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Maurer

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[54] **TRANSCUTANEOUS STIMULATOR AND STIMULATION METHOD**

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[52] **U.S. Cl.** **128/421**

[51] **Int. Cl.** **A61n 1/36**

[58] **Field of Search** ..... 128/1 C, 2.1 R, 419 C, 128/419 E, 419 R, 420, 421, 422, 423

[56] **References Cited**

UNITED STATES PATENTS

1,908,688	5/1933	Call	128/420
2,764,683	9/1956	Daust et al	128/423
2,771,554	11/1956	Gratz	128/421

FOREIGN PATENTS OR APPLICATIONS

1,088,607	10/1967	Great Britain	128/1 C

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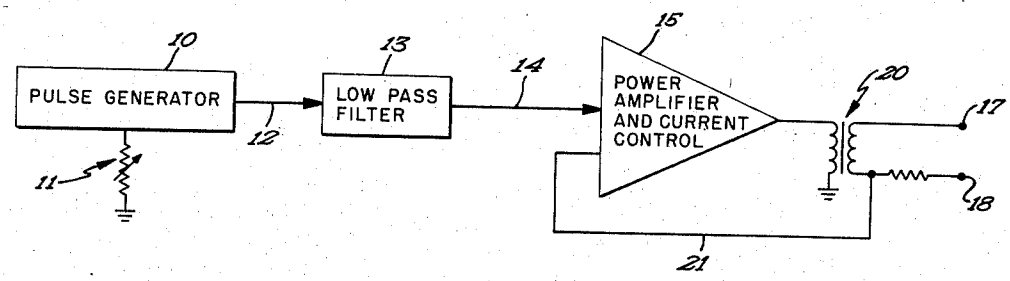
[57] **ABSTRACT**

A transcutaneous stimulator for stimulating portions of the body. The output of the stimulator is a stimulating pulse having frequency components falling within predetermined frequency band limits so as to optimally excite touch nerve fibres relative to nociceptor or pain receptor nerve fibres.

8 Claims, 2 Drawing Figures



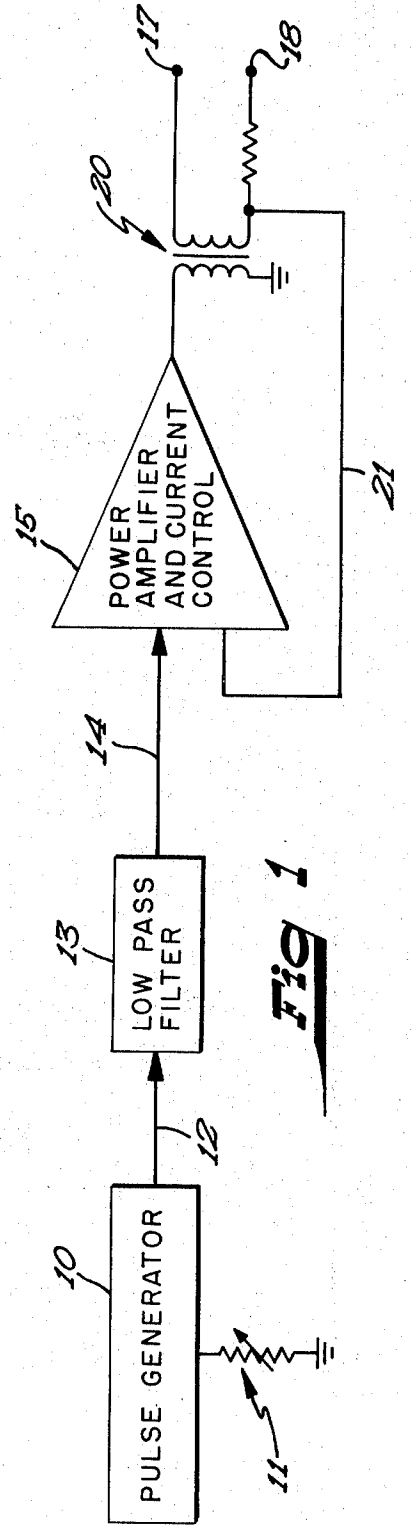

PULSE GENERATOR
LOW PASS FILTER
POWER AMPLIFIER AND CURRENT CONTROL
10
11
12
13
14
15
17
18
20
21

Fig 1

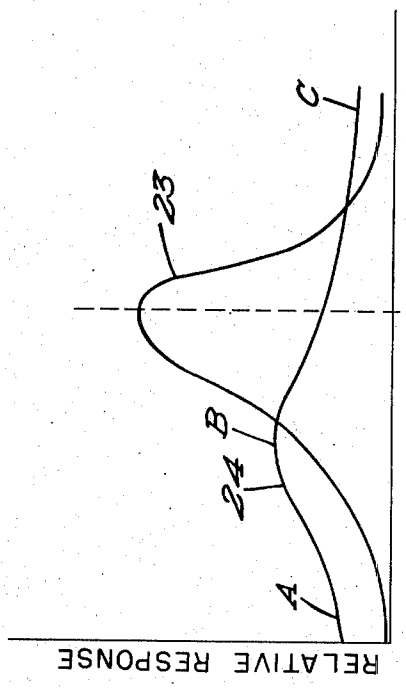

RELATIVE RESPONSE
FREQUENCY
A
B
C
23
24
X

Fig 2

TRANSCUTANEOUS STIMULATOR AND STIMULATION METHOD

BACKGROUND OF THE INVENTION

Peripheral nerve fibres have been classified in order of decreasing size and conduction velocity in a manner which is now standardized. Generally, as the fibre size decreases, the amplitude of electrical stimulation required to elicit an action potential increases. Also, the smaller fibre will require longer pulse durations than large fibre stimuli. These differences in nerve response have been used to selectively stimulate different types of nerve fibres by varying the amplitude, pulse duration, or pulse repetition rate of an electrical stimulating pulse. The desired degree of nerve fibre selectivity, however, has not been achieved in the prior art, with the result that, for example, an elicited touch response resulting from the stimulating pulse is often accompanied by a prickly, stinging, burning, sharp or other unpleasant noxious response.

SUMMARY OF THE INVENTION

The present invention provides a stimulating pulse having frequency components falling within predetermined frequency band limits. This pulse reliably elicits a touch response without the heretofore attendant noxious sensation mentioned above.

It has been demonstrated that the differential excitation of the touch fibres relative to pain specific fibres inhibits the transmission of pain to the conscious centers. The type of stimulation specified herein, optimizes the differential excitation between touch and pain specific fibres, thus optimizing the inhibition of pain transmission.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a transcutaneous stimulator embodying the present invention.

FIG. 2 is a graph of touch and pain response versus frequency.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

There is an increasing interest in external electrical skin stimulation for such purposes as pain suppression, neuro-muscular stimulation, communication systems, etcetera. The preferred embodiment of the present invention as described herein, is directed particularly at a transcutaneous stimulator for the suppression of organic pain, although it has obvious applications beyond this particular field. In understanding the present invention, the prior art devices shown in U.S. Patent Nos. 1,059,090 and No. 1,305,725 should be mentioned. These devices, are essentially pulse generators which have the capacity to suppress organic pain when applied to the body in proper relation to the nervous system. Along with the organic pain suppression, however, there is a concurrent noxious sensation produced by the stimulation which, over a period of time, may become more distracting that the organic pain being suppressed. Prior art attempts to eliminate this noxious sensation have included variations in the pulse amplitude, pulse duration, and pulse repetition rate. To an extent, these approaches have provided some success but, in their success, have limited the application of the technique by placing very restrictive parameters on its operation.

The present invention can best be understood by viewing the pulses used in the prior art devices in terms of a Fourier transform analysis. Any pulse has a fundamental sine wave component. Non-sine wave pulses, in addition, have sine wave components having frequencies which are multiples of the fundamental frequency. By determining which of these frequency components operate on which of the various nerve classifications, it is possible to generate a signal whose frequency components fall within predetermined frequency band limits, thus reducing the undesired noxious sensation. Peripheral nerve fibres have a standard classification in order of decreasing size and conduction velocity. Those of particular interest here are the class A-beta fibres which subserve touch and the class C fibres which are specific for pain. In addition, it has been demonstrated that the differential excitation of the A-beta fibres with respect to the C fibres will inhibit the transmission of pain information from the class C fibres.

With this background, we turn now to FIG. 1 which shows a block diagram of a stimulator employing the principles of the present invention. There is shown at **10** a pulse generator which may or may not be similar to that of the prior art devices. That is, the output of the pulse generator **10** may be either a full wave or half wave pulse. The pulse generator **10** is provided with a pulse rate control **11** which operates in a known manner. The output of the pulse generator **10** is transmitted by line **12** to a low pass active filter which may be one of a number of known types. Dependent upon the output of the pulse generator **10,** the low pass filter **13** will produce a full or half wave pulse of a single frequency or having a plurality of frequency components within the bonds to be described hereinafter. The filtered wave is passed from the filter **13** over the line **14** to a power amplifier and current control **15** whose output is coupled to the output electrodes **17** and **18** by a conventional transformer **20.** Either or both of the electrodes which are directly attached to the body may be of a type disclosed in my copending application, Ser. No. 251,179 filed May 8, 1972, for Electrode for Transcutaneous Stimulator. A feedback line **21** is employed to introduce a constant current feature to the stimulator of the present invention. In addition, in some applications it may prove necessary to vary the pulse repetition rate to overcome nerve adaption. This can be accomplished by providing a ramp generator as an input to the pulse generator **10** in any known manner.

Referring now to FIG. **2,** there is shown a plot of touch and pain response versus frequency. The touch response curve **23** is essentially a bell shaped curve which results from direct electrical stimulation. Curve **24** shows the pain response curve with segments A, B and C. Segments A and C result from secondary effects of the stimulation, such as, for example, chemical effects Segment B results from both the secondary effects and the effect of direct electrical stimulation. A greater differential excitation of touch nerve fibres over pain nerve fibres will inhibit the transmission of a pain signal from the pain fibres. Any specific frequency of stimulation which elicits a greater touch response than pain response will inhibit the pain transmission thereby eliminating any noxious sensation from the stimulation. An

example of such a frequency is indicated in FIG. 2 at X.

Similarly, any pulse having individual frequency components which collectively elicit a greater touch response than pain response will inhibit pain transmission and eliminate any noxious sensation from the stimulation.

I have discovered that a substantially pure sine wave pulse, either full or half wave, within the range of substantially 1,000–3,000 Hz produces a greater touch response than pain response thereby eliminating any noxious sensation. Similarly, a stimulation pulse having a plurality of frequency components and substantially 90 percent of its energy falling within the predetermined frequency band limits of substantially 100–5,000 Hz with the fundamental frequency preferably within the range of substantially 1,000–3,000 Hz will produce a greater touch response than pain response thereby eliminating any noxious sensations.

Obviously, many modifications and variations of the present invention are possible in light of the above teaching. Specifically, there are many alternative ways of generating the optimized waveforms disclosed herein which do not depart from the intended scope of the application. For example, a frequency synthesizer could be employed in place of the pulse generator **10** and filter **13**. Accordingly, it is to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

I claim:

1. A stimulator adapted for use as a transcutaneous stimulator for the purpose of organic pain suppression which comprises:

pulse generator means;

filter means for transforming the pulses of the pulse generator means into output pulses each comprising a plurality of frequency components having substantially 90 percent of their energy throughout substantially 100–5,000 Hz; and

output means connected to said filter means for applying said transformed pulses transcutaneously.

2. The stimulator of claim **1** wherein the transformed pulses are full cycle pulses.

3. The stimulator of claim **1** wherein the transformed pulses are half cycle pulses.

4. The stimulator of claim **1** wherein said output means further comprises constant current means for regulating the current output of said filter means.

5. A transcutaneous stimulator which comprises:

means for producing a series of pulses, each of said pulses having frequency components substantially 90 percent of the energy of which falls within substantially 100–5,000 Hz and

output means connected to said pulse series producing means.

6. The transcutaneous stimulator of claim **5** wherein the pulses are full cycle pulses.

7. The transcutaneous stimulator of claim **5** wherein the pulses are half cycle pulses.

8. A method of transcutaneous stimulation which comprises the steps of:

producing a series of pulses, each of said pulses comprising a plurality of frequency components having substantially 90 percent of their energy throughout substantially 100–5,000 Hz; and

applying the pulses to the portion of the body.

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