ABSTRACT: Electrical muscle stimulation is effected by means of a body garment having a plurality of body contact electrodes secured in it. The garment is wired to provide a single contact area for all the electrodes. The electrodes are selectively energized through a multiple contact switch associated with said contact area, so that the electrical muscle stimulating pulse output of a generator may be applied to a desired electrode pair through the switch.
ELECTRICAL CONTACT-CARRYING GARMENT FOR MUSCLE STIMULATION

The present invention relates to the field of electrical muscle stimulation, and particularly to a body garment adapted to provide for muscle stimulation selectively at desired areas of the body.

Muscle manipulation by the use of electrical pulse stimulation is well known, and numerous systems have been devised and used for this purpose. The most prominent approach in this art is to provide an electrode pad comprising two separate body-contacting electrodes united by means of a flexible web to form a single electrode pad. An electronic pulse generator is used to develop the muscle stimulating electrical pulses at a desired frequency, duration and power, and the output of this generator is coupled by wire leads to the electrode pad, one lead to each electrode. Binding posts or other connector structure are mounted on the electrodes to facilitate the coupling and decoupling of the pulse generator to the electrode pad structure. Thus in use, the electrode pad is placed where desired on the body of the user, with the two body-contacting electrodes engaging the skin of the user. With the generator wired to the electrode pad, its electrical pulse output is applied across the two electrodes of the pad, and hence across the body muscles between the two electrodes, causing these muscles to contract and relax in response to the pulses applied from the generator. The electrode pad is usually either held on the desired area of the body by hand, or by a belt or band, or the like. In use it is often desired to move the pad from one body area to another. Thus, with the conventional electrode pad arrangement the user must either be disrobed during use, or must partially disrobe to change position of the pad. Obviously the user is therefore greatly restricted in mobility during treatment, and is indeed severely restricted in the locale at which the muscle treatment can be applied. In accordance with the present invention, an alternative electrical stimulation system is provided wherein the user is afforded maximum mobility during treatment, and is indeed substantially unrestricted in the locale at which treatment can be had. Pursuant to the present invention it would not be necessary for the user to disrobe either wholly or partially during treatment or to change the area of treatment, and at all times the user may if desired remain fully clothed with normal outer garments on. Accordingly, a housewife during a period of treatment would be free to answer the door or move freely about the house in the performance of her chores without fear of embarrassment; and an office worker could undergo periods of treatment while at work, without embarrassment and without being conspicuous.

The advantages are obtained by providing a special undergarment or body garment with built-in or affixed electrodes appropriately placed to enable selective stimulation of desired muscle areas. Appropriate electrical conductor leads from each of the built-in electrodes are affixed to or entwined in the fabric of the garment, and are terminated in one selector switch. Energization of the electrodes through the selector switch may be made in several ways, as will be described subsequently; and by means of the switch, desired pairs of the electrodes may be energized to stimulate the muscle areas between the selected electrodes. In use it is contemplated that conventional outer clothing may be worn over the electrode undergarment; and depending upon the design of the system, the selector switch may be mounted on the electrode undergarment or removable plugged into a receptacle carried by the undergarment through the outer clothing of the user. In either event, the fully clad user may operate the switch and energize selected electrode pairs, or turn the energization off, at will, without disrobing or otherwise disturbing the outer clothing.

It is accordingly one object of the present invention to provide for electrical muscle stimulation of a plurality of selected areas of the body of a user.

Another object of the present invention is to provide for electrical muscle stimulation of a plurality of selected muscle areas of the body of a user without requiring selective positioning of electrodes in said plurality of areas.

And still another object of the present invention is to provide for electrical muscle stimulation of a plurality of selected muscle areas of the body of a user by electrical Switch commutation of said plurality of areas.

Other objects and advantages of the present invention will become apparent to those skilled in the art from a consideration of the following exemplary specific embodiments of the invention and in conjunction with the accompanying drawings, wherein like numerals refer to like or corresponding parts, and in which:

FIG. 1 is a front view of a body garment embodying the present invention;

FIG. 2 is a back view of said garment;

FIG. 3 is an enlarged detail of a portion of the garment of FIGS. 1 and 2, showing an electrode area;

FIG. 4 is a sectional view taken along the line 4–4 of FIG. 3;

FIG. 5 is an enlarged view of a plug receptacle attached to or carried by a body garment of FIGS. 1 and 2;

FIG. 6 is a sectional view taken along the line 6–6 of FIG. 5;

FIG. 7 is an enlarged view of a selector switch plug adapted to be inserted in the plug receptacle of FIG. 5;

FIG. 8 is an internal view of the switch plug of FIG. 7 with the cover removed;

FIG. 9 is an enlarged sectional view of the plug of FIG. 7 inserted through outer garments of a user into the plug receptacle of FIG. 5 carried upon the garment of FIGS. 1 and 2, together with an electrical muscle stimulation pulse generator connected by wire leads to the selector switch plug;

FIG. 10 is a schematic wiring diagram of the system as applied to a garment shown in FIGS. 1 and 2;

FIG. 11 is a front view of a garment as shown in FIG. 1 with a modified electrical stimulation pulse coupling system;

FIG. 12 is an enlarged view of the selector switch and pulse coupling unit carried by a garment of FIG. 11;

FIG. 13 is a sectional view taken along line 13–13 of FIG. 12;

FIGS. 14 and 15 are sectional views taken along lines 14–15 respectively of FIG. 13; and

FIG. 16 is a schematic electrical diagram of the system as applied to a garment of FIG. 11, including an electrical muscle-stimulating pulse generator for energizing the system.

In the embodiment of the present description, the body garment or undergarment is illustrated as a two-piece garment, comprising an upper body portion 12, for the upper torso, shoulders, and arms, and a lower body portion 11, for the lower torso, hips, and legs. A two-piece garment is preferred, so that the user may employ only one portion of the garment if desired, although certainly a one-piece leotard-type garment could be provided, if desired. The lower body garment 11 has a plurality of body contacting electrode pairs affixed to the inside thereof, as for example, the electrode pairs 23a–23b for the abdomen, 21a–21b for the front left thigh portion, 22a–22b for the front right thigh portion, 32a–32b for the left and right buttocks, and 31a–31b for the rear left and right thigh portions. Similarly the upper body garment 12 has appropriate body-contacting electrodes secured on the inside, as exemplified by electrode pairs 24a–24, 25a–25b, 26a–26b, 27a–27b, 33a–33b, and 34a–34b. Obviously, additional or different positioning of the electrode pairs may be selected in the design of the body garments.

The body garments 11 and 12 are fabricated to fit snugly to the body of the user to facilitate electrical contact between the electrodes and the skin of the user, and may preferably be made from a stretch material, such as a knit fabric, or a stretch yarn. The various body-contacting electrodes are affixed to the inside surface of the garment either by an adhesive or by stitching, or the like, and are formed of a flexible conductive material, such as a metal foil or a conductive plastic. As shown...
in FIGS. 3 and 4, the back side of body-contacting electrode 31c, for example, accommodates a wire lead 51, which may be branched to effect a distributed contact over its back surface. The distributed contact 51 is the terminus of an insulated conductive lead 52 which runs to the terminal plug receptacle 42 mounted on the garment 11. Lead 52 may be interwoven with the garment fabric, as shown in FIG. 4, or may be otherwise affixed to the garment fabric along its path to the terminal plug receptacle. Each of the other body-contacting electrodes or garment 11 is similarly contacted by the terminus of its own insulated electrical wire lead, and all these leads run from these respective electrodes to the terminal plug receptacle 42. The paths of these wire leads are all schematically represented by the heavy lines in FIGS. 1 and 2 all designated for convenience by the numeral 53. The structure of the upper garment is the same, and those leads are all represented by the heavy lines 54 running from the electrodes to the terminal plug receptacle 41.

The terminal plug receptacles, 41 for the upper garment 12 and 42 for the lower garment 11, are substantially identical and a description of one will suffice for both. The terminal plug receptacle 42 is shown in detail in FIGS. 5 and 6. It comprises a housing 43 having a base flange 44 secured to the garment fabric 11 by means of eyelets or rivets 45 passing through the flange and fabric. The body electrode wire leads 53 of the respective electrode housing as light wires 46a and 46b. In the housing the cables are separated into their component individual conductive leads, and each lead is soldered to the internal portion of its respective contact eyelet 47. The contact eyelets protrude through the exposed wall 48 of the housing 43, and thus form a multiple pin plug receptacle adapted to receive the multiple pins 62 shown in detail in FIGS. 7 and 8. The contact eyelets 47 are arranged in two circles, one of smaller and the other of larger diameter in the wall 48 of the receptacle housing.

The pin plug 61 is both a plug and a selector switch. Plug pins 62 protrude from the wall 63 of plug housing 64, and are arranged in two circles, one of smaller and the other of larger diameter, corresponding in arrangement to the contact eyelets 47 in the receptacle 42, so that when properly aligned the pins 62 will be received in the eyelets 47. To insure proper orientation of the plug 61 in the receptacle 42, an asymmetrical arrangement of the pins and eyelets may be employed, or an asymmetrical guide pin may be used. However, it is not thought that this is essential, and so it is not shown. Also, to facilitate insertion of the plug in the receptacle, one or two of the pins 62 may be made longer than the others, as a guide, if desired.

The interior of plug 61 is shown in FIG. 8. As there shown, the plug pins 62 that protrude from the wall 63 extend through the wall 63 to the back side thereof, where the pin heads 62a provide switch contacts. A pair of slippings 65 and 66 are also mounted on the back side of wall 63, which cooperate respectively with wiper arms 67 and 68 mounted on a rotary switch shaft 69. The lightweight cable 69 supplies desired electrical muscle-stimulating pulses from a generator 81 to the slippings 65 and 66. Thus, rotation of shaft 69 by means of indicator handle 60 causes wiper arm 67 to establish contact between slippings 65 and the outer circle of plug pins 62 in succession, and causes wiper arm 68 to establish contact between slippings 66 and the inner circle of plug pins 62 in succession. Wiper arms 67 and 68 are fixedly mounted on the shaft 69 at a selected angle, so that a paired relationship exists between the outer and inner circles of contacts. Thus, when the selector knob 60 is moved to a particular contact position, and the plug 61 is properly inserted in the receptacle 42, the electrical muscle-stimulation pulses fed from the generator 81 through wire 69 to slip rings 65 and 66, and thence through the wiper arms 67 and 68 to the selected pins 62, those leads 53 are energized which connect to a particular pair of body electrodes on the garment associated with that particular position of the selector knob. In this way, merely by turning the selector knob 60, the wearer of the garment 11 may change and select which pair of body contact electrodes are energized.

This electrical relationship is best illustrated in the schematic electrical diagram of FIG. 10. As there shown, the electrical muscle-stimulating pulse output of pulse generator 81 is conducted by cable 69 to the selector switch pin plug and plug receptacle 42, 61. The selector switch wiper arms 67 and 68 are shown set to those switch contacts 62a which connect with body electrodes 23a and 23b, so the muscles of the user between electrodes 23a and 23b are stimulated by the electrical pulses.

As is readily apparent from FIG. 10, other muscle areas of the body may be selectively stimulated by rotating the selector switch to the appropriate contact position. For example, if the switch is rotated to place the wipers 67 and 68 in the position shown in dotted lines in FIG. 10, the muscle area between contact electrodes 31a and 31c is stimulated.

FIG. 9 is a cross-sectional view of the receptacle 42 and plug 61 coupled together in operative relationship through the users outer clothing. The plug receptacle 42 is affixed to the body garment 11, and two layers of outer clothing 82 are indicated as overlying the plug receptacle. As shown, the pin prongs 62 of the plug 61, being about the diameter of ordinary straight pins, are penetrated through the outer garments 82 and caused to enter their appropriate eyelet receptacles 47. In this way, the electrical pulse output of generator 81 is coupled by cable 69 to the plug 61 into receptacle 42. By appropriate selection of the position of the selector switch through knob 60, the desired body electrodes of the garment 11 are energized to stimulate the mody muscles of that area.

Energization of the electrodes in the upper body garment 12 is effected in the same way as above-described, by inserting a pin plug substantially identical to plug 61 in the upper body garment plug receptacle 41.

Suitable pulse generator circuits for purposes of the present invention are well known in the art. One appropriate circuit is illustrated and described in the copending application of the present inventor, Ser. No. 598,845, filed Dec. 2, 1966, and entitled Electrical Muscle Stimulator, and the disclosure of that application is incorporated by reference into this specification.

Although it is preferred, as illustrated, to incorporate the selector switch in the pin plug, it is apparent that the plug can be merely a plug connected by a multistrand cable to the pulse generator, and the selector switch can be incorporated in the generator housing.

A second embodiment of the invention illustrated in FIGS. 11-16 utilizes a somewhat different mode of energizing the body contact electrodes. The body garments 11 and 12 shown in FIG. 11 are identical to the garments illustrated in FIGS. 1 and 2, and contain the same body contact electrodes and the same electrode leads 53 and 54. These portions of the system therefore need not be redescribed. Instead of the pin plug receptacles 41 and 42 of FIGS. 1 and 2, however, in the embodiment of FIG. 11 these are replaced by an induction or radiated energy pick up circuit and selector switch combination, indicated as 41' for the upper body garment 12 and 42' for the lower body garment 11.

The principles of and circuitry for utilizing an induction or radiated energy coupling between a pulse generator and a remote body electrode, for electrical pulse muscle stimulation, is the subject matter of the copending application of the present inventor, Ser. No. 598,495, filed Dec. 1, 1966, entitled Electrical Muscle Stimulator, and reference is made thereto for a detailed description of this concept, and the same is incorporated herein by reference. The present description therefore will be directed primarily to the application of that concept to the body garment approach of the present invention.

The energy pickup and selector switch combination units 41' and 42' are substantially identical, and therefore a description of one will suffice for both. The unit 42' on the lower body garment 11 is shown in detail in FIGS. 12-15. Unit 42' comprises a housing 72 having a base flange 95 by which
the unit is secured to the fabric of the body garment 11 by rivets 77. The housing 72 is divided into two compartments, compartment 96 for housing the electronic energy pickup components generally indicated by the numeral 93, and compartment 97 for housing the selector switch components. The pickup components comprise a ferrite core coil 101 for picking up the radiated or induction field pulses of a remote generator, and coupling this energy into detector and limiter circuits whose circuit components are schematically represented by the elements designated 93, all as more fully described in said copending application Ser. No. 598,495. The detected and limited output of this section of the unit 41' is coupled by leads 91 and 92 to the sliprings 79 and 78 respectively in the selector switch section 97 of unit 42'.

As in the preceding embodiment, the selector switch has a plurality of switch contact elements 71 arranged in two concentric circles, one of larger diameter than the other. The contacts forming the larger circle are positioned to be engaged sequentially by wiper arm 74 when it is rotated by the switch shaft 94 upon which it is mounted. At the same time, the contacts forming the smaller circle are positioned to be engaged sequentially by wiper arm 75, which is also mounted on shaft 94 for unison rotational movement with wiper arm 74. Wiper arm 74 also incorporates a contact portion 74' that sweeps over slipring 79, and wiper arm 75 likewise incorporates a contact portion 75' which sweeps over slipring 78. Thus, the wiper arms 74 and 75 transmit the output of the energy pickup unit from the collector rings 78 and 79 to the selected switch contacts 71 with which the wiper arms have been brought into engagement.

Each contact 71 is the terminal for a wire lead in cable 53 connected to a selected one of the body contact electrodes on thegarment 11. Accordingly, by proper positioning of the switch by rotation of knob 76 to one of the dial positions 73, a desired pair of body contact electrodes will be placed in circuit with the output leads 91 and 92 of the energy pickup unit 98. This relationship is best illustrated by the schematic circuit diagram of FIG. 16. A pulse generator circuit 99 similar to that shown and described in said copending application Ser. No. 598,495, radiates an induction or radiofrequency energy field from its transmitting loop 100. This energy field drives the pickup circuit 98, to provide a series of electrical muscle stimulating pulses on the pickup circuit output leads 91 and 92. These pulses are conducted through the selector switch wiper arms 74 and 75 to those selector switch contacts 71 which connect with body contact electrodes 23a-23b, thereby causing stimulation of the body muscles in the area of those electrodes. Obviously, the user may select any other body electrode pair by appropriate positioning of the selector switch wiper arms, as for example is indicated by their dotted line position, wherein electrode pair 22a-22b is energized.

In utilizing the present embodiment of the invention, if the user is wearing outer garments over the body garments 11 and 12, the entire pickup and selector units 41' and 42' are concealed beneath the outer garments. This presents both an advantage and disadvantage relative to the first described embodiment wherein the pin plug 61 is positioned outside the outer clothing, in that although the units 41' and 42' are completely concealed, the positioning of the selector switch knob 76 is not as convenient. Nevertheless, with but a little experience the user will be able to manipulate the selector knob 76 by feel to a particular position to energize a desired body electrode pair.

In the above-identified copending application Ser. No. 598,845, there is described a miniature battery-operated pulse generator for use with a muscle-stimulating body electrode pad. That miniature pulse generator could of course be incorporated in selector units 41' and 42' in compartment 96 in place of the pickup unit 98, and have its two output leads connected to the sliprings 78 and 79, so that its output pulses would be applied to a desired body electrode pair through the selector switch in compartment 97.

Other variations and modifications of the invention will be apparent to those skilled in the art, and therefore it is understood that the foregoing embodiments are presented merely as exemplary to enable a complete understanding of the invention. Such variations and modifications as are embraced by the spirit and scope of the appended claims are contemplated as within the purview of the present invention.

What is claimed is:
1. In a system for applying muscle-stimulating electrical energy to the body of a recipient, a body garment adapted to be worn directly against the body of the recipient, said garment having a plurality of electrode pairs affixed to the inside surface thereof for engagement with the body of the recipient, a terminal block affixed to the garment having a terminal for each electrode, an electrical conductor coupled to each said electrode and running along the garment from the electrode to its respective terminal on said terminal block, whereby electrical coupling may be had to selected electrode pairs through said terminal block, means carried by said garment for picking up the energy of an electromagnetic and a selector switch for coupling said energy to selected terminals of said terminal block, said terminals being switch contacts for said selector switch.