report and Declaration of Daniel Lanovaz dated Feb 14, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 6 pages. cited by applicant

Exhibit 54 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-54) Certified Copy of U.S. Pat. No. 8,712,533, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 13 pages. cited by applicant

Exhibit 55 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-55) U.S. Patent Application No. 2009/0204173 to Fang et al., Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 33 pages. cited by applicant

Exhibit 56 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-56) Deposition of Konstantinos Alataris dated Nov. 14, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 34 pages. cited by applicant

Exhibit 57 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-57) Videotaped Deposition of Andre B. Walker dated Nov. 10, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific*

Neuromodulation Corporation, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 26 pages. cited by applicant
Exhibit 58 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-58) Videotaped Deposition of Zi-Ping Fang dated Nov. 2, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 12 pages. cited by applicant
Exhibit 59 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-59) Videotaped Deposition of Anthony Vincent Caparso dated Nov. 2, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 8 pages. cited by applicant
Exhibit 60 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-60) Videotaped Deposition of Brian Erickson dated Dec. 15, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 44 pages. cited by applicant
Exhibit 61 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-61) Deposition of Yougandh Chitre dated Nov. 20, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 6 pages. cited by applicant
Exhibit 62 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-62) Deposition of Jon Parker dated Nov. 27, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 8 pages. cited by applicant
Exhibit 63 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-63) Deposition of Jon Parker dated Nov. 16, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 8 pages. cited by applicant
Exhibit 64 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-64) Videotaped James Thacker dated Dec. 7, 2017 (vol. 1), Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 10 pages. cited by applicant
Exhibit 65 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-65) Sep. 2007 Email between O. Filho and K. Alataris, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 4 pages. cited by applicant
Exhibit 66 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-66) Redacted Version of Document Sought to be Sealed—BSC's Dec. 1, 2017 Supplemental Responses and Objections to Nevro's Second Set of Interrogatories (Nos. 10 and 14), Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 13 pages. cited by applicant
Exhibit 67 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-67) Certified Copy of U.S. Appl. No. 60/985,353, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 63 pages. cited by applicant
Exhibit 68 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-68) Certified Copy of U.S. Appl. No. 12/264,836, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 67 pages. cited by applicant
Exhibit 69 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-69) Certified Copy for U.S. Appl. No. 12/264,836, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 119 pages. cited by applicant
Exhibit 70 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-70) Request to Add to Originally Named Inventors for U.S. Appl. No. 12/264,836, filed Aug. 13, 2012, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 27 pages. cited by applicant
Exhibit 71 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-71) Poster by Yearwood et al., Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity

Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 8 pages. cited by applicant

Exhibit 72 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-72) Case Report by Yearwood et al., Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 3 pages. cited by applicant

Exhibit 73 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-73) Entire Document Sought to be Sealed—Deposition of Rafael Carbunaru taken on Nov. 14, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 1 page. cited by applicant

Exhibit 74 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-74) Deposition of David Caraway dated Nov. 14, 2017, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 9 pages. cited by applicant

Exhibit 75 for Declaration of Eric C. Pai in Support of Nevro's Motion for Summary Adjudication (Document 343-75) Boston Scientific document, Boston Scientific Corporation's and Boston Scientific Neuromodulation Corporation's Invalidity Contentions, *Nevro Corp.* v. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC (N.D. Cal.), filed Apr. 12, 2018, 5 pages. cited by applicant

Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 348), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, Apr. 16, 2018, 10 pages. cited by applicant

Exhibit A for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-1) Redacted Version of Document Sought to Be Filed under Seal—Nevro's Notice of Motion, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, Apr. 16, 2018, 50 pages. cited by applicant

Exhibit A—Updated—for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-2 / Document 461) Redacted Version of Document Sought to Be Filed under Seal—Nevro's Motion for Summary Adjudication, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, Jul. 30, 2018, 50 pages. cited by applicant

Exhibit B for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-3) Redacted Version of Document Sought to Be Filed under Seal—Videotaped Deposition of Rafael Carbunaru, Ph.D., taken Nov. 15, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 46 pages. cited by applicant

Exhibit C for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-5) Boston Scientific Neuromodulation—Sprint High Rate—Product Opportunity Proposal, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 14 pages. cited by applicant

Exhibit D for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-7) Redacted Version of Document Sought to be Filed under Seal—Boston Scientific Neuromodulation—Sprint High Rate—Project Authorization Review, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 7 pages. cited by applicant

Exhibit E for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-9) Redacted Version of Document Sought to be Filed under Seal—Videotaped Deposition of Kaoru Lee Adair, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 12 pages. cited by applicant

Exhibit E—Updated—for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-10) Redacted Version of Document Sought to be Filed under Seal—Videotaped Deposition of Kaoru Lee Adair, taken Nov. 17, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 12 pages. cited by applicant

Exhibit F for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions o Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-11) Redacted Version of Document Sought to be Filed under Seal—Videotaped Deposition of Kaoru Lee Adair, taken May 10, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 23 pages. cited by applicant

Exhibit F—Updated—for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-12) Redacted Version of Document Sought to be Filed under Seal—Videotaped Deposition of Kaoru Lee Adair, taken May 10, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 23 pages. cited by applicant

Exhibit G for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-13) BSC's Supplemental Responses and Objections to Nevro's First Set of Interrogatory Requests (1-8), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 12 pages. cited by applicant

Exhibit H for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-15) Redacted Version of Document Sought to be Filed under Seal—BSC's Second Supplemental Responses and Objections to Nevro's First Set of Interrogatory Requests (1-8), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 12 pages. cited by applicant

Exhibit H—Updated—for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-16) Updated Redacted Version of Document Sought to be Filed under Seal—BSC's Second Supplemental Responses and Objections to Nevro's First Set of Interrogatory Requests (1-8), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 12 pages. cited by applicant

Exhibit I for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-17) Redacted Version of Document Sought to be Filed under Seal—Rebuttal Expert Report of Richard T. Mihran, Ph.D., *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 24 pages. cited by applicant

Exhibit J for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-19) Redacted Version of Document Sought to be Filed under Seal—Oct. 24, 2016 Boston Scientific Letter to U.S. Food and Drug Administration, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 5 pages. cited by applicant

Exhibit K for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-21) Redacted Version of Document Sought to be Filed under Seal—Rebuttal Expert Report and Declaration of Daniel Lanovaz dated Feb. 14, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 7 pages. cited by applicant

Exhibit L for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-23) Redacted Version of Document Sought to be Filed under Seal—Declaration of Ben Pless in Support of Nevro's Motion of Summary Adjudication dated Apr. 12, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 64 pages. cited by applicant

Exhibit L—Updated—for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-24) Updated Redacted Version of Document Sought to be Filed under Seal—Declaration of Ben Pless in Support of Nevro's Motion of Summary Adjudication dated Apr. 12, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 64 pages. cited by applicant

Declaration of Rafael Carbunaru in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (Document 347-25), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 13 pages. cited by applicant

[Proposed] Order Granting Administrative Motion to File under Seal Portions of Nevro's Administrative Motion to File under Seal Portions of Nevro's Motion for Summary Adjudication and Supporting Documents (ECF No. 341) (Document 347-26), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 16, 2018, 5 pages. cited by applicant

Boston Scientific's Responsive Claim Construction Brief, Opposition to Nevro's Motion for Summary Adjudication and Supporting Documents (Document 466), Updated Redacted Version of ECF No. 357-4, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Jul. 30, 2018, 61 pages. cited by applicant

Expert Report and Declaration of Gene Fridman, Ph.D., regarding Claim Construction (Document 358-1), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 18 pages. cited by applicant

Rebuttal Expert Report and Declaration of Gene Fridman, Ph.D., regarding Claim Construction (Document 358-2), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 11 pages. cited by applicant

Declaration of Richard T. Mihran, Ph.D., regarding Claim Construction Brief (Document 358-3), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 2 pages. cited by applicant

Exhibit A for Declaration of Richard T. Mihran, Ph.D., regarding Claim Construction Brief (Document 358-4), Expert Report of Richard T. Mihran, Ph.D. regarding Invalidity of U.S. Pat. No. 8,712,533; U.S. Pat. No. 9,327,125; U.S. Pat. No. 8,359,102; U.S. Pat. No. 9,480,842; U.S. Pat. No. 9,333,357; U.S. Pat. No. 8,792,988; and U.S. Pat. No. 8,768,472, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 129 pages. cited by applicant

Exhibit B Declaration of Richard T. Mihran, Ph.D., regarding Claim Construction Brief (Document 358-5), Redacted Version of Document Sought to be Filed under Seal—Rebuttal Expert Report of Richard T. Mihran, Ph.D., *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 79 pages. cited by applicant

Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 358-6), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 8 pages. cited by applicant

Exhibit 1 for Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 358-7), Sep. 2005 Email between K. Bradley and M. Moffitt, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 2 pages. cited by applicant

Exhibit 2 for Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 358-8), Filed under Seal—Document NEVRO_BSXCA0165810-52, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 1 page. cited by applicant

Exhibit 3 for Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 358-9), Filed under Seal—Document NEVRO_BSXCA0389050-100, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 1 page. cited by applicant

Exhibit 4 for Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 358-10), Summary of Safety and Effectiveness Data (SSED), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 57 pages. cited by applicant

Exhibit 5 for Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 358-11), Article by Andres et al., *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 22 pages. cited by applicant

Exhibit 6 for Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 358-12), Article by Thomson et al., *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 11 pages. cited by applicant

Exhibit 7 for Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 358-13), Filed under Seal—Document labeled NEVRO_BSXCA0053540-89, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 1 page. cited by applicant

Exhibit 8 for Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 358-14), Filed under Seal—Document labeled NEVRO_BSXCA0055766-70, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 1 page. cited by applicant

Exhibit 9 for Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 358-15), Filed under Seal—Document labeled NEVRO_BSXCA0049348-69, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 1 page. cited by applicant

Exhibit 10 for Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 358-16), Videotaped Deposition of Rafael Carbunaru, Ph.D., taken on Nov. 15, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 9 pages. cited by applicant

Exhibit 11 for Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 358-17), Redacted Version of Document Sought to be Filed under Sealed—Videotaped Deposition of Jim Cassidy, taken on Nov. 29, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 9 pages. cited by applicant

Exhibit 12 for Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 467), Filed under Sealed—Videotaped Deposition of Kaoru Lee Adair, taken on Nov. 17, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 10 pages. cited by applicant

Exhibit 13 for Declaration of Clara W. Wang in Support of Boston Scientific's Responsive regarding Claim Construction Brief; Opposition to Nevro's Motion for Summary Judgement and Opening Motion for Summary Judgement (Document 358-19), Redacted Version of Document Sought to be Filed under Seal—Videotaped Deposition of Jim Cassidy, taken on Nov. 30, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed Apr. 26, 2018, 10 pages. cited by applicant

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Exhibit 1 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-1), Claims Chart, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 3 pages. cited by applicant

Exhibit 2 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-2), Entire Document Sought to be Sealed—Document BSC-NVRO_00713169-172, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 1 page. cited by applicant

Exhibit 3 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-3), Redacted Version of Document Sought to be Sealed—BSC's Second Supplemental Responses and Objections to Nevro's First Set of Interrogatory Request (1-8), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 13 pages. cited by applicant

Exhibit 4 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-4), Redacted Version of Document Sought to be Sealed—Videotaped Deposition of Sridhar Kothandaraman, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 14 pages. cited by applicant

Exhibit 5 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-5), Videotaped Deposition of Brian Erickson dated Dec. 15, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 7 pages. cited by applicant

Exhibit 6 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-6), Plaintiff's Brief regarding Claim Construction of the “Adapted to” Claim Term, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 7 pages. cited by applicant

Exhibit 7 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-7), Plaintiff's Response Brief regarding Claim Construction of the “Adapted to” Claim Term, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 6 pages. cited by applicant

Exhibit 8 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-8), Deposition of Ben Pless dated Apr. 10, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 31 pages. cited by applicant

Exhibit 9 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-9), Deposition of Dr. Gene Fridman dated Mar. 7, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 62 pages. cited by applicant

Exhibit 10 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-10), Expert Report and Declaration of Gene Fridman, Ph.D., regarding Claim Construction, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 6 pages. cited by applicant

Exhibit 11 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-11), Article by Tan et al., *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 8 pages. cited by applicant

Exhibit 12 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-12), Decision Denying Institution of Inter Partes Review for U.S. Pat. No. 8,359,102 (Case IPR2015-01203), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 21 pages. cited by applicant

Exhibit 13 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-13), Certified Copy of U.S. Pat. No. 9,327,125, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 66 pages. cited by applicant

Exhibit 14 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-14), U.S. Pat. No. 9,492,664, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 25 pages. cited by applicant

Exhibit 15 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-15), U.S. Pat. No. 9,339,655, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ,

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Exhibit 16 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-16), Redacted Version of Document Sought to be Sealed—Videotaped Deposition of Richard T. Mihran, Ph.D., dated Mar. 12, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 29 pages. cited by applicant

Exhibit 17 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-17), Redacted Version of Document Sought to be Sealed—Videotaped Deposition of Jim Cassidy, dated May 17, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 13 pages. cited by applicant

Exhibit 18 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-18), Redacted Version of Document Sought to be Sealed—Deposition of Adam Lipson, M.D., dated Apr. 12, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 10 pages. cited by applicant

Exhibit 19 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-19), Redacted Version of Document Sought to be Sealed—BSC's Nov. 10, 2017 Supplemental Responses and Objections to Nevro's Interrogatory Requests Nos. 2, 4, 5, and 7, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 9 pages. cited by applicant

Exhibit 20 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-20), Entire Document Sought to be Sealed—Deposition of Kaoru Adair, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 1 page. cited by applicant

Exhibit 21—Updated—for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 471), Redacted Version of ECF No. 382-24—Videotaped Deposition of Kaoru Adair dated May 10, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 18 pages. cited by applicant

Exhibit 22 Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-22), Redacted Version of Document Sought to be Sealed—Nevro Corp.'s First Amended Disclosure of Asserted Claims and Infringement Contentions, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 6 pages. cited by applicant

Exhibit 23 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-23), Entire Document Sought to be Sealed—Document BSC-NVRO_00720938-940, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 1 page. cited by applicant

Exhibit 24 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-24), Redacted Version of Document Sought to be Sealed—Deposition of Joshua Goshorn, dated Mar. 23, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 15 pages. cited by applicant

Exhibit 25 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-25), Redacted Version of Document Sought to be Sealed—Videotaped Deposition of Daniel Lanovaz, dated Mar. 21, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 11 pages. cited by applicant

Exhibit 26 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-26), Redacted Version of Document Sought to be Sealed—Rebuttal Expert Report of Richard T. Mihran, Ph.D. dated Feb. 14, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 23 pages. cited by applicant

Exhibit 27 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-27), Expert Report of Richard T. Mihran, Ph.D., regarding Invalidity of U.S. Pat. No. 8,712,533; U.S. Pat. No. 9,327,125; U.S. Pat. No. 8,359,102; U.S. Pat. No. 9,480,842; U.S. Pat. No. 9,333,357; U.S. Pat. No. 8,792,988, and U.S. Pat. No. 8,768,472, *Nevro Corp.* vs. *Boston Scientific*

Corporation and Boston Scientific Neuromodulation Corporation, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 6 pages. cited by applicant

Exhibit 28 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-28), Declaration of Rafael Carbunaru in Support of Boston Scientific's Invalidity Contentions, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 13 pages. cited by applicant

Exhibit 29 for Declaration of Nicholas Fung in Support of Nevro's Reply in Support of Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 379-29), Redacted Version of Document Sought to be Sealed—Videotaped Deposition of Nevro Corp., with designated corporate representative Rafael Carbunaru, dated May 18, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 10, 2018, 8 pages. cited by applicant

Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 382), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 13 pages. cited by applicant

Exhibit A—Updated—for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 468), Redacted Version of ECF No. 382-2—Nevro's Reply in Support of its Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgment, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 40 pages. cited by applicant

Exhibit B for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 382-3), Redacted Version of Document Sought to be Filed under Seal—Expert Report of Joshua Goshorn, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 15 pages. cited by applicant

Exhibit C for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 382-5), Redacted Version of Document Sought to be Filed under Seal—Expert Report of William S. Rosenberg, M.D., Faans, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 41 pages. cited by applicant

Exhibit D—Updated—for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 469), Redacted Version of ECF No. 382-8—Opening Expert Report of Ben Pless regarding Infringement, dated Jan. 18, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 152 pages. cited by applicant

Exhibit E—Updated—for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 470), Redacted Version of ECF No. 382-10—Expert Report of Robert Schiff, Ph.D., RAC CQA, FRAPS, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 72 pages. cited by applicant

Exhibit F for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions o Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 382-11), Redacted Version of Document Sought to be Filed under Seal—Cross-Border HCP Arrangement Request, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 6 pages. cited by applicant

Exhibit G for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 382-13), Redacted Version of Document Sought to be Filed under Seal—BSC's Second Supplemental Responses and Objections to Nevro's First Set of Interrogatory Request (1-8), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 14 pages. cited by applicant

Exhibit H for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 382-15), Redacted Version of Document Sought to be Filed under Seal—Videotaped Deposition of Sridhar Kothandaraman, dated Nov. 17, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 15 pages. cited by applicant

Exhibit I for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of

Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 382-17), Redacted Version of Document Sought to be Filed under Seal—Videotaped Deposition of Richard T. Mihran, dated Mar. 12, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 30 pages. cited by applicant

Exhibit J for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 382-19), Redacted Version of Document Sought to be Filed under Seal—BSC's Nov. 10, 2017 Supplemental Responses and Objections to Nevro's Interrogatory Requests Nos. 2, 4, 5, and 7, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 10 pages. cited by applicant

Exhibit K for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 382-21), Redacted Version of Document Sought to be Filed under Seal—Dec. 14, 2016 Correspondence between Boston Scientific and U.S. Food and Drug Administration, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 23 pages. cited by applicant

Exhibit L—Updated for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 471), Updated Redacted Version of ECF No. 382-24—Videotaped Deposition of Kaoru Lee Adair, dated May 10, 2017, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 18 pages. cited by applicant

Exhibit M for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 382-25), Redacted Version of Document Sought to be Filed under Seal—Nevro Corp.'s First Amended Disclosure of Asserted Claims and Infringement Contentions, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 7 pages. cited by applicant

Exhibit N for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 382-27), Redacted Version of Document Sought to be Filed under Seal—Feb. 2016 Email regarding Precision 10K Training Follow-up, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 5 pages. cited by applicant

Exhibit O for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 382-29), Redacted Version of Document Sought to be Filed under Seal—Deposition of Joshua Goshorn dated Mar. 23, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 16 pages. cited by applicant

Exhibit P for Declaration of Carson D. Anderson in Support of Nevro's Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement (Document 382-31), Redacted Version of Document Sought to be Filed under Seal—Videotaped Deposition of Daniel Lanovaz dated Mar. 21, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 12 pages. cited by applicant

[Proposed] Order Granting Administrative Motion to File under Seal Portions of Nevro's Reply in Support of It's Motion for Summary Adjudication and Opposition to BSC's Motion for Summary Judgement and Supporing Documents (Document 382-33), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 14, 2018, 7 pages. cited by applicant

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Exhibit 2 for Declaration of Carson D. Anderson in Support of Boston Scientific's Reply in Support of Motion for Summary

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Exhibit 4 for Declaration of Carson D. Anderson in Support of Boston Scientific's Reply in Support of Motion for Summary Judgement (Document 398-5), Redacted Version of Document Sought to be Filed under Seal—Videotaped Deposition of Robert Schiff, dated Mar. 15, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 24, 2018, 19 pages. cited by applicant
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Exhibit 7 for Declaration of Carson D. Anderson in Support of Boston Scientific's Reply in Support of Motion for Summary Judgement (Document 398-8), Filed under Seal—Document NEVRO_BSXCA0147580-86, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 24, 2018, 1 page. cited by applicant
Exhibit 8 for Declaration of Carson D. Anderson in Support of Boston Scientific's Reply in Support of Motion for Summary Judgement (Document 398-9), Filed under Seal—Opening Expert Report of Ben Pless regarding Infringement, dated Jan. 18, 2018, *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 24, 2018, 7 pages. cited by applicant
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Exhibit 10 for Declaration of Carson D. Anderson in Support of Boston Scientific's Reply in Support of Motion for Summary Judgement (Document 398-11), Redacted Version of Document Sought to be Filed under Seal—Design Change Analysis Form (DCAF), *Nevro Corp.* vs. *Boston Scientific Corporation and Boston Scientific Neuromodulation Corporation*, Case No. 3:16-cv-06830-VC-MEJ, filed May 24, 2018, 2 pages. cited by applicant
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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) The present application is a continuation of U.S. patent application Ser. No. 16/781,960, filled Feb. 4, 2020, which is a continuation of U.S. patent application Ser. No. 16/048,131, filed Jul. 27, 2018, which is a divisional of U.S. patent application Ser. No. 14/534,769, filed on Nov. 6, 2014, which claims priority to U.S. Provisional Application No. 61/901,255, filed on Nov. 7, 2013, incorporated herein by reference.

TECHNICAL FIELD
(1) The present disclosure is directed generally to spinal cord modulation for inhibiting pain via short pulse width waveforms, and associated systems and methods.
BACKGROUND
(2) Neurological stimulators have been developed to treat pain, movement disorders, functional disorders, spasticity, cancer, cardiac disorders, and various other medical conditions. Implantable neurological stimulation systems generally have an implantable pulse generator and one or more leads that deliver electrical pulses to neurological

tissue via electrodes. For example, neurological stimulation systems for spinal cord stimulation (SCS) may include cylindrical leads that include a lead body with a circular cross-sectional shape and one or more conductive rings spaced apart from each other at the distal end of the lead body. The conductive rings operate as individual electrodes and, in many cases, the SCS leads are implanted percutaneously through a large needle inserted into the epidural space, with or without the assistance of a stylet.
(3) Once implanted, the pulse generator applies electrical pulses to the neurological tissue via the electrodes, which in turn modifies the function of the patient's nervous system. Conventional SCS pain treatments, for example, apply low-frequency (e.g., less than 1,500 Hz), large pulse width (e.g., greater than 50 microsecond) electrical pulses to the spinal cord to generate sensations of tingling or paresthesia that mask or otherwise alter the patient's sensation of pain. In some cases, patients report that the generated sensations of tingling or paresthesia are perceived as more pleasant and/or less uncomfortable than the underlying pain sensation. Studies have suggested (at least anecdotally) that longer pulse width electrical pulses (e.g., in excess of 450 microseconds) achieve better pain-paresthesia overlap and comfort for patients (Lee et al., Predicted effects of pulse width programming in spinal cord stimulation: a mathematical modeling study, Med Biol Eng Comput (2011) 49:765-774).

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1**A is a partially schematic illustration of an implantable spinal cord modulation system positioned at the spine to deliver therapeutic signals in accordance with several embodiments of the present disclosure.
(2) FIG. **1**B is a partially schematic, cross-sectional illustration of a patient's spine, illustrating representative locations for implanted lead bodies in accordance with embodiments of the disclosure.
(3) FIGS. **2**A and **2**B are flow diagrams illustrating methods conducted in accordance with embodiments of the disclosure.
(4) FIG. **2**C is a schematic illustration of a representative waveform having features in accordance with embodiments of the present technology.
(5) FIG. **3** illustrates an arrangement of leads.
(6) FIG. **4** is a partially schematic illustration of a lead body configured in accordance with an embodiment of the disclosure.
(7) FIGS. **5**A-**5**C are partially schematic illustrations of extendible leads configured in accordance with several embodiments of the disclosure.
(8) FIGS. **6**A-**6**C are partially schematic illustrations of multifilar leads configured in accordance with several embodiments of the disclosure.
DETAILED DESCRIPTION
1.0 Introduction
(9) The present technology is directed generally to spinal cord modulation and associated systems and methods for inhibiting pain via waveforms with short pulse widths (e.g., less than 50 microseconds). In at least some embodiments, the waveforms also have frequencies (and/or frequency elements or components, e.g., fundamental frequencies) in the range of from about 2 Hz to about 1,500 Hz. In general, the short pulse width characteristics of the signal, alone or in combination with other signal parameters (e.g., frequency and/or amplitude) can produce pain relief without using the generation of paresthesia to mask the patient's sensation of pain. Several embodiments also provide simplified spinal cord modulation systems and components, and simplified procedures for the practitioner and/or the patient. Specific details of certain embodiments of the disclosure are described below with reference to methods for modulating one or more target neural populations (e.g., nerves) or sites of a patient, and associated implantable structures for providing the modulation. Although selected embodiments are described below with reference to modulating the dorsal column, dorsal horn, dorsal root, dorsal root entry zone, and/or other particular regions of the spinal column to control pain, the modulation may in some instances be directed to other neurological structures and/or target neural populations of the spinal cord and/or other neurological tissues. Some embodiments can have configurations, components or procedures different than those described in this section, and other embodiments may eliminate particular components or procedures. A person of ordinary skill in the relevant art, therefore, will understand that the disclosure may include other embodiments with additional elements, and/or may include other embodiments without several of the features shown and described below with reference to FIGS. **1**A-**6**C.
(10) In general terms, aspects of many of the following embodiments are directed to producing a therapeutic effect that includes pain reduction in the patient. The therapeutic effect can be produced by inhibiting, suppressing, down-regulating, preventing, or otherwise modulating the activity of the affected neural population. In many embodiments of the presently disclosed techniques, therapy-induced paresthesia is not a prerequisite to achieving pain reduction.
(11) FIG. **1**A schematically illustrates a representative treatment system **100** for providing relief from chronic pain

and/or other conditions, arranged relative to the general anatomy of a patient's spinal cord **191**. The system **100** can include an implantable pulse generator **101**, which may be implanted subcutaneously within a patient **190** and may be coupled to a signal delivery element **110**. In a representative example, the signal delivery element **110** includes a lead or lead body **111** that carries features for delivering therapy to the patient **190** after implantation. The pulse generator **101** can be connected directly to the lead **111**, or it can be coupled to the lead **111** via a communication link **102** (e.g., an extension). Accordingly, the lead **111** can include a terminal section that is releasably connected to an extension at a break **114** (shown schematically in FIG. **1**A). This allows a single type of terminal section to be used with patients of different body types (e.g., different heights). As used herein, the terms lead and lead body include any of a number of suitable substrates and/or support members that carry devices for providing therapy signals to the patient **190**. For example, the lead **111** can include one or more electrodes or electrical contacts that direct electrical signals into the patient's tissue, such as to provide for patient relief. In other embodiments, the signal delivery element **110** can include devices other than a lead body (e.g., a paddle, a leadless implantable electrode, etc.) that also direct electrical signals and/or other types of signals to the patient **190**.

(12) The pulse generator **101** can transmit signals (e.g., electrical signals) to the signal delivery element **110** that up-regulate (e.g., stimulate or excite) and/or down-regulate (e.g., inhibit or suppress) target nerves. As used herein, and unless otherwise noted, the terms “modulate” and “modulation” refer generally to signals that have either type of the foregoing effects on the target nerves. The pulse generator **101** can include a machine-readable (e.g., computer-readable) medium containing instructions for generating and transmitting suitable therapy signals in accordance with the methods and/or parameters described herein. The pulse generator **101** and/or other elements of the system **100** can include one or more processors **107**, memories **108** and/or input/output devices. Accordingly, the process of providing modulation signals and/or executing other associated functions can be performed by computer-executable instructions contained on computer-readable media, e.g., at the processor(s) **107** and/or memory(s) **108**. The pulse generator **101** can include multiple portions, elements, and/or subsystems (e.g., for directing signals in accordance with multiple signal delivery parameters), housed in a single housing, as shown in FIG. **1**A, or in multiple housings.

(13) The pulse generator **101** can also receive and respond to an input signal received from one or more sources. The input signals can direct or influence the manner in which the therapy instructions are selected, executed, updated and/or otherwise performed. The input signal can be received from one or more sensors **112** (one is shown schematically in FIG. **1** for purposes of illustration) that are carried by the pulse generator **101** and/or distributed outside the pulse generator **101** (e.g., at other patient locations) while still communicating with the pulse generator **101**. The sensors **112** can provide inputs that depend on or reflect patient state (e.g., patient position, patient posture and/or patient activity level), and/or inputs that are patient-independent (e.g., time). In other embodiments, inputs can be provided by the patient and/or the practitioner, as described in further detail later.

(14) In some embodiments, the pulse generator **101** can obtain power to generate the therapy signals from an external power source **103**. The external power source **103** can transmit power to the implanted pulse generator **101** using electromagnetic induction (e.g., RF signals). For example, the external power source **103** can include an external coil **104** that communicates with a corresponding internal coil (not shown) within the implantable pulse generator **101**. The external power source **103** can be portable for ease of use.

(15) In another embodiment, the pulse generator **101** can obtain the power to generate therapy signals from an internal power source, in addition to or in lieu of the external power source **103**. For example, the implanted pulse generator **101** can include a non-rechargeable battery or a rechargeable battery to provide such power. When the internal power source includes a rechargeable battery, the external power source **103** can be used to recharge the battery. The external power source **103** can in turn be recharged from a suitable power source (e.g., conventional wall power).

(16) In some cases, a trial modulator **105** can be coupled to the signal delivery element **110** during an initial implant procedure, prior to implanting the pulse generator **101**. For example, a practitioner (e.g., a physician and/or a company representative) can use the trial modulator **105** to vary the modulation parameters provided to the signal delivery element **110** in real time, and select optimal or particularly efficacious parameters. These parameters can include the position of the signal delivery element **110**, as well as the characteristics of the electrical signals provided to the signal delivery element **110**. In a typical process, the practitioner uses a cable assembly **120** to temporarily connect the trial modulator **105** to the signal delivery device **110**. The cable assembly **120** can accordingly include a first connector **121** that is releasably connected to the trial modulator **105**, and a second connector **122** that is releasably connected to the signal delivery element **110**. Accordingly, the signal delivery element **110** can include a connection element that allows it to be connected to a signal generator either directly (if it is long enough) or indirectly (if it is not). The practitioner can test the efficacy of the signal delivery element **110** in an initial position. The practitioner can then disconnect the cable assembly **120**, reposition the signal delivery element **110**, and reapply the electrical modulation. This process can be performed iteratively until the practitioner obtains the desired position for the signal delivery device **110**. Optionally, the practitioner may move the partially implanted signal delivery element **110** without disconnecting the cable assembly **120**.

(17) After the position of the signal delivery element **110** and appropriate signal delivery parameters are established using the trial modulator **105**, the patient **190** can receive therapy via signals generated by the trial modulator **105**, generally for a limited period of time. In a representative application, the patient **190** receives such therapy for one week. During this time, the patient wears the cable assembly **120** and the trial modulator **105** outside the body. Assuming the trial therapy is effective or shows the promise of being effective, the practitioner then replaces the trial modulator **105** with the implanted pulse generator **101**, and programs the pulse generator **101** with parameters selected based on the experience gained during the trial period. Optionally, the practitioner can also replace the signal delivery element **110**. Once the implantable pulse generator **101** has been positioned within the patient **190**, the signal delivery parameters provided by the pulse generator **101** can still be updated remotely via a wireless external programmer **109** (e.g., a physician's remote, laptop, PDA, tablet, etc.) and/or a wireless patient programmer **106** (e.g., a patient remote). Generally, the patient **190** has control over fewer parameters than does the practitioner. For example, the capability of the patient programmer **106** may be limited to only starting and/or stopping the pulse generator **101**, and/or adjusting the signal amplitude.

(18) In any of the foregoing embodiments, the parameters in accordance with which the pulse generator **101** provides signals can be adjusted during portions of the therapy regimen. For example, the frequency, amplitude, pulse width and/or signal delivery location can be adjusted in accordance with a preset program, patient and/or physician inputs, and/or in a random or pseudorandom manner. Such parameter variations can be used to address a number of potential clinical situations, including changes in the patient's perception of pain, changes in the preferred target neural population, and/or patient accommodation or habituation.

2.0 Representative Therapy Parameters

(19) FIG. **1**B is a cross-sectional illustration of the spinal cord **191** and an adjacent vertebra **195** (based generally on information from Crossman and Neary, “Neuroanatomy,” 1995 (published by Churchill Livingstone)), along with the locations at which leads **110** can be implanted in representative patients. The spinal cord **191** is situated between a ventrally located ventral body **196** and the dorsally located transverse process **198** and spinous process **197**. Arrows V and D identify the ventral and dorsal directions, respectively. The spinal cord **191** itself is located within the dura mater **199**, which also surrounds portions of the nerves exiting the spinal cord **191**, including the dorsal roots **193**, dorsal root entry zone **188**, and dorsal root ganglia **194**. The leads **110** (indicated by leads **110***b*) can be positioned just off the spinal cord midline **189** (e.g., about 1 mm. offset) in opposing lateral directions so that the two leads **110***b* are spaced apart from each other by about 2 mm, in particular embodiments. In other embodiments, a single lead **110***a* can be positioned at the midline **189**. In still further embodiments, lead(s) can be positioned at or proximate to the dorsal root **193** (as shown by lead **110***c*) and/or at or proximate to the dorsal root ganglia **194** (as shown by lead **110***d*).

(20) FIGS. **2**A and **2**B are flow diagrams illustrating methods for treating patients in accordance with particular embodiments of the present disclosure. Manufacturers or other suitable entities can provide instructions to practitioners for executing these and other methods disclosed herein. Manufacturers can also program devices of the disclosed systems to carry out at least some of these methods. FIG. **2**A illustrates a method **600** that includes implanting a signal generator in a patient (block **610**). The signal generator can be implanted at the patient's lower back or other suitable location. The method **600** further includes implanting a signal delivery device (e.g., a lead, paddle or other suitable device) at the patient's spinal cord region (block **620**). This portion of the method can in turn include implanting the device (e.g., active contacts of the device) at a vertebral level ranging from about T8 to about T12 (e.g., about T8-T12, inclusive) (block **621**), and at a lateral location ranging from the spinal cord midline to the DREZ, inclusive (block **622**). At block **630**, the method includes applying a short pulse width waveform, via the signal generator and the signal delivery device. In particular examples, the signal (or at least a portion of the signal) can have pulses with pulse widths ranging from about 10-50 microseconds, or from about 20-40 microseconds, or from about 25-35 microseconds, or from about 30-35 microseconds, or about 30 microseconds. The amplitude of the waveform (e.g., the amplitudes of the individual pulses) can be from about 0.5-20 mA, or from about 2-18 mA, or from about 5-15 mA, or from about 7-10 mA, or about 0.5-7 mA. The frequency of the signal (or at least a portion of the signal) can be at or below 1.5 kHz, e.g., from about 2 Hz to about 1.5 kHz, or from about 500 Hz to about 1.5 kHz, or from about 700 Hz to about 1.5 kHz, or from about 1 kHz to about 1.5 kHz, or about 1.2 kHz, or from about 500 Hz to about 1.2 kHz. In one representative example, the waveform includes a frequency of 1,200 Hz, a pulse width of 30 microseconds, and an amplitude that provides pain relief without generating paresthesia (generally between 0.5-20 mA).

(21) The method **600** further includes suppressing, inhibiting or otherwise reducing the patient's pain, e.g., chronic low back pain (block **640**). This portion of the method can in turn include reducing pain without unwanted sensory effects and/or limitations (block **641**), and/or without motor effects (block **642**). For example, block **641** can include reducing or eliminating pain without reducing patient perception of other sensations, and/or without triggering additional pain and/or paresthesia. Block **642** can include reducing or eliminating pain without triggering muscle action and/or without interfering with motor signal transmission.

(22) FIG. **2**B illustrates a method **601** that includes features in addition to those described above with reference to FIG. **2**A. For example, the process of applying a short pulse width waveform (block **630**) can include doing so over a wide amplitude range (e.g., over any of the amplitude ranges described immediately above) without creating unwanted side effects, such as undesirable sensations and/or motor interference (block **631**). In another embodiment, the process of applying a short pulse width waveform can include applying the waveform at a fixed amplitude (block **632**).
(23) The process of inhibiting, suppressing or otherwise reducing patient pain (block **640**) can include doing so without creating paresthesia (block **643**), or in association with a deliberately generated paresthesia (block **644**). For example, paresthesia may be used by the practitioner for site selection (e.g., to determine the location at which active electrodes are positioned). In addition to the above, reducing patient pain can include doing so with relative insensitivity to patient attributes that standard SCS is normally highly sensitive to (block **645**). These attributes can include patient movement (block **646**) and/or patient position (block **647**).
(24) FIG. **2**C illustrates a representative waveform **650** having pulses **660** and other characteristics, parameters and/or features in accordance with representative embodiments of the present technology. The pulses **660** can include cathodic phase pulses **651** paired with anodic phase pulses **652**. The cathodic phase pulses **651** can be separated from the anodic phase pulses **652** by an interphase interval **653**. A pulse pair interval **656** can separate one pulse pair (e.g., a cathodic phase pulse **651** paired with an anodic phase pulse **652**) from the next. The frequency of the waveform **650** is generally defined as the inverse of the period **657**. The period **657** is in turn the sum of a cathodic phase pulse width **654**, an anodic phase pulse width **655**, the interphase interval **653** and the pulse pair interval **656**.
(25) The values described above with reference to FIG. **2**A for pulse width can apply to the cathodic phase pulse width **654** and/or the anodic phase pulse width **655**. The cathodic and anodic phase pulse widths **654**, **655** are equal in some embodiments, and unequal in others. In general, the area enclosed by the cathodic phase pulses **651** and the anodic phase pulses **652**, as shown in FIG. **2**C, can be equal. Accordingly, the overall charge applied to the patient as a result of the cathodic phase pulses **651** can be equal and opposite to the overall charge applied to the patient as a result of the anodic phase pulses **652**. This charge balancing approach can reduce or eliminate potential adverse effects associated with charge accumulation within the patient.
(26) In general, e.g., when the cathodic and anodic pulse widths **654**, **655** are equal, the amplitudes of the cathodic phase pulses **651** and the anodic phase pulses **652** are also equal, but in at least some embodiments, the amplitudes can be different. For example, when the pulse widths of the cathodic phase pulses **651** are different than those of the anodic phase pulses **652**, the respective amplitudes of the pulses can also be different, and can be selected to balance the overall charge applied to the patient.
(27) In particular embodiments, the interphase interval **653** can have a value of from about 10 microseconds to about 980 milliseconds. The pulse pair interval **656** can have a value in the range of from about 10 microseconds to about 980 milliseconds. In at least some embodiments, the value of pulse pair interval **656** results from the selection of the cathodic phase pulse width **654**, the anodic phase pulse width **655**, the interphase interval **653** and the period **657**. In other embodiments, the pulse pair interval **656** can be selected first with other parameters (e.g., the interphase interval **653**) being secondary. In still further embodiments, the parameters can be selected in other orders, with the pulse width(s) (anodic and/or cathodic) generally being an independent variable.
(28) FIG. **3** is a schematic illustration of a typical lead placement used during a representative treatment regimen. Two leads **111** (shown as a first lead **111***a* and a second lead **111***b*) can be positioned generally end-to-end to provide a modulation capability that extends over several vertebral levels of the patients' spine. The leads **111***a*, **111***b* can be positioned to overlap slightly, to account for possible shifts in lead location. During the course of the therapy, contacts C of the two leads **111***a*, **111***b* can be activated on one lead at a time. In other words, the contacts C of only one lead **111** can be active at any one time, and signals need not directed between the contacts C located on different leads **111**. While two leads can be used is some cases, it is expected that in other cases, a single lead can be positioned at the appropriate vertebral level. The lead can have more widely spaced contacts to achieve the same or similar effects as those described herein as will be described in greater detail below with reference to FIG. **4**.
(29) The contacts C of each lead **111***a*, **111***b* have a width W**2** of approximately 3 mm, and are separated from each other by a distance D**1** of approximately 1 mm. Accordingly, the center-to-center spacing S between neighboring contacts C is approximately 4 mm. The leads **111***a*, **111***b* can be positioned at or close to the patients' spinal midline **189**. In a representative embodiment one lead can be positioned on one side of the midline **189**, and the other lead can be positioned on the other side of the patients' midline **189**. The leads **111***a*, **111***b* can be positioned at any of a variety of locations within a relatively wide window W**1** having an overall width of +3-5 mm from the midline **189** (e.g., an overall width of 6-10 mm), without significantly affecting the efficacy of the treatment.
(30) In one embodiment, one or more of the above-described waveform parameters and lead placements are used to produce an incomplete conduction block (e.g., an incomplete block of afferent and/or efferent signal transmission) at the dorsal root level. This block may occur at the dorsal column, dorsal horn, and/or dorsal root entry zone, in

addition to or in lieu of the dorsal root. In any of these cases, the conduction block is selective to and/or preferentially affects the smaller Aδ and/or C fibers and is expected to produce a decrease in excitatory inputs to the second order neurons, thus producing a decrease in pain signals supplied along the spinal thalamic tract.

(31) In another embodiment, one or more of the above-described waveform parameters and lead placements are used to activate an interneuron pool and thus increase the inhibition of inputs into second order neurons. This activation can, in effect, desensitize the second order neurons and convert them closer to a normal state before the effects of the chronic pain associated signals have an effect on the patient.

(32) In still another embodiment, one or more of the above-described waveform parameters and lead placements are used to reduce the hypersensitivity of neurons by restoring or moving the “baseline” of the neural cells in chronic pain patients toward the normal baseline and firing frequency of non-chronic pain patients. This effect can in turn reduce the sensation of pain in this patient population without affecting other neural transmissions (for example, touch, heat, etc.).

(33) In another embodiment, one or more of the above-described waveform parameters and lead placements are used to (1) reduce neural transmissions entering the spinal cord at the dorsal root and/or the dorsal root entry zone, and/or (2) reduce neural activity at the dorsal horn itself. It is generally known that chronic pain patients may be in a state of prolonged sensory sensitization at both the nociceptive afferent neurons (e.g., a peripheral nerve and its associated dorsal root) and at higher order neural systems (e.g., the dorsal horn neuron). It is also known that the dorsal horn neurons (e.g., the width dynamic range or WDR cells) are sensitized in chronic pain states. Chronic pain can be associated with an acute “windup” of the WDR cells (e.g., to a hyperactive state). It is believed that the therapy signals applied using the disclosed parameters may be used to reduce pain by reducing, suppressing, and/or attenuating the afferent nociceptive inputs delivered to the WDR cells, as it is expected that these inputs, unless attenuated, can be responsible for the sensitized state of the WDR cells. In one embodiment, the disclosed parameters may be used to act directly on the WDR cells to desensitize these cells. The effect of the presently disclosed therapy on peripheral inputs may produce short term pain relief, and the effect on the WDR cells may produce longer term pain relief.

(34) In one embodiment, one or more of the above-described waveform parameters and lead placements are used to modulate glial cells in the nervous system. Glial cells were traditionally thought to play primarily a structural role in the nervous system, for example by surrounding neurons, holding neurons in place, providing electrical insulation, and destroying pathogens. However, in recent years it has been suggested that glial cells play a role in the transmission of chronic pain by releasing various mediators such as nitric oxide, pro-inflammatory cytokines, excitatory amino acids, and prostaglandins. Release of these mediators can cause the release of substance P and excitatory amino acids by peripheral nerves, which in turn results in action potential generation. Substance P and excitatory amino acid release can also further activate glial cells, creating a positive feedback loop. Glial cells communicate via slow inward calcium currents, which are activated by a variety of factors including potassium. The short pulse width waveform parameters disclosed herein may be used to reduce extracellular potassium levels by primary afferent inhibition, thereby reducing glial cell activity. The short pulse width waveform parameters disclosed herein may also be used to produce pain reduction in part by changing the conductance of fast sodium channels in neurons and/or glial cells, thereby specifically down-regulating those sodium channels that are most involved with chronic pain.

(35) As disclosed herein, short pulse width electrical modulation can be used to normalize pathological neural networks associated with fast sodium channel activity and/or expression by attenuating pathology-induced sodium channel activity and modulating glial neuronal cell interaction (GNI). Based on this, the present application provides methods and devices for attenuating pathology-induced sodium channel activity, modulating GNI, and treating various conditions associated with fast sodium channel activity and/or expression and GNI.

(36) In certain embodiments, methods are provided for attenuating pathology-induced sodium channel activity by applying short pulse width electrical stimulation to a target tissue or organ (e.g., the spinal cord). This attenuation may result in decreased activity and/or expression of one or more fast sodium channels, including for example NaV1.8 or NaV1.9. In certain embodiments, decreased activity and/or expression of one or more fast sodium channels results in decreased glial cell and/or neuronal activity. In certain embodiments, attenuation of pathology-induced sodium channel activity may also result in increased activity and/or expression of one or more slow sodium channels, including for example NaV1.3.

4.0 Expected Benefits Associated With Certain Embodiments

(37) As discussed above, an expected benefit of short pulse width waveforms (e.g., having pulse widths within the ranges described above) is that when applied at the appropriate amplitude, to the appropriate neural population, such pulses can effectively reduce or eliminate patient pain without the signal producing, creating, or generating paresthesia. In addition to providing pain relief without paresthesia, such waveforms can produce pain relief with less power than is required for waveforms having longer pulse widths, depending upon the values selected for other signal delivery parameters.

(38) In any of the foregoing embodiments, aspects of the therapy provided to the patient may be varied within or outside the parameters described above, while still obtaining beneficial results for patients suffering from chronic pain (e.g., chronic lower back pain, chronic leg pain, chronic limb pain, etc.). For example, the location of the lead body (and in particular, the lead body electrodes or contacts) can be varied over the significant lateral and/or axial ranges described above. Other characteristics of the applied signal can also be varied. For example, the frequency of the signal (or at least a portion of the signal) can be at or below 1.5 kHz, e.g., from about 2 Hz to about 1.5 kHz, or from about 500 Hz to about 1.5 kHz, or from about 700 Hz to about 1.5 kHz, or from about 1 kHz to about 1.5 kHz, or about 1.2 kHz, or from about 500 Hz to about 1.2 kHz. The amplitude of the signal can range from about 0.1 mA to about 20 mA in a particular embodiment, and in further particular embodiments, can range from about 0.5 mA to about 10 mA, or about 0.5 mA to about 7 mA, or about 0.5 mA to about 5 mA. The amplitude of the applied signal can be ramped up and/or down. In particular embodiments, the amplitude can be increased or set at an initial level to establish a therapeutic effect, and then reduced to a lower level to save power without forsaking efficacy. In particular embodiments, the signal amplitude refers to the electrical current level, e.g., for current-controlled systems. In other embodiments, the signal amplitude can refer to the electrical voltage level, e.g., for voltage-controlled systems. In particular embodiments, the signal (or at least a portion of the signal) can have pulses with pulse widths ranging from about 10-50 microseconds, or from about 20-40 microseconds, or from about 25-35 microseconds, or from about 30-35 microseconds, or about 30 microseconds. The specific values selected for the foregoing parameters may vary from patient to patient and/or from indication to indication and/or on the basis of the selected vertebral location. In addition, the methodology may make use of other parameters, in addition to or in lieu of those described above, to monitor and/or control patient therapy. For example, in cases for which the pulse generator includes a constant voltage arrangement rather than a constant current arrangement, the current values described above may be replaced with corresponding voltage values. In another example, it is expected that the signal can have short pulse widths over a wide range of frequencies while producing pain relief without paresthesia. For example, pulse widths of 10-50 microseconds may be used to produce such results at frequencies ranging from about 2 Hz to about 1,500 Hz.

(39) Patients can receive multiple signals in accordance with still further embodiments of the disclosure. For example, patients can receive two or more signals, each with different signal delivery parameters. In one particular example, the signals are interleaved with each other. In other embodiments, patients can receive sequential “packets” or “bursts” of pulses at different frequencies, with each packet having a duration of less than one second, several seconds, several minutes, or longer depending upon the particular patient and indication.

(40) In still further embodiments, the duty cycle can be from about 50%-100%. In further embodiments, the duty cycle can have a value of less than 50%, e.g., at or less than 20% or at or less than 10%. In yet another embodiment, the duty cycle parameters can be set to 2 seconds on, 20 seconds off. In still further embodiments, the duty cycle parameters can be set to 20 seconds on, 120 seconds off.

5.0 Representative Lead Configurations

(41) FIG. **4** is a partially schematic illustration of a lead **910** having first and second contacts C**1**, C**2** positioned to deliver modulation signals in accordance with particular embodiments of the disclosure. The contacts are accordingly positioned to contact the patient's tissue when implanted. The lead **910** can include at least two first contacts C**1** and at least two second contacts C**2** to support bipolar modulation signals via each contact grouping. In one aspect of this embodiment, the lead **910** can be elongated along a major or lead axis A, with the contacts C**1**, C**2** spaced equally from the major axis A. In general, the term elongated refers to a lead or other signal delivery element having a length (e.g., along the spinal cord) greater than its width. The lead **910** can have an overall length L (over which active contacts are positioned) that is longer than that of typical leads. In particular, the length L can be sufficient to position first contacts C**1** at one or more vertebral locations (including associated neural populations), and position the second contacts C**2** at another vertebral location (including associated neural populations) that is spaced apart from the first and that is superior the first. For example, the first contacts C**1** may be positioned at vertebral levels T8-T12 to treat low back pain, and the second contacts C**2** may be positioned at superior vertebral locations (e.g., cervical locations) to treat arm pain. Representative lead lengths are from about 30 cm to about 150 cm, and in particular embodiments, from about 40 cm to about 50 cm. Pulses may be applied to both groups of contacts in accordance with several different arrangements. For example pulses provided to one group may be interleaved with pulses applied to the other, or the same signal may be rapidly switched from one group to the other. In other embodiments, the signals applied to individual contacts, pairs of contacts, and/or contacts in different groups may be multiplexed in other manners. In any of these embodiments, each of the contacts C**1**, C**2** can have an appropriately selected surface area, e.g., in the range of from about 3 mm.sup.2 to about 25 mm.sup.2, and in particular embodiments, from about 8 mm.sup.2 to about 15 mm.sup.2. Individual contacts on a given lead can have different surface area values, within the foregoing ranges, than neighboring or other contacts of the lead, with values selected depending upon features including the vertebral location of the individual contact.

(42) Another aspect of an embodiment of the lead **910** shown in FIG. **4** is that the first contacts C**1** can be spaced

apart (e.g., closest edge to closest edge) by a first distance S**1** that is greater than a corresponding second distance S**2** between immediately neighboring second contacts C**2**. In a representative embodiment, the first distance S**1** can range from about 3 mm up to a distance that corresponds to one-half of a vertebral body, one vertebral body, or two vertebral bodies (e.g., about 16 mm, 32 mm, or 64 mm, respectively). In another particular embodiment, the first distance S**1** can be from about 5 mm to about 15 mm. This increased spacing can reduce the complexity of the lead **910**, and can still provide effective treatment to the patient. In still further embodiments, the inferior first contacts C**1** can have the close spacing S**2**, and the superior second contacts C**2** can have the wide spacing S**1**, depending upon patient indications and/or preferences. In still further embodiments, as noted above, contacts at both the inferior and superior locations can have the wide spacing. In other embodiments, the lead **910** can include other arrangements of different contact spacings, depending upon the particular patient and indication. For example, the widths of the second contacts C**2** (and/or the first contacts C**1**) can be a greater fraction of the spacing between neighboring contacts than is represented schematically in FIG. **4**. The distance S**1** between neighboring first contacts C**1** can be less than an entire vertebral body (e.g., 5 mm or 16 mm) or greater than one vertebral body while still achieving benefits associated with increased spacing, e.g., reduced complexity. The lead **910** can have all contacts spaced equally (e.g., by up to about two vertebral bodies), or the contacts can have different spacings, as described above. Two or more first contacts C**1** can apply modulation at one vertebral level (e.g., T9) while two or more additional first contacts C**1** can provide modulation at the same or a different frequency at a different vertebral level (e.g., T10).

(43) In some cases, it may be desirable to adjust the distance between the inferior contacts C**1** and the superior contacts C**2**. For example, the lead **910** can have a coil arrangement (like a telephone cord) or other length-adjusting feature that allows the practitioner to selectively vary the distance between the sets of contacts. In a particular aspect of this arrangement, the coiled portion of the lead can be located between the first contacts C**1** and the second contacts C**2**. For example, in an embodiment shown in FIG. **5**A, the lead **910** can include a proximal portion **910***a* carrying the first contacts C**1**, a distal portion **910***c* carrying the second contacts C**2**, and an intermediate portion **910***b* having a pre-shaped, variable-length strain relief feature, for example, a sinusoidally-shaped or a helically-shaped feature. The lead **910** also includes a stylet channel or lumen **915** extending through the lead **910** from the proximal portion **910***a* to the distal portion **910***c*.

(44) Referring next to FIG. **5**B, the practitioner inserts a stylet **916** into the stylet lumen **915**, which straightens the lead **910** for implantation. The practitioner then inserts the lead **910** into the patient, via the stylet **916**, until the distal portion **910***c* and the associated second contacts C**2** are at the desired location. The practitioner then secures the distal portion **910***c* relative to the patient with a distal lead device **917***c*. The distal lead device **917***c* can include any of a variety of suitable remotely deployable structures for securing the lead, including, but not limited to an expandable balloon.

(45) Referring next to FIG. **5**C, the practitioner can partially or completely remove the stylet **916** and allow the properties of the lead **910** (e.g., the natural tendency of the intermediate portion **910***b* to assume its initial shape) to draw the proximal portion **910***a* toward the distal portion **910***c*. When the proximal portion **910***a* has the desired spacing relative to the distal portion **910***c*, the practitioner can secure the proximal portion **910***a* relative to the patient with a proximal lead device **917***a* (e.g., a suture or other lead anchor). In this manner, the practitioner can select an appropriate spacing between the first contacts C**1** at the proximal portion **910***a* and the second contacts C**2** at distal portion **910***c* that provides effective treatment at multiple patient locations along the spine.

(46) FIG. **6**A is an enlarged view of the proximal portion **910***a* of the lead **910**, illustrating an internal arrangement in accordance with a particular embodiment of the disclosure. FIG. **6**B is a cross-sectional view of the lead **910** taken substantially along line **11**B-**11**B of FIG. **6**A. Referring now to FIG. **6**B, the lead **910** can include multiple conductors **921** arranged within an outer insulation element **918**, for example, a plastic sleeve. In a particular embodiment, the conductors **921** can include a central conductor **921***a*. In another embodiment, the central conductor **921***a* can be eliminated and replaced with the stylet lumen **915** described above. In any of these embodiments, each individual conductor **921** can include multiple conductor strands **919** (e.g., a multifilar arrangement) surrounded by an individual conductor insulation element **920**. During manufacture, selected portions of the outer insulation **918** and the individual conductor insulation elements **920** can be removed, thus exposing individual conductors **921** at selected positions along the length of the lead **910**. These exposed portions can themselves function as contacts, and accordingly can provide modulation to the patient. In another embodiment, ring (or cylinder) contacts are attached to the exposed portions, e.g., by crimping or welding. The manufacturer can customize the lead **910** by spacing the removed sections of the outer insulation element **918** and the conductor insulation elements **920** in a particular manner. For example, the manufacturer can use a stencil or other arrangement to guide the removal process, which can include, but is not limited to, an ablative process. This arrangement allows the same overall configuration of the lead **910** to be used for a variety of applications and patients without major changes. In another aspect of this embodiment, each of the conductors **921** can extend parallel to the others along the major axis of the lead **910** within the outer insulation **918**, as opposed to a braided or coiled arrangement. In addition, each of the conductor strands **919** of an individual conductor element **920** can extend parallel to its

neighbors, also without spiraling. It is expected that these features, alone or in combination, will increase the flexibility of the overall lead **910**, allowing it to be inserted with a greater level of versatility and/or into a greater variety of patient anatomies then conventional leads.

(47) FIG. **6**C is a partially schematic, enlarged illustration of the proximal portion **910***a* shown in FIG. **6**A. One expected advantage of the multifilar cable described above with reference to FIG. **6**B is that the impedance of each of the conductors **921** can be reduced when compared to conventional coil conductors. As a result, the diameter of the conductors **921** can be reduced and the overall diameter of the lead **910** can also be reduced. One result of advantageously reducing the lead diameter is that the contacts C**1** may have a greater length in order to provide the required surface area needed for effective modulation. If the contacts C**1** are formed from exposed portions of the conductors **921**, this is not expected to present an issue. If the contacts C**1** are ring or cylindrical contacts, then in particular embodiments, the length of the contact may become so great that it inhibits the practitioner's ability to readily maneuver the lead **910** during patient insertion. One approach to addressing this potential issue is to divide a particular contact C**1** into multiple sub-contacts, shown in FIG. **6**C as six sub-contacts C**1***a*-C**1***f*. In this embodiment, each of the individual sub-contacts C**1***a*-C**1***f* can be connected to the same conductor **921** shown in FIG. **6**B. Accordingly, the group of sub-contacts connected to a given conductor **921** can operate essentially as one long contact, without inhibiting the flexibility of the lead **910**.

(48) As noted above, one feature of the foregoing arrangements is that they can be easy to design and manufacture. For example, the manufacturer can use different stencils to provide different contact spacings, depending upon specific patient applications. In addition to or in lieu of the foregoing effect, the foregoing arrangement can provide for greater maneuverability and facilitate the implantation process by eliminating ring electrodes and/or other rigid contacts, or dividing the contacts into subcontacts. In other embodiments, other arrangements can be used to provide contact flexibility. For example, the contacts can be formed from a conductive silicone, e.g., silicone impregnated with a suitable loading of conductive material, such as platinum, iridium or another noble metal.

(49) Yet another feature of an embodiment of the lead shown in FIG. **4** is that a patient can receive effective therapy with just a single bipolar pair of active contacts. If more than one pair of contacts is active, each pair of contacts can receive the identical waveform, so that active contacts can be shorted to each other. In another embodiment, the implanted pulse generator (not visible in FIG. **4**) can serve as a return electrode. For example, the pulse generator can include a housing that serves as the return electrode, or the pulse generator can otherwise carry a return electrode that has a fixed position relative to the pulse generator. Accordingly, the modulation provided by the active contacts can be unipolar modulation, as opposed to the more typical bipolar stimulation associated with standard SCS treatments.

6.0 Representative Modulation Locations and Indications

(50) Many of the embodiments described above were described in the context of treating chronic, neuropathic low back pain with modulation signals applied to the lower thoracic vertebrae (T8-T12). In other embodiments, modulation signals having parameters (e.g., frequency, pulse width, amplitude, and/or duty cycle) generally similar to those described above can be applied to other patient locations to address other indications. For example, while the foregoing methodologies included applying modulation at lateral locations ranging from the spinal cord midline to the DREZ, in other embodiments, the modulation may be applied to the foramen region, laterally outward from the DREZ. In other embodiments, the modulation may be applied to other spinal levels of the patient. For example, modulation may be applied to the sacral region and more particularly, the “horse tail” region at which the sacral nerves enter the sacrum. Urinary incontinence and fecal incontinence represent example indications that are expected to be treatable with modulation applied at this location. In other embodiments, the modulation may be applied to other thoracic vertebrae. For example, modulation may be applied to thoracic vertebrae above T8. In a particular embodiment, modulation may be applied to the T3-T6 region to treat angina. Modulation can be applied to high thoracic vertebrae to treat pain associated with shingles. Modulation may be applied to the cervical vertebrae to address chronic regional pain syndrome and/or total body pain, and may be used to replace neck surgery. Suitable cervical locations include vertebral levels C3-C7, inclusive. In other embodiments, modulation may be applied to the occipital nerves, for example, to address migraine headaches.

(51) As described above, modulation in accordance with the foregoing parameters may also be applied to treat acute and/or chronic nociceptive pain. For example, modulation in accordance with these parameters can be used during surgery to supplement and/or replace anesthetics (e.g., a spinal tap). Such applications may be used for tumor removal, knee surgery, and/or other surgical techniques. Similar techniques may be used with an implanted device to address post-operative pain, and can avoid the need for topical lidocaine. In still further embodiments, modulation in accordance with the foregoing parameters can be used to address other peripheral nerves. For example, modulation can be applied directly to peripheral nerves to address phantom limb pain.

(52) From the foregoing, it will be appreciated that specific embodiments of the disclosure have been described herein for purposes of illustration, but that various modifications may be made without deviating from the disclosure. For example, the specific parameter ranges and indications described above may be different in further

embodiments. The lead described above with reference to FIGS. **4**-**6**C can have more than two groups of contacts, and/or can have other contact spacings in other embodiments. In some embodiments, as described above, the signal amplitude applied to the patient can be constant. In other embodiments, the amplitude can vary in a preselected manner, e.g., via ramping up/down, and/or cycling among multiple amplitudes. The signal delivery elements can have an epidural location, as discussed above with regard to FIG. **1**B, and in other embodiments, can have an extradural location. In particular embodiments described above, signals having the foregoing characteristics are expected to provide therapeutic benefits for patients having low back pain and/or leg pain, when stimulation is applied at vertebral levels from about T8 to about T12. In at least some other embodiments, it is believed that this range can extend from about T5 to about L1.

(53) Certain aspects of the disclosure described in the context of particular embodiments may be combined or eliminated in other embodiments. For example, therapies directed to particular indications may be combined in particular embodiments. Further, while advantages associated with certain embodiments have been described in the context of those embodiments, other embodiments may also exhibit such advantages, and not all embodiments need necessarily exhibit such advantages to fall within the scope of the present disclosure. Accordingly, the present disclosure and associated technology can encompass other embodiments not expressly shown or described herein.

Claims

1. A method for reducing or eliminating pain in a patient, without causing paresthesia in the patient, the method comprising: programming a computer-readable medium of an implantable signal generator to: generate a non-paresthesia-producing therapy signal, wherein at least a portion of the therapy signal is at a frequency of from 2 Hz to 1,000 Hz, with a pulse width in a pulse width range from 10 microseconds to 50 microseconds, and a current amplitude in a current amplitude range from 0.5 mA to 20 mA; and transmit the therapy signal to the dorsal column of the patient's spinal cord via a signal delivery device implanted in the patient's epidural space and electrically coupled to the implanted signal generator.
2. The method of claim 1, wherein the therapy signal has a duty cycle.
3. The method of claim 2, wherein the duty cycle is 100%.
4. The method of claim 2, wherein the duty cycle is 50-100%.
5. The method of claim 2, wherein the frequency is applied throughout the length of an on period in the duty cycle.
6. The method of claim 2, wherein the frequency is applied during a portion of an on period in the duty cycle.
7. The method of claim 1, wherein the therapy signal has a current amplitude of about 2.5 mA.
8. The method of claim 1, wherein at least a portion of the therapy signal is a square-wave signal.
9. The method of claim 1, wherein the signal delivery device is a percutaneous lead.
10. The method of claim 1, wherein the signal delivery device is a paddle lead.
11. The method of claim 1, wherein the signal delivery device is an elongated lead having one or more electrodes.
12. The method of claim 1, wherein the signal delivery device is an elongated lead having a bipole arrangement of electrodes.
13. The method of claim 1, wherein programming the computer-readable medium includes programming the computer-readable medium to transmit the therapy signal to modulate glial cell activity at the patient's spinal cord.
14. The method of claim 1, wherein the pulse width is in a pulse width range from 20 microseconds to 40 microseconds.
15. The method of claim 1, wherein the current amplitude is in a current amplitude range from 0.5 mA to 7 mA.
16. The method of claim 1, wherein the current amplitude is in a current amplitude range from 0.5 mA to 5 mA.
17. The method of claim 1, wherein the current amplitude is in a current amplitude range from 0.5 mA to 2 mA.
18. A spinal cord stimulation system for reducing or eliminating pain in a patient, the system comprising: an implantable signal generator programmed to generate a non-paresthesia-producing therapy signal, wherein at least a portion of the therapy signal is at a frequency of from 2 Hz to 1,000 Hz, with a pulse width in a pulse width range from 10 microseconds to 50 microseconds, and a current amplitude in a current amplitude range from 0.5 mA to 7 mA; and a signal delivery device electrically coupled to the implantable signal generator to deliver the therapy signal to the dorsal column of the patient's spinal cord.
19. The system of claim 18, wherein the implantable signal generator generates the therapy signal at a duty cycle.
20. The system of claim 19, wherein the duty cycle is 100%.
21. The system of claim 19, wherein the duty cycle is 50-100%.
22. The system of claim 19, wherein the frequency is applied throughout the length of an on period in the duty cycle.
23. The system of claim 19, wherein the frequency is applied during a portion of an on period in the duty cycle.
24. The system of claim 18, wherein the therapy signal is delivered at a current amplitude of 2.5 mA.
25. The system of claim 18, wherein at least a portion of the therapy signal is a square-wave signal.
26. The system of claim 18, wherein the signal delivery device is a percutaneous lead.

27. The system of claim 18, wherein the signal delivery device is a paddle lead.
28. The system of claim 18, wherein the signal delivery device is an elongated lead having one or more electrodes.
29. The system of claim 18, wherein the signal delivery device is an elongated lead having a bipole arrangement of electrodes.