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(54) **Multichannel stimulator electronics**

Elektronische Mehrkanalschaltungsanordnung für Gewebestimulator

Système électronique multicanaux destiné à un stimulateur

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Description**BACKGROUND AND SUMMARY OF THE INVENTION**

[0001] The present invention relates to a tissue stimulation system.

[0002] The concept of using electronic stimulation systems for the purpose of controlling nerves or muscles is well known. These systems typically utilize an implantable or an external pulse generator. The external systems consist of a transmitter and antenna which transmits energy and/or stimulation signals transcutaneously through a patient's skin to an implanted receiver. The receiver provides signal processing of the received pulses and transmits the energy derived therefrom to activate electrodes implanted adjacent to specific types of tissue to be stimulated. A system like the one described above has been disclosed previously in U.S. Patent 3,727,616. It is also known in prior art where more than one pair of electrodes are activated such as Patent 3,449,768.

[0003] Problems arise in these prior art systems where electrode placement fails to provide the desired physical response. It may also occur later if a change in patient condition or change in electrode position occurs. This failure may also be caused by improper polarity of the stimulated electrodes relative to one another. Furthermore, it is often required that the electrodes be implanted surgically adjacent to one or more nerve fibers. This type of procedure involves inherent risks due to the fact that it is often performed in close proximity to the brain or spinal cord or other sensitive nerves or tissues. It is therefore desirable to perform the electrode implantation only once to minimize the surgical risks to the patient as well as the financial burdens.

[0004] Moreover, even when a plurality of electrodes have been utilized, such that repeated surgical procedures are not required, the prior art systems did not provide for dynamic programming and reprogramming of different electrodes after surgery until U.S. Patent 4,459,989 to Borkan. The Borkan patent '989 disclosed an external stimulator system which allowed noninvasive programming of the stimulated electrodes. Each electrode was capable of assuming a positive, negative or open circuit status with respect to the other electrodes. This effectively allowed the electrodes to be "repositioned" non-invasively. That same programming ability (plus/minus/off) was later applied to totally implantable systems as well. The system had mono/biphasic control also.

[0005] Further improvements are described in U.S. Patent 4,612,934 also to Borkan. The Borkan patent '934 provides programming to the surgically implanted stimulator receiver to define electrode selection and polarity and stimulation pulse parameters. The pulse parameters included frequency, amplitude and pulse width. The impedance of the electrodes are measured and used to modify the programmed stimulation pulse as were inputs from measured physical parameters. A single stimulation

pulse was developed and provided to any or all the selected electrode combinations. There was not the ability to provide individual pulses simultaneously to different selected electrodes. Also, the impedance of the individual electrodes were not measured, but only the electrodes as a group.

[0006] An apparatus for controlling and steering an electric field for nerve stimulation with the features included in the first part of claim 1 is described in U.S. Patent 5,895,415.

[0007] Another neural stimulation technique with feedback is described in U.S. Patent 5,913,882.

[0008] An edge-effect electrode producing spatially controlled distributions of electric potentials in volume conductive media is described in U.S. Patent 5,649,970. A plurality of electrodes are spaced along an elongated stimulation lead.

[0009] The tissue stimulation system in accordance with the present invention is defined in claim 1, preferred embodiments being set forth in the dependent claims. Other embodiments described in the following are not encompassed by the present invention.

[0010] A tissue stimulation system includes an electrode assembly having at least three electrodes spaced to be stimulated in a patient. A programmable stimulator is connected to and provides stimulation pulses to the electrode assembly. Programming data in the stimulator define, for each of the electrodes, individual stimulation pulses of varying polarity and at least one of amplitude, frequency, pulse width and pulse shape.

[0011] The stimulator may include a pulse generator for each of the electrodes, or a common pulse generator for all the electrodes and a variable impedance circuitry for each of the electrodes. A variable impedance circuit may include a voltage divider or an analog switch, for example. The stimulator would individually control the amplitude and pulse width using the variable impedance circuit.

[0012] The stimulator can measure the impedance of each of the electrodes and modifies the stimulation pulse for each electrode defined by the programming data as a function of the measured impedance of that electrode.

[0013] Also, the stimulator may measure physical or physiological parameters and modifies the stimulation pulse for each electrode defined by the parameter data as a function of the measured parameters. The measured parameters may include one of the following: EMG, EKG, or EEG measurements. The measurement circuit may include chemical or biochemical sensors. The stimulator includes a signal input and modifies the stimulation pulses as a function of input signals on the signal input. The input signals may include processed audio or visual signals.

[0014] The stimulator may determine the position of the electrode from the measured parameters and modifies the stimulation pulses as a function of the determined position. A display is provided for showing the determined position.

[0015] An additional electrode spaced from the at least three electrodes is provided. The additional electrode has a surface area greater than the surface area of each of the at least three electrodes. The additional electrode is at least twice the surface area of each of the at least three electrodes. The additional electrode is spaced from the at least three electrode by at least 10 millimeters.

[0016] The programming data defines bipolar mode, monopolar mode and simultaneous bipolar/monopolar mode stimulation. The bipolar mode uses at least two of the at least three electrodes and the monopolar mode uses the additional electrode as an anode electrode and at least one of the at least three electrodes as a cathode electrode.

[0017] The present tissue stimulation system maybe used to perform a method of tissue stimulation by positioning the electrode assembly with the electrodes lying along a tissue to be stimulated in the patient and the stimulator connected to the electrodes. Stimulation pulses are provided from the stimulator to the at least three electrodes with independently assigned polarity and at least one of amplitude, frequency, pulse width and pulse shape. The stimulator may be external or preferably implanted.

[0018] The method may further include measuring the series impedance of each of the electrodes and modifying the stimulation pulse for each electrode defined as a function of the measured impedance of that electrode.

[0019] Additionally, physical or physiological parameters can be measured and the simulation pulse modified for each electrode defined as a function of the measured parameters. The measured parameters may include one of the following: EMG, EKG, or EEG measurements. Information may be obtained from at least one of pulmonary, cardiac or neuro monitors; and the stimulation pulses are modified as a function of the information and measured parameters.

[0020] Additionally, the relative position of the electrodes to the desired tissue to be stimulated may be determined using the measured parameters. The determined electrode's relative position may be displayed. The display may show overlays of an image of the desired electrode position and/or movement on an x-ray or fluoroscopic image. The system provides feedback to a physician as the electrode is moved in real time.

[0021] The stimulation pulses may be modified as a function of the relative position. The measuring may include EMG measurements of specific muscles. The stimulation pulses are modified to determine the relative position of one or more of the individual electrodes.

[0022] The method may also include simultaneously providing stimulation pulses to at least two of the at least three electrodes in a bipolar mode and to an additional electrode as an anode and at least one of the at least three electrodes as a cathode in a monopolar mode.

[0023] Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when con-

sidered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

5 **[0024]**

Figure 1 is a block diagram of a stimulator system. Figure 2 is a block diagram of a first embodiment of portions of stimulator system using individual pulse generators for each electrode.

10 Figure 3 is a block diagram of a portion of the stimulator including a common pulse generator with individual pulse width and amplitude modification for each electrode.

15 Figure 4 is a block diagram of an output circuit.

Figure 5 is a schematic of an embodiment of a polarity switch.

Figure 6 is a perspective view of a lead with an additional electrode.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] Current neurostimulation leads are placed in or near the spinal cord, brain or individual nerves and the power required to generate functional stimulation is determined directly by the size, shape, material, configuration and orientation of the active electrode contacts. Decreasing the surface area of the electrode results in decreased power requirements from the stimulator in order to create the same functional effect due to increased field density.

[0026] Electrodes used for spinal cord stimulation are typically implanted in the epidural space. This is done for various reasons, including reduced complexity of the surgery, reduced potential complications, an increased stability of the implant. However, implantation in the epidural space requires a significant amount of additional stimulation power since the signal must be transmitted through the dura and cerebrospinal fluid in order to reach its desired neural targets in the spinal cord.

[0027] Limitations of the currently available systems to refine the delivered stimulation field often lead to ineffective therapy and/or additional surgical intervention. Current state of the art systems use reprogramming of relative electrode polarity to effectively "move" the stimulation field non-invasively. The object of the present invention is to provide additional and more sensitive methods to move the stimulation field (and therefore the activated neural fibers and tissues) to achieve effective therapy.

[0028] The present invention alters the size, shape, and position of the electrical field by changing the relative amplitude or impedance of the stimulation pulse for the stimulated electrodes individually. For instance, if four electrodes are activated-two as cathodes and two as anodes - the electrical field may be altered by changing the relative amplitude, pulse width and/or pulse shape deliv-

ered to the individual electrodes.

[0029] Many applications of electrical stimulation in nervous tissue (including the brain, spinal cord, auditory and visual nerve fibers) require very precise positioning of the electrical field to achieve the desired effects. Further advances in the treatment of spinal cord injury and treatment of paralyzed limbs will also require highly refined methods of activating targeted tissues and nerve fibers.

[0030] The present invention provides the highly refined targeting capabilities for optimal therapeutic results. Use of independent amplitude control allows reprogramming of an electrode array to compensate for less than optimal position relative to the targeted neural fibers. For instance, two catheters placed off the midline of the spinal cord may stimulate undesirable nerve roots at the levels required to activate desired longitudinal fibers making it impossible to achieve acceptable therapeutic results with a conventional stimulator. By changing the relative amplitude of the stimulation pulse for the electrodes individually the stimulation field can be moved to avoid activating the undesirable fibers.

[0031] Some nerve fibers are more sensitive to different pulse shapes or pulse widths. Altering these parameters for each electrode individually allows more selective activation of desired neural targets while minimizing activation of undesirable structures.

[0032] The method could further include measuring certain physical or physiological parameters and modifying the stimulation pulses based on these measurements. For instance, during implantation of a spinal cord stimulator, placement of the electrode at a specific dermatomal location and/or lateral position relative to the spinal cord is critical. Measurement of stimulation induced muscle contractions by a series of individually generated stimulation pulses can be performed such that a system to indicate when the desired location is achieved based on physiological measurements becomes practical. Without individual pulse parameter control, this procedure would be time consuming, impractical and in many instances impossible.

[0033] A stimulator 10 is shown in Figure 1 as including a microprocessor and control circuit 20 having programming data 22 stored therein. The programming data determines which electrodes are to be stimulated, the polarity of the electrodes relative to each other, and the stimulator pulse to be applied to each of the individual electrodes defined. Although the programming data is shown stored in the circuit, it could be stored externally or downloaded from an external source via interface 25. The data may be downloaded on a pulse to pulse basis, for instance in an auditory or visual prosthetic application.

[0034] The microprocessor and control circuit 20 may also include measurement circuits to measure the impedance of each electrode through electrode impedance measurement circuit 24 which senses the impedance of each of the individual electrode. It may also monitor physical or physiological parameters using measurement cir-

cuit 26. The measurement circuit 26 may include chemical or biochemical sensors. These physical parameters may be biological parameters or other information. The measured parameters may include one of the following: EMG, EKG, or EEG measurements received via interface 25. Information may be obtained via interface 25 from at least one of pulmonary, cardiac or neuro monitors.

[0035] Additionally, the relative position of the electrodes to the desired tissue to be stimulated may be determined using the measured parameters. The stimulation pulses may be modified as a function of the relative position. The measuring may include EMG measurements of specific muscles. The stimulation pulses are modified to determine the relative position of one or more of the individual electrodes. The determined electrode's relative position may be displayed. The display 27 may show overlays an image of the desired electrode position and/or movement on an x-ray or fluoroscopic image. The system provides feedback to a physician as the electrode is moved in real time.

[0036] The microprocessor and control circuit 20 may modify the programming data 22 based on one or all of these measured parameters as well as the determined position. This will vary which electrodes are to be stimulated, their polarity relative to each other and the stimulation pulse for each of the individual electrodes. The measured parameters may be stored and/or transmitted via the interface 25.

[0037] Control information is provided from the microprocessor and control circuit 20 to a pulse generator 30 via line 28 and to an output circuit 40 via line 29 for each electrode. The pulse generator 30 provides a stimulation pulse to the output circuit 40 via line 31. The outputs 50 of the output circuits 40 are connected to individual electrodes. There is a pulse generator 30 and an output circuit 40 for each of the individual electrodes. Three are shown for sake of clarity. This system allows each of the individual electrodes to have its individually defined pulse generator.

[0038] Figure 2 shows further details of the pulse generator 30 and the output circuit 40. The pulse generator 30 includes also a pulse amplitude defining circuit 32, pulse shape defining circuit 34, frequency defining circuit 36 and a pulse width defining circuit 38. Control of each of these are from the microprocessor and control circuit 20 via line 28.

[0039] The output circuit 40 also includes an electrode polarity circuit 42 receiving controls from the microprocessor and control circuit 20 via line 29. The output of the electrode polarity circuit 42 is provided via line 41 to the output switch 44. The pulse on line 31 from the pulse generator 30 may be transmitted by the output switch 44 to the electrode at output 50, depending upon the polarity or high impedance as determined by electrode polarity circuit 42. The electrode may either be in a positive, negative or high impedance state.

[0040] A modification is illustrated in Figure 3. A common pulse generator which includes the circuits 34, 36

of Figure 2 provides at line 35 to the output switch 44 a pulse of a shape and frequency defined by the control on line 28 from the microprocessor and control circuitry 20. The pulse amplitude defining circuit 32 also provides an output on line 33 to the output switch 44 as does pulse width defining circuit 38 via output on line 39.

[0041] The pulse amplitude defining circuit 32 and pulse width defining circuit 38 modify the common pulse received on line 35 by controlling the output switch 44. The amplitude input via line 33 could control a variable impedance network, which may be a resistor divider array controlled by a multiplexer. The pulse width input via line 39 controls the on/off of the switch to determine the pulse width. This could also generate a timing change in the delivered pulses (starting later and ending sooner than other outputs). The polarity is still determined by electrode polarity circuit 42.

[0042] A more detailed explanation of the output switch 44 is illustrated in Figure 4. A digital to analog converter 43 receives a pulse amplitude signal over line 33 and the pulse width signal over line 39. This is converted to an analog signal on line 45. The analog signal on line 45, is provided to a variable impedance circuit 46, which also receives the common pulse on line 35, and controls the variable impedance circuit 46 to modify the common pulse. The individual designed pulse is then provided via line 47 to a polarity switch 48 which receives the polarity control on line 41. The output is provided on output 50 to the individual electrode. Alternatively, the pulse width control on line 39 may be used with logic to control the polarity switch 48.

[0043] The variable impedance network may be a switch, for example an FET operated in the analog region. The analog switch impedance can vary from ON, being less than 10 Ω , to an off, being greater than 1 M Ω . The variable impedance would typically operate in the range of a few hundred to a few thousand ohms range. This will produce a voltage divider effect since the nerve tissue being stimulated has a nominal impedance of 500-1200 Ω .

[0044] The measurement circuits 24, 26 could be implemented to interact with the implanted microprocessor and control circuit 20 to automatically reprogram the stimulation parameters. This would dynamically reprogram a stimulation regimen in response to measured parameters to a programmed level. The methods described herein may also be performed wherein the stimulator 10 is external the patient.

[0045] The polarity switch is illustrated in Figure 5 as including a pair of complementary field effect transistors 52 and 54 connected in parallel and receiving an analog stimulation pulse on line 39 to be transmitted depending

upon the inputs Q_P and $\overline{Q_P}$ at the respective gates. The output is connected through capacitor 49 to the electrode output 50. A third FET 56 is connected between the capacitor 49 and ground and controlled at its gate by input

$\overline{Q_N}$. If Q_N is high, the output polarity is positive. If Q_P is high, the output is negative. If Q_N and Q_P are both high, the output is open or high impedance.

[0046] For more detailed explanation of the circuitry, reference should be made to U.S. Patents 4,459,989 and 4,612,934 both to Borkan, incorporated herein by reference.

[0047] Although the present stimulator system has been designed to allow the capability of providing individually designed stimulation pulses for each of the electrodes, the system could operate as a conventional neurostimulator system using delivery of a common stimulation pulse to select electrodes.

[0048] As illustrated in Figure 6, a stimulation lead 60 includes a sheath 62 having a plurality of in-line electrodes 64 mutually spaced by a distance D_1 and an additional electrode 65 on a sheath wire extension 67 extending from the distal end 66. The proximal end 68 has contacts 69 connected to each electrode and to the stimulator outputs 50. The additional electrode 65 has a greater surface area on the sheath/wire than the surface area on the sheath of each of the electrodes 64.

[0049] The electrodes 64 all may have a length L_1 and the additional electrode 65 has a length L_2 . Length L_2 is greater than L_1 , at least twice its length. Thus, for example, if length L_1 is 2 mm, the length L_2 is 4 mm. The length L_2 may be anywhere between 2-4 times that of the length L_1 . Also, the additional electrode 65 may have a greater circumferential dimension than each of the electrodes 64. The additional electrode 65 may have a 360° circumference and the electrodes 64 be 180° or less, for example.

[0050] Also, it should be noted that the additional electrode 65 is spaced by a distance D_2 from the nearest electrode 64. Where D_1 is approximately 6 mm, the distance D_2 is at least 10 mm and can be as much as 20 mm or more. With this distance, the electrodes 64 each acts as a point source when used in conjunction with the additional electrode 65 of the increased area.

[0051] Although a specific electrode is illustrated in Figure 6, other electrodes may be used with the stimulator system of the present invention. This is an example of an electrode which is capable of simultaneous operation in a bipolar mode and a monopolar mode as well as each mode alone. In the bipolar mode, at least two of the electrodes 64 are used while in the monopolar mode, the additional electrode 65 is used as an anode with at least one of the electrodes 64 as a cathode. The individual programming of the stimulation pulse allows this to occur.

[0052] These stimulation paradigms could include sophisticated programs that switch stimulation between a number of electrodes slowly (over seconds or minutes, hours or days) to avoid accommodation of the stimulation or to treat multiple neural targets, or could be fast (approximately the same speed of the electrical activity of neurons in the spinal cord) artificially generating neural

signals along the spinal cord or a nerve which could be perceived as any other sensory function with signals that travel through the spinal cord or nerve. For instance, a signal could be generated that would correspond to heat being applied to a patient's big toe, or pressure being applied to a patient's foot, or the sensation of a limb in a different orientation than it actually is.

[0053] Theoretically, tastes, smells, sights or even thoughts could be created in this manner allowing various artificial prosthesis (visual, auditory, etc.) to interface with the human body.

[0054] Although the present invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example only, and is not to be taken by way of limitation.

Claims

1. A tissue stimulation system comprising:
 - an electrode assembly (60) having at least three electrodes (64) to be stimulated in a patient, a programmable stimulator (10) connected to and providing stimulation pulses to the electrode assembly (60), and programming data (22) in the stimulator (10) defining, for each of the at least three electrodes (64), individual stimulation pulses of varying polarity and at least one of amplitude, frequency, pulse width and pulse shape, **characterised in that** the stimulator (10) includes:
 - a separate variable impedance circuit (46) for each electrode (64), and
 - a common pulse generator (30) to provide a common stimulation voltage pulse to each of the variable impedance circuits (46), and
 the stimulator (10) individually modifies the amplitude and pulse width of the common stimulation voltage pulse to each electrode (64).
2. The system of claim 1, wherein the variable impedance circuit (46) includes a voltage divider for each electrode (64).
3. The system of claim 1, wherein the variable impedance circuit (46) includes an analog switch for each electrode (64).
4. The system of claim 1, wherein the stimulator (10) measures the series impedance of each of the electrodes (64) and modifies the stimulation pulse for each electrode (64) defined by the programming data as a function of the measured impedance of that electrode (64).
5. The system of claim 1, wherein the stimulator (10) measures physical parameters and modifies the stimulation pulse for each electrode (64) defined by the programming data as a function of the measured parameters.
6. The system of claim 1, including an additional electrode (65) spaced from the at least three electrodes (64), the additional electrode (65) having a greater surface area than each of the at least three electrodes (64).
7. The system of claim 6, wherein the additional electrode (65) has at least twice the surface area of each of the at least three electrodes (64).
8. The system of claim 6, wherein the additional electrode (65) is spaced from the at least three electrodes (64) by at least 10 mm.
9. The system of claim 6, wherein the programming data (22) defines simultaneously stimulation in a bipolar mode using at least two of the at least three electrodes (64) and in a monopolar mode using the additional electrode (65) as an anode electrode and at least one of the at least three electrodes (64) as a cathode electrode.
10. The system of claim 6, wherein the programming data (22) defines stimulation in a bipolar mode.
11. The system of claim 6, wherein the programming data (22) defines stimulation in a monopolar mode using the additional electrode (65) as a common anode electrode with at least one of the at least three electrodes (64) as a cathode electrode.
12. The system of claim 1, including a measurement circuit (26) to measure certain physiological parameters, and wherein the stimulator (10) modifies the stimulation pulses as a function of the measured parameters.
13. The system of claim 12, wherein the measured parameters include one of the following: EMG, EKG, or EEG measurements.
14. The system of claim 12, wherein the measurement circuit (26) includes chemical or biochemical sensors.
15. The system of claim 12, wherein the stimulator (10) includes a signal input and modifies the stimulation pulses as a function of input signals on the signal input.
16. The system of claim 15, wherein the input signals include processed audio or visual signals.

17. The system of claim 12, wherein the stimulator (10) determines the position of the electrode (64) from the measured parameters and modifies the stimulation pulses as a function of the determined position.
18. The system of claim 17, including a display (27) for showing the determined position.

Patentansprüche

1. Gewebestimulationssystem mit:

einer Elektrodenanordnung (60) aus mindestens drei innerhalb eines Patienten zu stimulierenden Elektroden (64), einem mit der Elektrodenanordnung (60) verbundenen und diese mit Stimulationsimpulsen beaufschlagenden programmierbaren Stimulator (10), und Programmierdaten (22) in dem Stimulator (10), die für jede der mindestens drei Elektroden (64) individuelle Stimulationsimpulse definieren, die in der Polarität und mindestens einer der Größen Amplitude, Frequenz, Pulsbreite und Pulsform variieren,
dadurch gekennzeichnet, dass
 der Stimulator (10)

für jede Elektrode (64) eine separate Stufe variabler Impedanz (46) und einen gemeinsamen Pulsgenerator (30) zur Beaufschlagung aller Stufen variabler Impedanz (46) mit einem gemeinsamen Stimulations-Spannungsimpuls

aufweist und der Stimulator (10) die Amplitude und die Pulsbreite des gemeinsamen Stimulations-Spannungsimpulses für jede Elektrode (64) individuell modifiziert.

2. System nach Anspruch 1, wobei die Stufe variabler Impedanz (46) für jede Elektrode (64) einen Spannungssteiler aufweist.
3. System nach Anspruch 1, wobei die Stufe variabler Impedanz (46) für jede Elektrode (64) einen Analogschalter aufweist.
4. System nach Anspruch 1, wobei der Stimulator (10) die Serienimpedanz jeder der Elektroden (64) misst und für jede Elektrode den Stimulationsimpuls (64), durch die Programmierdaten als Funktion der gemessenen Impedanz der betreffenden Elektrode (64) definiert, modifiziert.
5. System nach Anspruch 1, wobei der Stimulator (10) physikalischen Parameter misst und den Stimulati-

onsimpuls für jede Elektrode (64), durch die Programmierdaten als Funktion der gemessenen Parameter definiert, modifiziert.

- 5 6. System nach Anspruch 1, mit einer in Abstand von den mindestens drei Elektroden (64) angeordneten Zusatzelektrode (65), die eine größere Fläche hat als jede der mindestens drei Elektroden (64).
- 10 7. System nach Anspruch 6, wobei die Zusatzelektrode (65) eine doppelt so große Fläche hat wie jede der mindestens drei Elektroden (64).
- 15 8. System nach Anspruch 6, wobei die Zusatzelektrode (65) von den mindestens drei Elektroden (64) einen Abstand von mindestens 10 mm hat.
- 20 9. System nach Anspruch 6, wobei die Programmierdaten (22) simultane Stimulation in einem Bipolarmodus unter Verwendung von mindestens zwei der mindestens drei Elektroden (64) und in einem Monopolarmodus unter Verwendung der Zusatzelektrode (65) als Anodenelektrode und mindestens einer der mindestens drei Elektroden (64) als Kathodenelektrode definieren.
- 25 10. System nach Anspruch 6, wobei die Programmierdaten (22) Stimulation in einem Bipolarmodus definieren.
- 30 11. System nach Anspruch 6, wobei die Programmierdaten (22) Stimulation in einem Monopolarmodus unter Verwendung der Zusatzelektrode (65) als gemeinsame Anodenelektrode mit mindestens einer der mindestens drei Elektroden (64) als Kathodenelektrode definieren.
- 35 12. System nach Anspruch 1 mit einer Messstufe (26) zur Messung bestimmter physiologischer Parameter, wobei der Stimulator (10) die Stimulationsimpulse als Funktion der gemessenen Parameter modifiziert.
- 40 13. System nach Anspruch 12, wobei zu den gemessenen Parametern EMG-, EKG-, oder EEG-Messdaten gehören.
- 45 14. System nach Anspruch 12, wobei die Messstufe (26) chemische oder biochemische Sensoren aufweist.
- 50 15. System nach Anspruch 12, wobei der Stimulator (10) einen Signaleingang aufweist und die Stimulationsimpulse als Funktion der Eingangssignale an dem Signaleingang modifiziert.
- 55 16. System nach Anspruch 15, wobei zu den Eingangssignalen aufbereitete hör- oder sichtbare Signale gehören.

17. System nach Anspruch 12, wobei der Stimulator (10) die Position der Elektrode (64) aus den gemessenen Parametern ermittelt und die Stimulationsimpulse als Funktion der ermittelten Position modifiziert.
18. System nach Anspruch 17 mit einem Display (27) zur Anzeige der ermittelten Position.

Revendications

1. Système de stimulation de tissu comprenant :

un ensemble d'électrodes (60) comprenant au moins trois électrodes (64) à stimuler dans un patient, un stimulateur programmable (10) connecté à et fournissant des impulsions de stimulation à l'ensemble d'électrodes (60), et des données de programmation (22) dans le stimulateur (10) définissant, pour chacune des au moins trois électrodes (64), des impulsions de stimulation individuelles ayant une polarité variable et au moins l'une parmi une amplitude, une fréquence, une largeur d'impulsion et une forme d'impulsion,

caractérisé en ce que

le stimulateur (10) comprend :

un circuit séparé d'impédance variable (46) pour chaque électrode (64), et un générateur d'impulsions commun (30) pour fournir une impulsion de tension de stimulation commune à chacun des circuits d'impédance variable (46), et le stimulateur (10) modifie individuellement l'amplitude et la largeur d'impulsion de l'impulsion de tension de stimulation commune à chaque électrode (64).

2. Système selon la revendication 1, dans lequel le circuit d'impédance variable (46) comprend un diviseur de tension pour chaque électrode (64).
3. Système selon la revendication 1, dans lequel le circuit d'impédance variable (46) comprend un commutateur analogique pour chaque électrode (64).
4. Système selon la revendication 1, dans lequel le stimulateur (10) mesure l'impédance série de chacune des électrodes (64) et modifie l'impulsion de stimulation pour chaque électrode (64) définie par les données de programmation en fonction de l'impédance mesurée de cette électrode (64).
5. Système selon la revendication 1, dans lequel le stimulateur (10) mesure des paramètres physiques et

modifie l'impulsion de stimulation pour chaque électrode (64) définie par les données de programmation en fonction des paramètres mesurés.

6. Système selon la revendication 1, comprenant une électrode supplémentaire (65) espacée des au moins trois électrodes (64), l'électrode supplémentaire (65) ayant une aire de surface plus grande que celle de chacune des au moins trois électrodes (64).
7. Système selon la revendication 6, dans lequel l'aire de surface de l'électrode supplémentaire (65) est au moins deux fois plus grande que l'aire de surface de chacune des au moins trois électrodes (64).
8. Système selon la revendication 6, dans lequel l'électrode supplémentaire (65) est espacée d'au moins 10 mm des au moins trois électrodes (64).
9. Système selon la revendication 6, dans lequel les données de programmation (22) définissent la stimulation simultanée dans un mode bipolaire en utilisant au moins deux des au moins trois électrodes (64) et dans un mode monopolaire en utilisant l'électrode supplémentaire (65) comme électrode anodique et au moins une des au moins trois électrodes (64) comme électrode de cathode.
10. Système selon la revendication 6, dans lequel les données de programmation (22) définissent la stimulation simultanée dans un mode bipolaire.
11. Système selon la revendication 6, dans lequel les données de programmation (22) définissent la stimulation simultanée dans un mode monopolaire en utilisant l'électrode supplémentaire (65) comme électrode d'anode commune avec au moins une des au moins trois électrodes (64) comme une électrode de cathode.
12. Système selon la revendication 1, comprenant un circuit de mesure (26) pour mesurer certains paramètres physiologiques et dans lequel le stimulateur (10) modifie les impulsions de stimulation en fonction des paramètres mesurés.
13. Système selon la revendication 12, dans lequel les paramètres mesurés comprennent l'un parmi les suivants : EMG, ECG ou EEG.
14. Système selon la revendication 12, dans lequel le circuit de mesure (26) comprend des détecteurs chimiques ou biochimiques.
15. Système selon la revendication 12, dans lequel le stimulateur (10) comprend une entrée de signaux et modifie les impulsions de stimulation en fonction de signaux d'entrée sur l'entrée de signaux.

16. Système selon la revendication 15, dans lequel les signaux d'entrée comprennent des signaux auditifs ou visuels traités.

17. Système selon la revendication 12, dans lequel le stimulateur (10) détermine la position de l'électrode (64) à partir des paramètres mesurés et modifie les impulsions de stimulation en fonction de la position déterminée.

18. Système selon la revendication 17, comprenant un écran (27) pour afficher la position déterminée.

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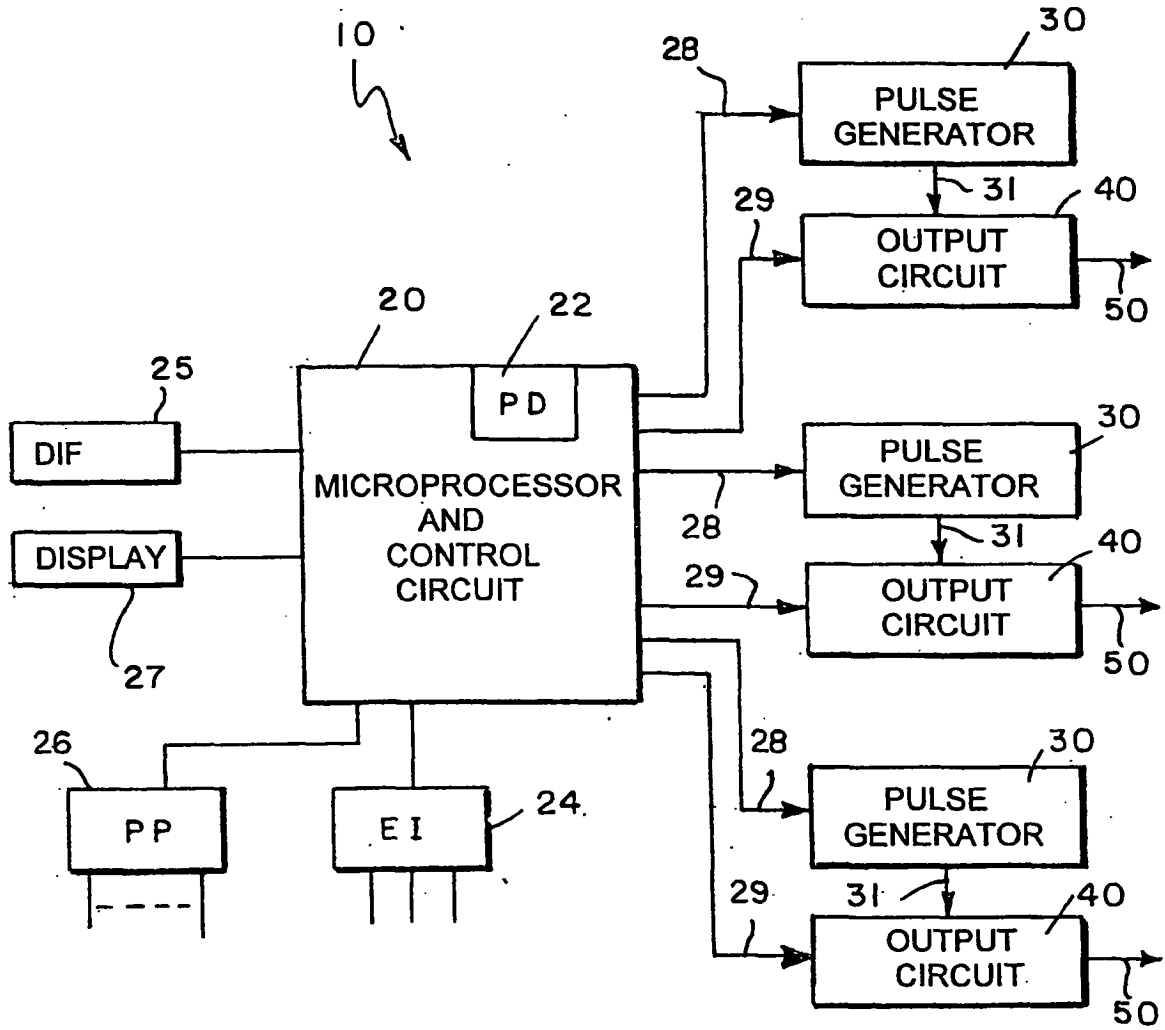


FIG. 1

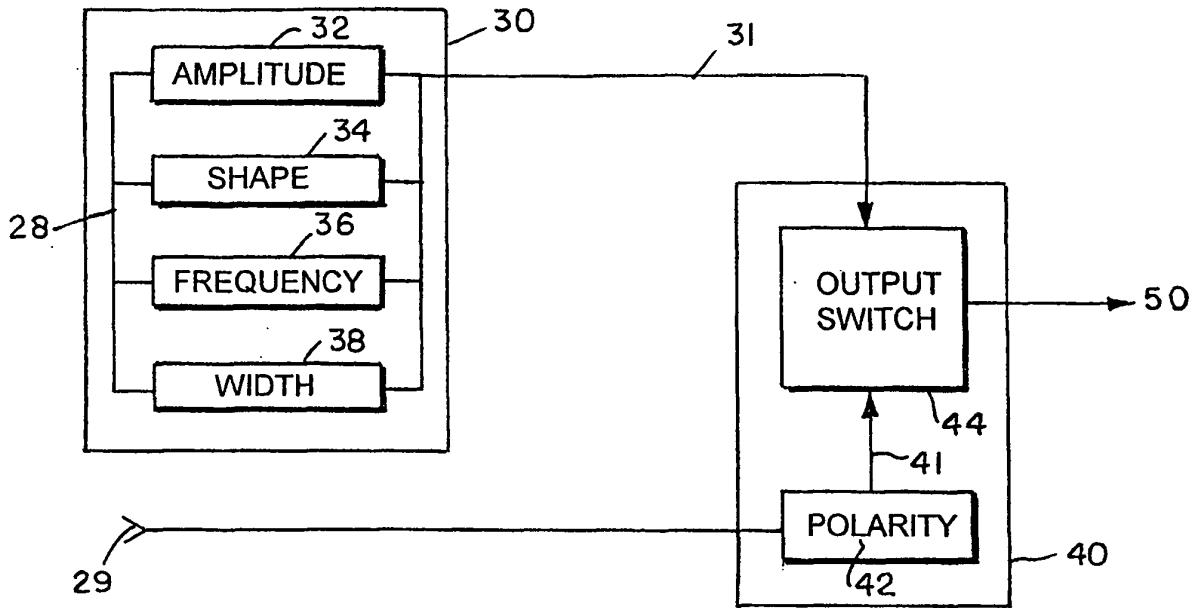


FIG. 2

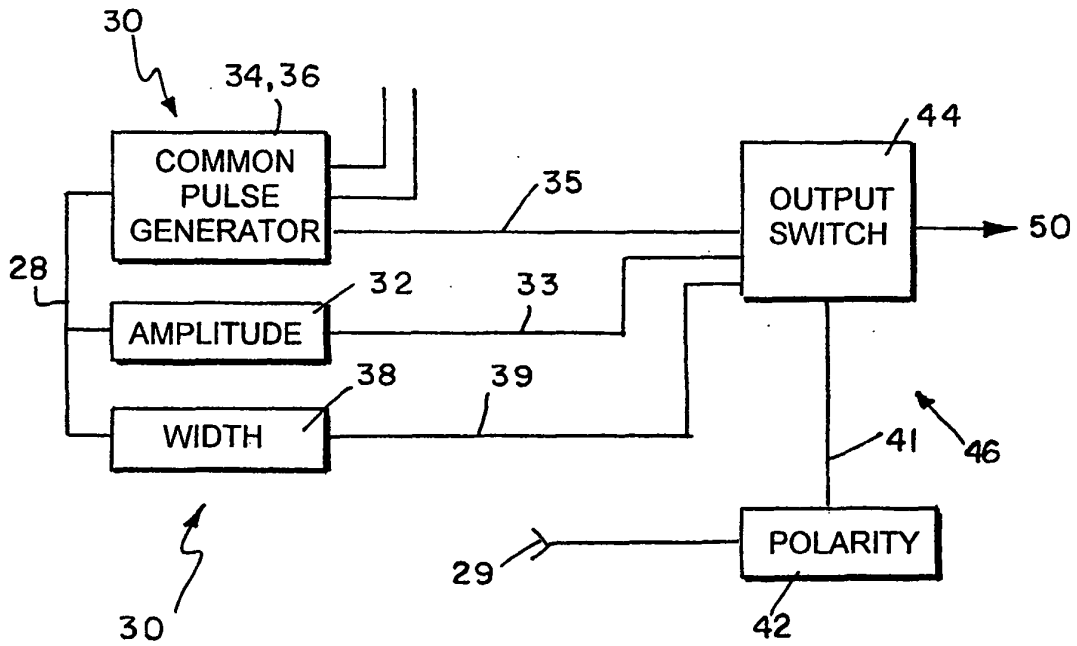


FIG. 3

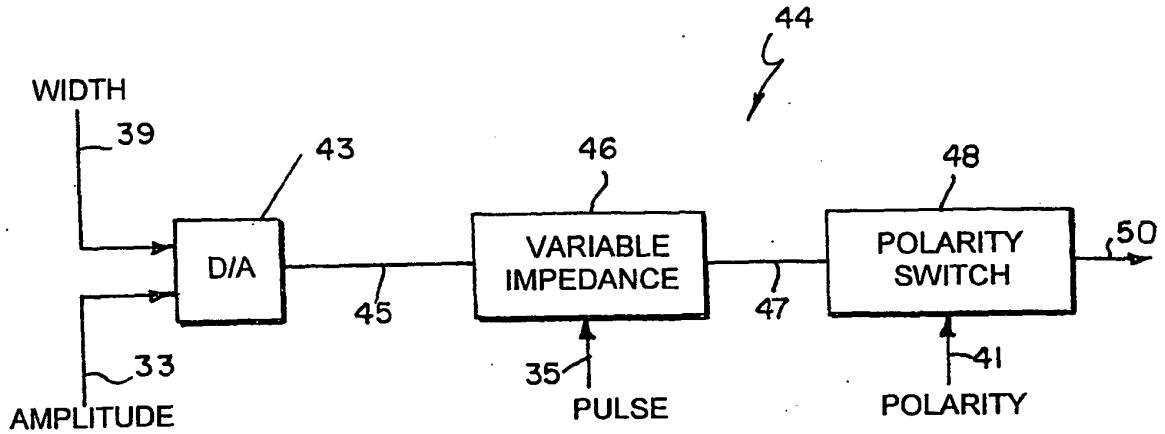
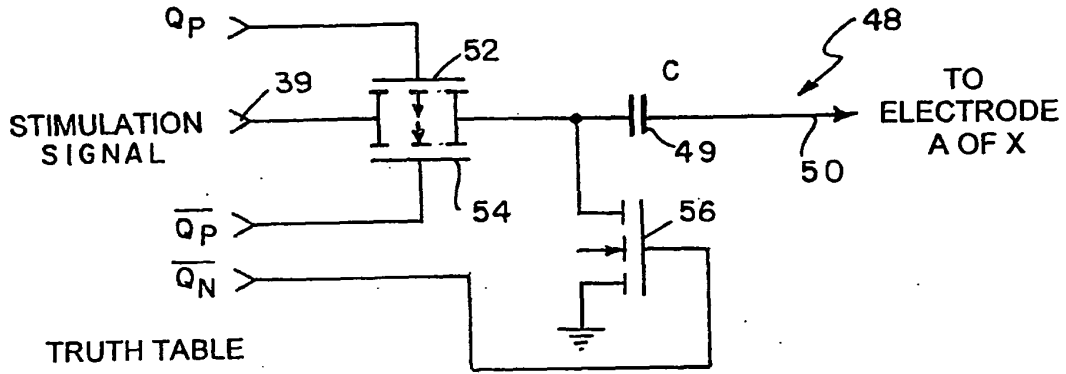


FIG. 4



TRUTH TABLE

	Qp	QN
POSITIVE	0	1
NEGATIVE	1	0
OPEN	1	1
INVALID	0	0

FIG. 5

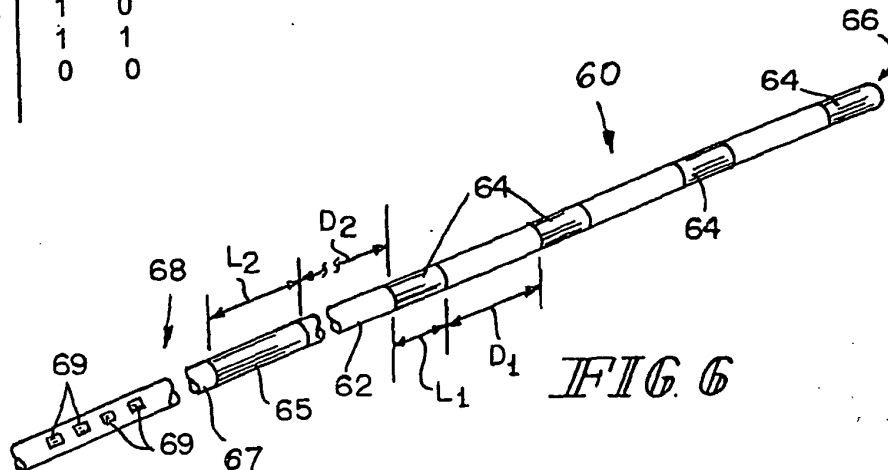


FIG. 6

专利名称(译)	多通道刺激器电子设备		
公开(公告)号	EP1181949B1	公开(公告)日	2006-10-18
申请号	EP2001119556	申请日	2001-08-14
[标]申请(专利权)人(译)	BORKAN WILLIAMñ		
申请(专利权)人(译)	BORKAN , WILLIAM N.		
当前申请(专利权)人(译)	BORKAN , WILLIAM N.		
[标]发明人	BORKAN WILLIAM N		
发明人	BORKAN, WILLIAM N.		
IPC分类号	A61N1/34 A61N1/372 A61B5/00 A61N1/05 A61N1/08		
CPC分类号	A61N1/056 A61N1/36003 A61N1/36067 A61N1/36135 A61N1/36185		
优先权	60/225731 2000-08-17 US		
其他公开文献	EP1181949A2 EP1181949A3		
外部链接	Espacenet		

摘要(译)

组织刺激系统包括电极组件，该电极组件具有间隔开的至少三个电极以在患者体内受到刺激。可编程刺激器连接到电极组件并向电极组件提供刺激脉冲。刺激器中的编程数据为至少三个电极中的每一个定义具有变化极性和幅度，频率，脉冲宽度和脉冲形状中的至少一个的各个刺激脉冲。

