## Description

### Technical Field

The present invention relates generally to transcutaneous electrical nerve stimulators and more particularly to transcutaneous electrical nerve stimulators designed to alleviate chronic pain.

### Background Art

Transcutaneous electrical nerve stimulators are typically utilized to mask pain signals of a human body before they reach the brain giving the subject apparent relief from the pain. Electrical pulses are delivered to the skin of the subject by one or more electrodes. The subject typically can control the transcutaneous electrical nerve stimulator through adjustment of its output current of the pulses. The transcutaneous electrical nerve stimulator may have a plurality of outputs, e.g., two, channels, each simultaneously and independently providing electrical stimulation pulses.

One common use for a transcutaneous electrical nerve stimulator is for chronic pain situations such as those related to menstrual pain, dysmenorrhea and for lower back pain.

Prior transcutaneous electrical nerve stimulators have used rectangular cases with relatively sharp corners. US-A-4 324 235 discloses a transcutaneous pain control apparatus in a rectangular case with well rounded edges and knurled rotatable disc-switches for control of the emitted pulses.

For menstrual pain and lower back pain applications, a transcutaneous electrical nerve stimulator is desirably worn on the body of the person in a relatively inconspicuous location, consistent with ready, comfortable, and reliable access to its operable controls.

Transcutaneous electrical nerve stimulators with rectangular case designs have sharp corners which when placed under pressure next to the body, can cause user discomfort by marking, scratching or abraiding the skin. Yet, pain and discomfort are exactly what the stimulator should help prevent. Further, user controls are often either confusing in their location or are not easily operable with one hand. Also, little consideration has previously been give to the ease of attachment of the transcutaneous electrical nerve stimulator to the body.

### Disclosure of Invention

According to this invention there is provided a transcutaneous electrical nerve stimulator, having an electrical means for generating a predetermined set of electrical stimulus signals adapted to be applied to a body, and capable of generating said electrical stimulus signal with an amplitude which may be varied; a housing containing said electrical means, having a first switch mounted on a side edge of said housing and coupled to said electrical means; and having a second switch mounted on a side edge of said housing and coupled to said electrical means, said second switch controlling the power to said electrical means, being characterized by:

said housing being of a generally flattened disk shape with well rounded edges;

said first switch being a rocker switch which operates to increase said amplitude when said first rocker switch is pushed by an operator in a first direction and operates to decrease said amplitude when said first rocker switch is pushed by an operator in the opposite direction, said first rocker switch controlling the intensity of said electrical stimulus signal.

In one embodiment of the present invention, the transcutaneous electrical nerve stimulator has an electrical circuit having a plurality of independent stimulation channels each generating a predetermined set of electrical stimulus signals. The first switch controls the electrical stimulus signal for one of the plurality of independent stimulation channels and the stimulator further has at least one additional rocker switch mounted on an edge of the housing and coupled to the electrical circuit for controlling the amplitude of the electrical stimulus signal of another of the plurality of stimulation channels in a manner similar to the manner in which the first rocker switch controls the amplitude of its associated one of said set of electrical stimulus signals.

The unique shape of the transcutaneous electrical nerve stimulator of the present invention is advantageous for immediate placement next to the body without sharp edges to scratch, rub or abraid the skin. The flattened disk shape provides for unobtrusive wearability on the body, particularly the female body. The slightly convex surfaces of the flattened disk shape allow internal placement of a rigid printed circuit board containing electrical components. Components with the highest profile are mounted toward the center of the board, and those of a lower profile are located towards the circumference of the board. This arrangement provides a more compact size and, even more importantly, a much smaller perceived size by the user than with prior rectangular case designs.

The optimum user control interface has operable switches positioned on the side edges of the flattened disk. The force required to operate the controls on the side edges may be easily balanced by the forces applied by opposing fingers of the

same hand. This approach minimizes discomfort by obviating the need to push the case (housing) into the body when operating the controls. Rocker switches are utilized to minimize the number of switches required, facilitate the user's location of controls under clothing, and to increase the ease of output amplitude adjustment. An increase in amplitude requires simply a push of the rocker mechanism towards the top of the case (when hung properly) and vice versa for a decrease in stimulation amplitude.

The transcutaneous electrical nerve stimulator has advantageously designed and located attachment points enabling the stimulator to be conveniently attached to the body. For example, the stimulator may be hung from the strap of bras or other undergarments, from a belt at the waist, or "pendant style" from straps fitted around the neck.

## Brief Description of Drawings

The foregoing advantages, operation, and construction of the present invention will become more readily apparent from the following description and accompanying drawings in which:

Figure 1 is a top view of a transcutaneous electrical nerve stimulator of the present invention;

Figure 2 is a rear view of the transcutaneous electrical nerve stimulator of the present invention;

Figure 3 is a block diagram of the internal electrical components of the transcutaneous electrical nerve stimulator of the present invention;

Figure 4 and 5 illustrates alternative bra strap attachment mechanisms for the transcutaneous electrical nerve stimulator of the present invention; and

Figures 6 and 7 illustrate alternative waist belt attachment mechanisms for the transcutaneous electrical nerve stimulator of the present invention.

## Detailed Description

Figures 1 and 2 show the top and the front views of a transcutaneous electrical nerve stimulator (TENS) 10. The stimulator 10 has a housing 12 which is of a generally flattened disk shape having well rounded edges. The flattened disk shape is of slightly eliptical dimension to aid in appearance and to facilitate a hanging-style attachment. At one location on the side edge of the housing 12 is mounted a power switch 14 which may be operator controlled to quickly turn on or off the power to the stimulator. An indicator light 16 is also provided, in a preferred embodiment, as an aid to showing the user that power is being supplied to the stimulator 10 and/or that battery power is nearly exhausted. In the preferred embodiment, the stimulator 10 has two output channels. The amplitude of the current pulses supplied by each output channel is controlled by rocker switches 18 and 20, respectively, each mounted on one side edge of the housing 12. Rocker switch 18 controls the current amplitude of the stimulation pulse to be delivered by channel 1 of the stimulator 10 while rocker switch 20 controls the current amplitude of the current stimulation pulse supplied by channel 2 of the stimulator 10. Preferably, rocker switches 18 and 20 are located on one lateral hemisphere of housing 12. Preferably the rocker switch 18 for channel 1 is positioned toward the top of the stimulator 10 while the rocker switch for channel 2 is located in the lower portion of stimulator 10. Rocker switch 18 rests in a neutral position when not being operated by the user. When rocker switch 18 is pushed at end 22, an increase in the current amplitude of the channel 1 stimulation pulse is accomplished. Conversely, pushing rocker switch 18 at end 24 operates to decrease the current amplitude of the channel 1 stimulation pulse. Similarly, rocker switch 20 when pushed at end 26 increases the current amplitude of the channel 2 stimulation pulse. Correpondingly, a push at end 28 decreases the current amplitude. Electrical jacks 30 are provided to individually allow connection of stimulation electrodes to the stimulator 10. A first attachment point 32 is provided on the housing 12 at the top of the stimulator 10. A second attachment point 34 is provided on a side edge of the housing 12 opposite the first attachment point 32. In a preferred embodiment, attachment points 32 and 34 are formed as an attachment bar mounted on housing 12 over a tapered depression in the housing thus forming an unobtrusive channel. A mounting strap may then be passed through said channel and secured to the body or to clothing.

Figure 3 illustrates a general block diagram of the electrical circuit 36 required to supply high voltage current output pulses 38 of the stimulator 10. Generally, battery power 40 is supplied to a switched inductor circuits 42. A clock 44 drives a control circuit 46 which in turn supplies a programmable logic block 48 which supplies switching signals 51 to switched inductor circuit 42 for generating a high-voltage signal 52 to be supplied to output stages 54. Programmable logic block 48 also supplies timing and amplitude information signals 50 to output stages 54 which then utilizes a high-voltage signal 52 to supply electrical stimulation signal 38. Programmable logic block 48 receives external status information 56 and conditionally supplies power to indicator light 16 on a periodic basis. Included in the external status in-

formation 56 is the condition of switches 14, 18 and 20 and the voltage level of the battery power supply. The block diagram of the electrical circuit 36 illustrated in Figure 3 is general and of the generally perferred electrical circuit of the transcutaneous electrical nerve stimulator 10 of the present invention. It is to be recognized and understood that electrical circuits for use in transcutaneous electrical nerve stimulators are well known in the art. Any of the generally available electrical circuits could be utilized in the transcutaneous electrical nerve stimulator 10 of the present invention. The particular block diagram illustrated in Figure 3 is supplied for convenience and no particular engineering skill should be required to obtain or design any one of a number of existing electrical circuits 36 which can be utilized in transcutaneous electrical nerve stimulators 10.

The transcutaneous electrical nerve stimulator 10 shown and described uses a variety of technics to both improve wearability and to give a visual impression of small size and good asthetics. The significant radiusing of the outside edges of housing 12, the angled placement of jacks 30 and the spherically convex shaping of the front and rear surfaces of housing 12 contribute to the desired result. The placement on side edges of user control switches 14, 18 and 20 make them less conspicuous while making them easier to operate. The asymmetrical placement of power switch 14 as compared to amplitude switches 18 and 20 aids in their location and positive identification by the user even when the stimulator 10 is worn under clothing. The rocker switches 18 and 20 permit amplitude to be adjusted in steps. Depression of the rocker switches 18 and 20 toward the top of the housing 12 causes an increase in stimulation pulse 38 amplitude while depression toward the bottom of the housing 12 causes a decrease in pulse amplitude. When not actively depressed by the user, rocker switches 18 and 20 rest in a neutral position. Rocker switches 18 and 20 are provided with an electronic delay mechanism so that rocker switch depressions of less than 0.5 second only result in a single step change in amplitude. However, if the rocker switches 18 or 20 are continuously depressed, step changes will be generated at regular intervals (typically 0.5 seconds) until either stimulation amplitude has been decreased to zero or stimulation amplitude has reached its maximum allowable amplitude. In a preferred embodiment, a total of 64 steps in current amplitude are provided. These timing parameters are chosen to permit a precise setting of comfortable stimulation amplitudes by the user. Continuous depression of rocker switches 18 or 20 is generally used to rapidly reach the general region of comfortable current amplitudes, while subsequent discrete depressions are designed to provide single step amplitude corrections.

Rocker switches were chosen for switches 18 and 20 rather than individual increase and decrease buttons to simplify the user interface since only one switch (rather than two) needs to be located for each channel of operation. The side edge mounting of rocker switches 18 and 20 minimize the pressure against the skin. The pressure necessary to activate the side-mounted switches 18 and 20 by one finger is easily opposed by fingers of the same hand resting on the opposite side of the stimulator 10. Thus, the forces applied to the rocker switches 18 or 20 are not also directed at tender regions of the body such as the breasts or abdomen. Preferably, rocker switches 18 and 20 are designed to minimize their projection from the side of the housing 12 and, thus, reduce the chance for inadvertent amplitude adjustment as well as being selected for good tactile feedback.

Housing 12 has two attachment points 32 and 34, top and bottom, respectively. These attachment points 32 and 34 consist of "channels" or depressions in the case over which a bar is mounted to the housing permitting the use of various ribbons or straps as attachment devices. These ribbon attachments may consist of a self-fastening material such as a hook and loop fastener or elastic materials. One of these attachment mechanisms is illustrated in Figure 4. Here the stimulator 10 is hung from the first attachment point 32 by a strap 58 which passes around the center portion of a bra 60. An alternative bra attachment mechanism is illustrated in Figure 5 in which the stimulator 10 is again held by a strap 58 passed around the central portion of a bra 60 but this time made more secure by having strap 58 pass through both top attachment point 32 and bottom attachment point 34.

Two examples of waist attachments are illustrated in Figures 6 and 7. In Figure 6 the stimulator 10 is secured to a belt 62 by hook-and-loop strap 64 passing through first attachment point 32 and second attachment point 34. The belt 62 is secured around the waist of the wearer by a hook-and-loop fastener portion 66 fed through a D-ring 68. Figure 7 shows a similar arrangement in which the stimulator 10 is secured to belt 62 by having belt pass through first attachment point 32 and second attachment point 34. Belt 62 is secured around the waist by a swimsuit closure hook 70. Belt 62 may be adjusted by a slide 72. It is preferred that the belt 62 be constructed from an approximately one-half inch (1.27 centimeters) stretch soft bra strap material.

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## Claims

1. A transcutaneous electrical nerve stimulator (10), having an electrical means for generating a predetermined set of electrical stimulus signals adapted to be applied to a body, and capable of generating said electrical stimulus signal with an amplitude which may be varied; a housing (12) containing said electrical means, having a first switch (18) mounted on a side edge of said housing (12) and coupled to said electrical means; and having a second switch (14) mounted on a side edge of said housing (12) and coupled to said electrical means, said second switch (14) controlling the power to said electrical means, being characterized by:

   said housing (12) being of a generally flattened disk shape with well rounded edges;

   said first switch (18) being a rocker switch which operates to increase said amplitude when said first rocker switch (18) is pushed by an operator in a first direction (24) and operates to decrease said amplitude when said first rocker switch (18) is pushed by an operator in the opposite direction (22), said first rocker switch (18) controlling the intensity of said electrical stimulus signal.

2. A transcutaneous electrical nerve stimulator (10) as in claim 1 wherein said electrical means has a plurality of independent stimulation channels each generating a predetermined set of electrical stimulus signals, wherein said first switch (18) controls electrical stimulus signals of one of said plurality of independent stimulation channels and which further comprises at least one further rocker switch (20) mounted on an edge of said housing (12) and coupled to said electrical means for controlling the amplitude of said electrical signal of another of said plurality of stimulation channels in a manner similar to the manner in which said first rocker switch (18) controls the amplitude of its associated one of said set of electrical stimulus signals.

3. A transcutaneous electrical nerve stimulator (10) as in claim 2 wherein said first switch (18) and said further switch are mounted on the side edge of the same lateral hemisphere of said housing (12).

4. A transcutaneous electrical nerve stimulator (10) as in claim 1 wherein said second switch (14) is a slide switch and wherein said first switch (18) and said second switch (14) are mounted on opposite side edges of said housing (12).

5. A transcutaneous electrical nerve stimulator (10) as in claim 1 wherein said first switch (18) when pushed momentarily operates to change said amplitude by one of a plurality of discrete steps and when pushed continuously for at least one half-second operates to change said amplitude sequentially through said plurality of said discrete steps.

6. A transcutaneous electrical nerve stimulator (10) as in claim 1 wherein said housing (12) is of a slightly elliptical shape.

7. A transcutaneous electrical nerve stimulator (10) as in claim 6 wherein said housing (12) has a first strap attachment point (32) along said side edge of said flattened disk at the desired top of said stimulator (10).

8. A transcutaneous electrical nerve stimulator (10) as in claim 7 wherein said housing (12) has a second strap attachment point (34) along said side edge of said flattened disk opposite said first strap attachment point (32).

9. A transcutaneous electrical nerve stimulator (10) as in claim 8 wherein said first strap attachment point (32) and said second strap attachment point (34) each comprises an attachment bar mounted on said housing (12) over a tapered depression in said housing (12).

## Patentansprüche

1. Transkutaner elektrischer Nervenstimulator (10) mit einer elektrischen Einrichtung zur Generierung eines vorgegebenen Satzes elektrischer Stimulanssignale, die zum Anlegen an einen Körper geeignet sind, und die in der Lage ist, diese elektrischen Stimulanssignale mit einer veränderbaren Amplitude zu generieren; einem die elektrische Einrichtung aufnehmenden Gehäuse (12) mit einem ersten Schalter (18), der an einem seitlichen Rand des Gehäuses (12) angeordnet und mit der elektrischen Einrichtung gekoppelt ist; und mit einem zweiten Schalter (14), der an einem seitlichen Rand des Gehäuses (12) angeordnet und mit der elektrischen Einrichtung gekoppelt ist, wobei der zweite Schalter (14) die an der elektrischen Einrichtung liegende Spannung steuert, dadurch gekennzeichnet daß:
   das Gehäuse (12) eine im allgemeinen abgeflachte Scheibenform mit gut gerundeten Kanten aufweist;

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der erste Schalter (18) als Kippschalter ausgeführt ist, der eine Erhöhung der Amplitude herbeiführt, wenn der erste Kippschalter (18) durch einen Benutzer in einer ersten Richtung (24) gedrückt wird, und der eine Verringerung der Amplitude herbeiführt, wenn der erste Kippschalter (18) durch einen Benutzer in der entgegengesetzten Richtung (22) gedrückt wird, wobei der erste Kippschalter (18) die Intensität des elektrischen Stimulanssignals steuert.

2. Transkutaner elektrischer Nervenstimulator (10) gemäß Anspruch 1, dadurch gekennzeichnet, daß die elektrische Einrichtung eine Vielzahl von unabhängigen Stimulationskanälen aufweist, von denen jeder einen vorgegebenen Satz elektrischer Stimulanssignale generiert, wobei der erste Schalter (18) die elektrischen Stimulanssignale eines Kanals aus der Vielzahl der unabhängigen Stimulationskanäle steuert, und daß sie außerdem mindestens einen weiteren Kippschalter (20) umfaßt, der an einem Rand des Gehäuses (12) angeordnet und mit der elektrischen Einrichtung zur Steuerung der Amplitude des elektrischen Signals eines anderen Kanals aus der Vielzahl der Stimulationskanäle in einer ähnlichen Weise gekoppelt ist, in der der erste Kippschalter (18) die Amplitude seines zugehörigen Satzes elektrischer Stimulanssignale steuert.

3. Transkutaner elektrischer Nervenstimulator (10) gemäß Anspruch 2, dadurch gekennzeichnet, daß der erste Schalter (18) und der weitere Schalter am Seitenrand derselben seitlichen Halbkugel des Gehäuses (12) angeordnet sind.

Transkutaner elektrischer Nervenstimulator (10) gemäß Anspruch 1, dadurch gekennzeichnet, daß der zweite Schalter (14) ein Schiebeschalter ist, und daß der erste Schalter (18) und der zweite Schalter (14) an einander gegenüberliegenden Seitenrändern des Gehäuses (12) angeordnet sind.

5. Transkutaner elektrischer Nervenstimulator (10) gemäß Anspruch 1, dadurch gekennzeichnet, daß der erste Schalter (18) bei kurzzeitiger Betätigung eine Amplitudenänderung um einen Schritt aus einer Vielzahl definierter Schritte herbeiführt, und bei kontinuierlicher Betätigung von mindestens einer halben Sekunde die Amplitude sequentiell durch die Vielzahl der definierten Schritte durchschaltet bzw. ändert.

6. Transkutaner elektrischer Nervenstimulator (10) gemäß Anspruch 1, dadurch gekennzeichnet, daß das Gehäuse (12) eine leicht elliptische Form aufweist.

7. Transkutaner elektrischer Nervenstimulator (10) gemäß Anspruch 6, dadurch gekennzeichnet, daß das Gehäuse (12) mit einem ersten Laschenbefestigungspunkt (32) entlang dem Seitenrand der abgeflachten Scheibe am gewünschten oberen Ende des Stimulators (10) ausgeführt ist.

8. Transkutaner elektrischer Nervenstimulator (10) gemäß Anspruch 7, dadurch gekennzeichnet, daß das Gehäuse (12) mit einem zweiten Laschenbefestigungspunkt (34) entlang dem Seitenrand der abgeflachten Scheibe gegenüber dem ersten Laschenbefestigungspunkt (32) ausgeführt ist.

9. Transkutaner elektrischer Nervenstimulator (10) gemäß Anspruch 8, dadurch gekennzeichnet, daß der erste Laschenbefestigungspunkt (32) und der zweite Laschenbefestigungspunkt (34) jeweils einen Befestigungsstab umfassen, der an dem Gehäuse (12) über einer konischen Vertiefung in dem Gehäuse (12) angebracht ist.

**Revendications**

1. Stimulateur transcutané des nerfs (10), comprenant des moyens électriques pour engendrer un ensemble prédéterminé de signaux électriques de stimulation pouvant être appliqués à un corps, et capables d'engendrer ledit signal électrique de stimulation avec une amplitude qui peut être modifiée ;un boîtier (12) contenant lesdits moyens électriques, qui comporte un premier contact ( 18) monté sur un bord latéral dudit boîtier (12) et raccordé auxdits moyens électriques, et qui comporte un deuxième contact (14) monté sur un bord latéral dudit boîtier (12) et raccordé auxdits moyens électriques, ledit deuxième contact (14) commandant l'alimentation desdits moyens électriques ;
caractérisé en ce que :
ledit boîtier (12) est en forme de disque sensiblement aplati à bords bien arrondis ; et
ledit premier contact (18) est un contact basculant qui agit pour augmenter ladite amplitude lorsque ledit premier contact basculant (18) est poussé par un opérateur dans une première direction (24), et qui agit pour diminuer ladite amplitude lorsque ledit premier contact basculant (18) est poussé par un opérateur dans la direction opposée (22), ledit premier contact basculant (18) réglant l'inten-

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sité dudit signal électrique de stimulation.

2. Stimulateur électrique transcutané des nerfs (10) suivant la revendication 1, dans lequel les dits moyens électriques comprennent une pluralité de canaux de stimulation indépendants engendrant chacun un ensemble prédéterminé de signaux électriques de stimulation, dans lequel ledit premier contact (18) commande les signaux électriques de stimulation d'un de ladite pluralité de canaux de stimulation indépendants, et qui comprend en outre au moins un autre contact basculant (20) monté sur un bord dudit boîtier (12) et raccordé auxdits moyens électriques pour régler l'amplitude dudit signal électrique d'un autre de ladite pluralité de canaux de stimulation d'une manière similaire à la manière dont ledit premier contact basculant (18) règle l'amplitude de son signal associé dudit ensemble de signaux électriques de stimulation.

3. Stimulateur électrique transcutané des nerfs (10) suivant la revendication 2, dans lequel le dit premier contact (18) et ledit autre contact sont montés sur le bord latéral du même hémisphère latéral dudit boîtier (12).

4. Stimulateur électrique transcutané des nerfs (10) suivant la revendication 1, dans lequel le dit deuxième contact (14) est un contact coulissant, et dans lequel ledit premier contact (18) et ledit deuxième contact (14) sont montés sur des bords latéraux opposés dudit boîtier (12).

5. Stimulateur électrique transcutané des nerfs (10) suivant la revendication 1, dans lequel le dit premier contact (18), lorsqu'on le pousse momentanément, agit pour faire varier ladite amplitude d'un d'une pluralité de paliers discrets et, lorsqu'on le pousse de façon continue pendant au moins une demiseconde, il agit pour faire varier ladite amplitude séquentiellement suivant ladite pluralité dedits paliers discrets.

6. Stimulateur électrique transcutané des nerfs (10) suivant la revendication 1, dans lequel le dit boîtier (12) est de forme légèrement elliptique.

7. Stimulateur électrique transcutané des nerfs (10) suivant la revendication 6, dans lequel ledit boîtier (12) comporte un premier point d'attache de bande (32) le long dudit bord latéral dudit disque aplati, à l'endroit du sommet désiré dudit stimulateur (10).

8. Stimulateur électrique transcutané des nerfs (10) suivant la revendication 7, dans lequel ledit boîtier (12) comporte un deuxième point d'attache de bande ( 34) le long dudit bord latéral dudit disque aplati, à l'opposé dudit premier point d'attache de bande (32).

9. Stimulateur électrique transcutané des nerfs (10) suivant la revendication 8, dans lequel ledit premier point d'attache de bande (32) et ledit deuxième point d'attache de bande (34) comprennent chacun une barrette de fixation montée sur ledit boîtier (12) au-dessus d'un évidement incliné ménagé dans le dit boîtier (12).