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Micro-Controller Based Exerciser Footboard Designed For Fast Treatment And Detection Of Diabetic Peripheral Neuropathy

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Abstract

Neuropathic foot exerciser is an electronic foot massager with acupressure effect. This foot exerciser is combination of three techniques: magnetic coil phenomenon, vibration method using motor and infrared heat source. With the help of Microcontroller, treatment is controlled as a timed sequence. This exerciser footboard helps in the treatment of Diabetic Peripheral neuropathy. In this paper we are presenting the effectiveness of treatment for neuropathy, as each therapy is given for a period of 10 seconds and changed automatically depending on the mode selected. The specific design of this footboard plays a very important role in the faster and effective treatment of Diabetic peripheral Neuropathy.

1. Introduction

Diabetic neuropathy is nerve damage caused by diabetes. When it affects the arms, hands, legs and feet it is known as diabetic peripheral neuropathy. Diabetic peripheral neuropathy is different from peripheral arterial disease (poor circulation), which affects the blood vessels rather than the nerves [1].

Three different groups of nerves can be affected by diabetic neuropathy:

- Sensory nerves, which enable people to feel pain, temperature, and other sensations
- Motor nerves, which control the muscles and give them their strength and tone
- Autonomic nerves, which allow the body to perform certain involuntary functions, such as sweating.

Diabetic peripheral neuropathy doesn't emerge overnight. Instead, it usually develops slowly and worsens over time. Some patients have this condition long before they are diagnosed with diabetes. Having diabetes for several years may increase the likelihood of having diabetic neuropathy.

The loss of sensation and other problems associated with nerve damage make a patient prone to developing skin ulcers (open sores) that can become infected and may not heal. This serious complication of diabetes can lead to loss of a foot, a leg, or even a life.

2. Neuropathic Foot Exerciser

Neuropathic foot exerciser is an electronic foot massager with acupressure effect. It is based on different techniques such as:

- Heat and cold technique using DC motor
- AC relay mechanism
- Automatic software operated unit
- Vibration method using motor
- Infrared heat source

This foot exerciser is combination of three techniques magnetic coil phenomenon, vibration method using motor and infrared heat source.

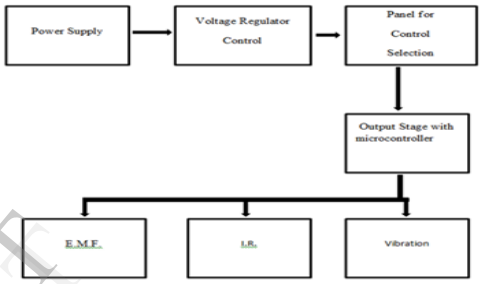

Fig. 2.1 BLOCK DIAGRAM OF NEUROPATHIC FOOT EXERCISER

2.1. Explanation

POWER SUPPLY: This unit provides 12-volt supply.

VOLTAGE REGULATORY CIRCUIT: This circuit provides a varying voltage ranges from 9 V to 18V which is then given to the voltage regulator circuit which is used to control the voltage. These varying voltages are given to the control panel circuit.

OUTPUT STAGE CIRCUITRY: We can obtain three different treatments as an output according to the different switching mechanisms. Output stage consists of timer circuit which switches the three therapies with 10 second time delay. So 3 treatments can be switched on and off after each 10 second delay.

IR SOURCE: The voltages from the voltage regulatory circuit is given to the different infrared LEDs which is located on the middle portion of the foot platform which causes the LEDs to glow.

Using I.R. source it is possible to apply heat treatment by producing heat using this light source.

VIBRATION: For vibrating mechanism the 12 V DC motor is used such that vibration is distributed equally to the foot. To achieve vibration, the spiral cut metallic part is connected to the one end of the DC motor.

MAGNETIC THERAPY: In this the EMF is induced in the footpad through the inducting wires, which is oscillated along its own axis, results in magnetization.

CONTROL PANEL: the control panel includes the on off switches for selecting the various treatments and sliding switch for keeping on one treatment at time.

3. Therapies

3.1 IR Therapy

Near-infrared therapy is a type of light therapy has become more and more popular over the years with various studies (not all though) showing good results with reduction in pain and relief of overall neuropathic symptoms.

Infrared is light just as visible light is. We can't see infrared light, however, because it has too long a wavelength. Differing wavelengths of visible light create different colours; similarly, there are two basic types of infrared, near-infrared and far-infrared, named for how close the wavelengths are to the visible light wavelengths.

Far infrared lamps are what we are all familiar with. They would be the heat lamps commonly seen in bathrooms or saunas. Unfortunately, the primary effect far-infrared light has on humans is in the generation of heat, which doesn't seem to be effective in the care of neuropathy.

How near-infrared (and to a lesser extent, visible red light) helps is not exactly clear, but it seems that it operates through two mechanisms. First it significantly increases blood flow, increasing the flow of nutrients to the damaged nerves, and second, it seems to release chemicals that promote better oxygenation of injured tissue [2]. This means that it addresses the damaged tissue directly and if totally successful (i.e., the nerve damage hasn't gone past its ability to regenerate), can result in both symptom reduction and actual improvements in the health of the nerves, reducing any need for medications

3.2 Electromagnetic Therapy

Magnets are composed of metal alloys such as iron, nickel or cobalt they will attract many different types of metallic particles. The blood contains iron and when therapeutic magnets are placed on the skin the magnetic field penetrates through the skin and into the surrounding tissues and blood stream. The iron in the blood is attracted to the magnetic field; this causes movement within the blood stream and the increased activity causes the blood flow to improve.

The increase in blood flow is localized to the area where the magnets are placed, unless the magnets are placed directly over a major artery such as the radial artery (the wrist pulse point) or the carotid artery (the pulse point in the neck)[3]. When magnets are placed over a major artery there is a much larger perfusion of blood flow so the magnetic field is carried further around the body.

When the body's blood flow is increased oxygen, nutrients and hormones are distributed to the organs and tissues much more effectively and quickly. Your organs have a fresh rich supply of oxygen and nutrients to nourish them. Plus the tissues also gain oxygen, healing nutrients and hormones including endorphins, which are the body's natural painkilling hormone.

If you have an injury or ailment which is supplied with regular fresh oxygen, nutrients and endorphins then your injury or ailment will heal much faster and the pain will be reduced by the body's own pain killing hormones (endorphins).

3.3 Vibration Therapy

More motor units are activated under the influence of vibration than in normal, conscious muscle contractions. Due to this, muscles are incited more efficiently.

The immediate effect is therefore that the muscles can be used quickly and efficiently, rendering them capable of producing more force. However, this process will only be effective if the

stimulus is not too intense and does not last too long, because otherwise performance will diminish due to fatigue [4].

Another immediate effect is an improvement of circulation. The rapid contraction and relaxation of the muscles at 20 to 50 times per second basically works as a pump on the blood vessels.

4. Foot Exerciser Design

Neuropathic foot exerciser is designed in such a way that it considers specific foot areas for the treatment purpose. In the prototype designed, vibrator is placed in the front half of the foot whereas the infrared source is placed at the centre of the foot and the Electromagnetic source is placed near the heel area. Due to this specific design of the foot exerciser can be used by any patient without any size adjustment also it adds effectiveness to the treatment.

5. Working

On switching on the microcontroller 8051, the ports of the microcontroller go high. After which the microcontroller ports initialize themselves at the starting addresses.

Port pin P3.7 is then checked for the mode of operation. If it is low it is working in auto mode else it is in manual mode. If it is in auto mode, all the three therapies work one after the other for 10 seconds each with a delay of 1 second in between required for switching.

Now if the mode is manual, the microcontroller checks for which of the therapies are selected by the user. For e.g.: If the user selects I.R. therapy and vibration therapy then both the therapies will work one after the other with a delay of 10 second.

But if the user selects only one therapy the therapy will go on till either the mode is changed or till another therapy has been selected. In manual mode the user can select one or two at a time.

6. Applications

1) For three types of treatment, foot platform is being specially designed;

INFRARED THERAPY- To increase the blood circulation.
E.M.F - For healing of bones, nerves, etc. In the blood, the level of irons will get increased.
VIBRATION-To stimulate the nerves on various power points on the foot.

2) For obese patients to enhance the blood circulation.

3) Cures diabetic disorder: When diabetes is not well controlled, damage to the organs and impairment of the immune system is likely. Foot problems like sensation loss, ulceration, hypotonic muscles. This unit not only removes the diabetic disorders but also cures the diabetic disorders by prolonged use of this exerciser.

4) It is also applied in Sciatica: Irradiation or inflammation of the sciatic nerves characterized by a severe pain from the lower back into the leg.

5. References

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