Sept. 13, 1955 R. A. SCHLESINGER 2,717,736

EXERCISE COUNTING APPARATUS

Filed July 17, 1951 2 Sheets-Sheet 1

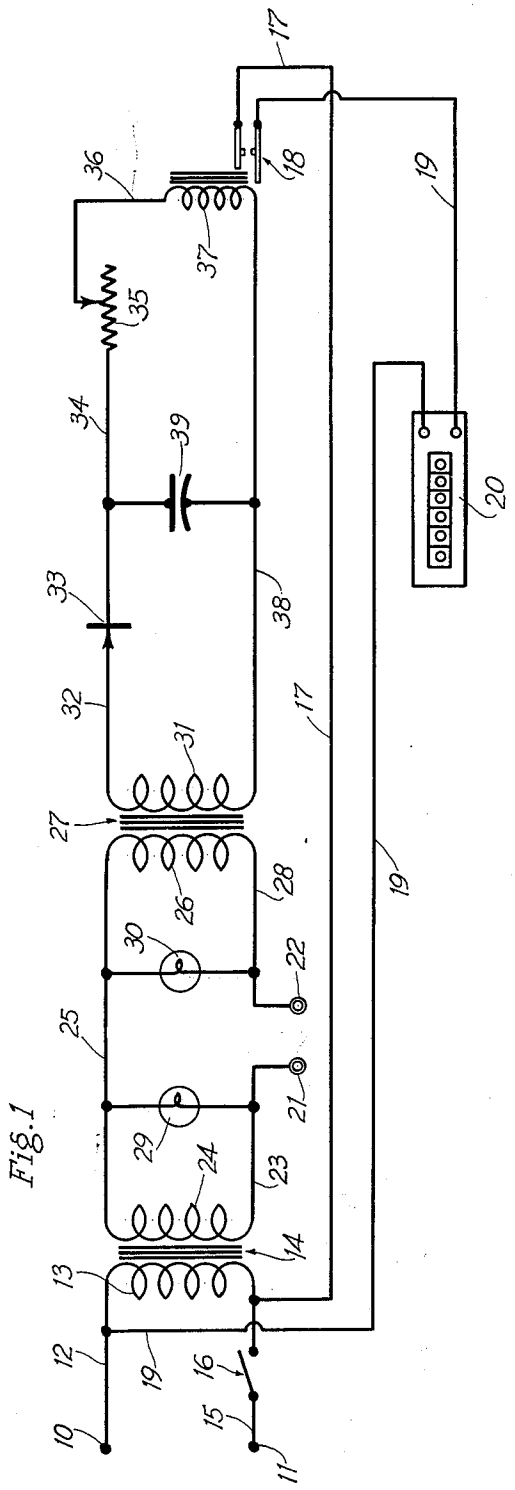

Fig. 1

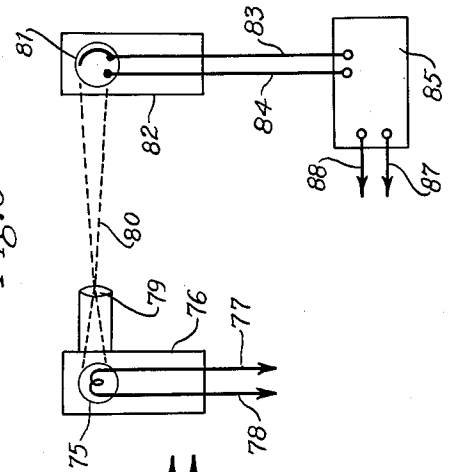

Fig. 8

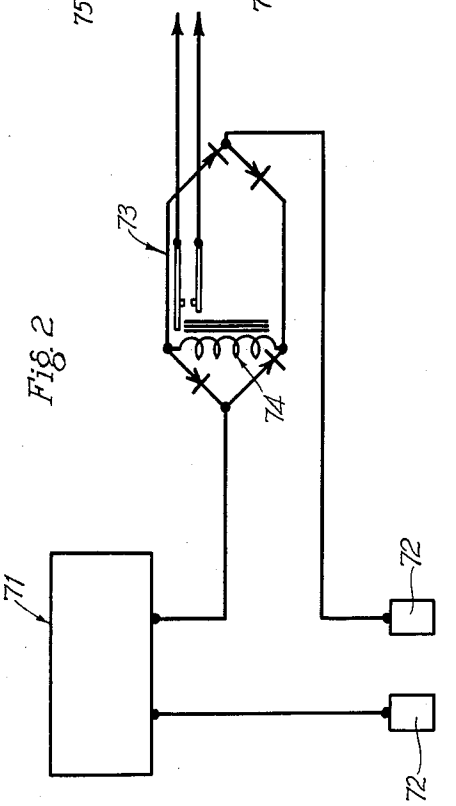

Fig. 2

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Fig. 3

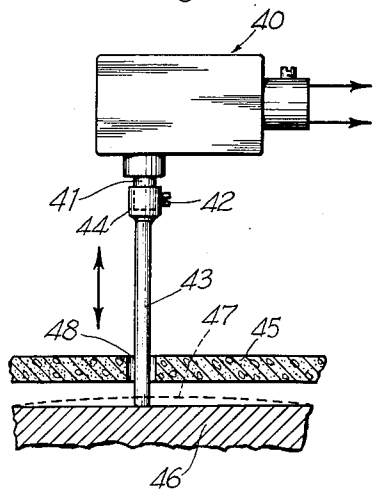


Fig. 4

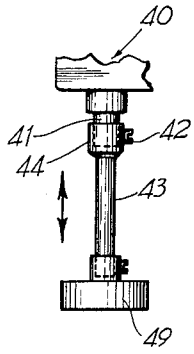


Fig. 5

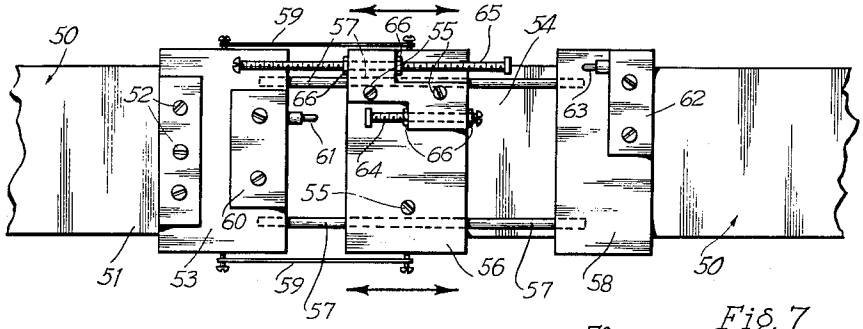


Fig. 6

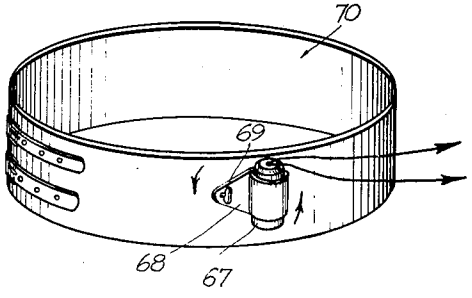
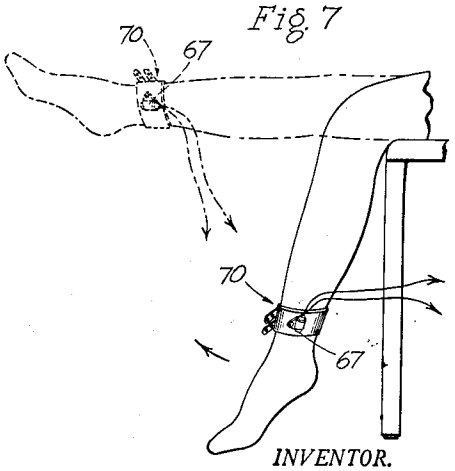


Fig. 7



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EXERCISE COUNTING APPARATUS

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5 Claims. (Cl. 235—92)

This invention relates generally to physical medicine and, in particular, to apparatus for regulating performance of muscular activity prescribed therein.

The prescription specifies the performance of a certain amount and type of muscular work to be done by the patient in a rhythmic manner over a given period of time. An exercise prescription for a patient requires a series of muscular movements to be made at a particular rate. The therapeutic value of the exercise resides in the fact that the prescribed movements are all like employments of the muscles under treatment each separated by like intervals of relaxation; thus, a proper regulation of the exercise must control not only the amount of work done, the range of motion, and the number of movements, but also maintenance of a proper rate of performance. A common tendency of the patient during exercise treatment is to speed up the series of movements as exercise progresses in order to complete the treatment more quickly. This tendency results in acceleration of the rate of contraction and a failure to produce, in the accelerated movements, the amount of of work prescribed. The range of movement is of first importance; and the tendency to speed up the exercse frequently results also in a diminution of such range. Thus if the exercise is speeded up, and if the full range of motion is not carried out, the intended treatment is not accomplished, and, further, excessive fatigue with consequent indifference to the therapy may result. This tendency of the patient is so well recognized by the therapist that normally he constantly supervises the patient throughout the exercise period to make sure that the prescribed number of movements is properly made in a specified manner.

Thus, the general object of the invention is to provide novel, simple, and efficient apparatus for regulating the performance of exercise prescribed in physical medicine. The apparatus has as a particular advantage the feature that its use relieves the therapist of the necessity of constant attention to the patient during the exercise period, and thereby frees the therapist for other duties.

The invention contemplates apparatus which is designed to regulate the range of movement, as well as the rate and number of movements; and a special feature of the invention is that it may be adapted to register such movements made at intervals at least as great as those called for by the prescription, and not faster movements, so that if the patient attempts to speed up the exercise, certain of the rapid movements are not recorded at all. In consequence, the patient, who may observe the count of movements registered by the apparatus, quickly realizes that the result of accelerating the individual movements is merely to prolong the exercise period, and he also realizes that he has to perform the proper range of movement in order to receive additive response by the apparatus. The psychological effect is normally that the patient makes, thereafter, a serious attempt to perform the exercise in the proper manner.

The principle involved in the present apparatus is that the patient, directly or indirectly by muscular effort, sequentially makes and breaks a circuit by actuating any one of a variety of types of switches operated by suitable means depending upon the particular conditions of the treatment, so as to pulse an electrical indicator adjustably arranged to be responsive to pulses received only at predetermined intervals. For example, the extent of angular range of muscular movement prescribed may be kept uniform by positioning the means for making and breaking the circuit at a given distance from the relaxed position of that part of the body required to actuate the pulsing mechanism. If a patient is required to raise an arm a number of times to a certain height, a suitable switch may be fixed at such height above the relaxed position of the arm and in the proposed path thereof. The limits of this range of motion may be increased from one treatment to the next as required in order to effect an increase in the patient's muscular effectiveness.

The apparatus may be adjusted so that the indicator will operate upon energization of the circuit only if the switch is closed sequentially not more rapidly than at the prescribed rate. Thus, if the patient is to raise his arm to a certain height a given number of times at a particular rate, he can effect registration of the required total upon the indicator with the least effort only by performing the exercise correctly; of course, if the positional limit of the range of motion is insufficient to actuate the switch, he obtains no additive response, and if he speeds up the movement, although maintaining a constant range of motion, he loses additive response upon certain consecutive movements not sufficiently spaced from the preceding movement. Realization that the apparatus is itself a sort of vigilant observer normally tends to create a disposition on the part of the patient to perform the exercise in the prescribed manner and thereby to save himself the useless fatigue incident to an attempt to speed up or otherwise vary the prescribed treatment.

The apparatus comprises a responder or control unit, which may be constructed as a small, portable device, and means whereby the patient may actuate the responder by exercise movements. Since the exercise prescribed may be any of a great variety and may require performance under many different conditions, it will be obvious that the means whereby the patient actuates the responder must be suitable for the particular conditions of the treatment. As examples of exercises to be regulated there may be mentioned active or passive exercise, contractions of muscles within a cast, respiratory movement, and underwater exercise. Thus the present invention includes, in addition to the responder or control unit, several means for actuating the same and which may be employed by the patient under different conditions of treatment.

The apparatus may also be employed to regulate electrical stimulation of muscles and nerves. Further, it will be seen herein that the apparatus may be generally used for measuring, recording, and regulating various types of muscular activity wherein repeated movements of particular range and frequency are involved. The apparatus is not only useful in physical medicine but may be employed in connection with certain gymnasium equipment.

Also it will be understood that the responder or control unit may be actuated by any suitable means for signaling a physical change occasioned by muscular activity, as that relating to an actual muscular movement or that relating to an electrical-potential difference resulting from an attempt to make a visible muscular movement.

In the drawing:

Fig. 1 is a diagram illustrating a representative type of circuit arrangement and parts for a responder or control unit.

Fig. 2 is a diagram illustrating a modified circuit for electrical stimulation of muscles and nerves of a patient in physical medicine, said modified circuit being adapted to be used in connection with the responder or control unit of the invention.

Fig. 3 is a view of switching apparatus to be used in connection with the responder or control unit for the purpose of regulating exercise movements performed by muscles within a cast.

Fig. 4 is a view of a similar switching apparatus adapted to be used for regulating the number, frequency, and extent of range of exercise movements such as repeated elevations of the arm or leg of the patient. This arrangement, as will be more particularly described, is also suitable for use in regulating underwater exercise, as in a whirlpool or other bath, as well as exercise performed on gymnasium or occupational therapy equipment.

Fig 5 shows switching apparatus particularly useful for regulating the number, frequency, and extent of respiratory movements, and includes a belt, shown only in part, which may be applied to the patient's chest or abdomen.

Fig. 6 shows, in perspective, a belt which may be used as a cuff, anklet, or the like, carrying a gravity sensitive switch, and which may be conveniently employed for signaling the number, frequency, and extent of angular changes of parts of the body, as, for example, the patient's leg.

Fig. 7 is an illustration of the last-named use.

Fig. 8 illustrates typical photoelectric means for pulsing the responder or control unit in accordance with muscular activity of the patient.

The apparatus of the invetion is preferably constructed as a portable unit; and, as the essential parts are of small size, this may easily be done. However, herein no design is shown for the actual construction of the responder or control unit, as this unit may be fabricated in various forms using various circuits, as desired; but several means for actuating the responder or control unit are shown, and the structural designs illustrated have been found to be satisfactory in actual tests in treatments in physical medicine. All essentials of a representative general circuit arrangement and related parts for the responder or control unit are shown diagrammatically.

The responder comprises an electrically operated indicator or counter in a pulse responsive circuit adjustably adapted to operate at a rate not greater than a predetermined frequency. This unit comprises, more particularly, a circuit having a power source, a variable time delay circuit keyed therewith, and an electrically operated indicator or counter. Exercise activity is utilized to effect actuation of a suitable external switch or other signaling means which keys the source of power, preferably at low potential for reasons of safety, to produce a pulse of operating energy. This energy, suitably retarded by the time delay circuit, effects operation of the indicator or counter to register exercise activity at not greater than a predetermined rate. A subsequent pulse received before the delay period is over causes the indicator circuit to be unexcited and no additive count results.

Fig. 1 is a diagram of a representative type of circuit arrangement and parts for a responder or control unit suitable for connection with the usual 110 v. A. C. house line. This type of unit comprises three circuits inductively keyed together; an indicator or counter in series with the first circuit, which circuit is directly connected with the house line as by plugging in a drop from the unit; jack terminals for a loop having a plug and a switch adapted to be actuated in response to exercise movements, the terminals being in the second circuit, and the switch being in series therewith when the plug and jack are connected; and a variable time delay switch in series with the third circuit, the time delay switch controlling the indicator or counter.

In Fig. 1 the terminals of a plug for connecting the responder or control unit to the house line are designated

10 and 11; and line 12 connects terminal 10 with the primary 13 of a stepdown transformer 14, from which line 15 leads through a main switch 16 to terminal 11. Connected in parallel with the drop, by means of a line 17, the switch 18 of a relay (see below), and line 19, is a pulse responsive counter 20. The foregoing is a description of the first circuit.

The second circuit is assumed to include a loop connected with the responder or control unit and extending therefrom to a switch adapted to be actuated in response to exercise movements. This loop is not indicated completely in Fig. 1; but the jack terminals to which the omitted portion of the loop connects are shown and designated 21 and 22. From terminal 21 a line 23 leads to the secondary 24 of stepdown transformer 14; and a line 25 ties this secondary in series with primary 26 of a stepup transformer 27, from which a line 28 leads to terminal 22. In parallel with the secondary 24 of transformer 14 is an indicator light 29 which serves to show when the main switch 16 is closed. In parallel with the primary 26 of transformer 27 is an indicator light 30 which is lit only when the loop of the second circuit is completed at terminals 21 and 22 by an external switch.

The third circuit is a rectifying and time delay circuit, always closed. From secondary 31 of transformer 27 line 32 leads to a rectifier 33 from which a line 34 extends to a variable resistance 35. The circuit is completed from resistance 35 by line 36 which leads to coil 37 of the aforementioned relay whose switch is designated 18, and by a line 38 which extends back to secondary 31 of transformer 27. The circuit is bridged between lines 34 and 38 by condenser 39.

When the third circuit is inductively energized by the closing of the second circuit in response to exercise movement the relay is actuated, switch 18 is closed, and the counter 20 is operated to register the movement. When the third circuit is deenergized the condenser 39 discharges and the relay returns to normal condition in which switch 18 is opened. The adjustment of resistance 35 determines the speed of discharge of condenser 39 and the time of the opening of switch 18.

Particular means whereby the second circuit is closed in response to exercise movements are described in detail below; but here it is sufficient, for the purpose of describing the operation of the responder or control unit, to assume that the second circuit may be sequentially made and broken in any suitable manner in accordance with muscular activity. The unit being plugged to the house line and main switch 16 being closed, primary 13 of transformer 14 is energized; but so long as the second circuit is not closed, as by an external switching means arranged to be operated in response to exercise movements, the relay cannot operate to close switch 18, and the counter 20 is not actuated. However, indicator light 29 is lit to show that the responder is ready to work. As soon as the second circuit is closed its inductive excitation effects inductive energization of the third circuit. Indicator light 30 is lit incidentally with the closing of the second circuit. Condenser 39 is charged by the output of rectifier 33, and remains charged until the second circuit is opened. Meanwhile the relay is actuated and switch 18 is closed, effecting one registration upon the counter. When the second circuit is opened condenser 39 discharges through resistance 35 and coil 37 at a rate determined by the setting of the resistance. Resistance 35 is preferably so designed that a considerable lag may be provided for, whereby certain types of exercises calling for long intervals of attainment may be accommodated. When the second circuit is closed again too promptly after a preceding completion of the circuit, due to the predetermined lag effected by adjustment of the resistance, the relay remains energized and switch 18 remains closed; so, in consequence, no additive count is registered by the indicator or counter 20.

It can be seen that if transformers 14 and 27 and

rectifier 33 are removed, and lines 12, 25, and 34 are made continuous, and lines 17 and 23, and lines 28 and 38, are each made continuous, and if the indicator or counter 20 is of the type which may be operated by direct current, a simplified circuit is provided. If this circuit is energized at terminals 10 and 11 by direct current from a suitable source, as, for example, a battery, the circuit will perform in a functionally equivalent manner to that described above.

Fig. 3 shows a pressure sensitive switch arranged to be actuated in response to exercise movements of muscles within a cast. The switch is generally designated 40; the usual button by means of which the switch may be actuated is indexed 41. The button is assumed to be maintained by a spring (not shown) in extended position, in which position the switch is open. Secured to the button, as by a set screw 42, is a rod 43 having a cup 44 at one end and surrounding the button. In the figure 45 is part of a cast, and 46 is part of the body of the patient. Surgical dressing material normally present between the surface of the body and the inside of the cast is not shown, so that a dotted line 47, indicative of the contour of the surface of the body portion during muscular contraction, may be clearly seen. In solid line the body portion is shown relaxed. The lower portion of rod 43 is passed through a hole 48 in the cast 45; and the switch is assumed to be rigidly mounted in any suitable manner so that the lower end of the rod is in contact with the body portion at all times, whereby, when the muscle is relaxed, the rod may descend sufficiently to open the switch. When the patient contracts the muscle within the cast the rod is pushed upward as the surface of the body portion assumes the contour indicated by dotted line 47, and switch 40 is accordingly closed. A signal corresponding to the accomplished exercise movement is transmitted to the responder or control unit by means of suitable lines (arrows in Fig. 3) which are connected to terminals 21 and 22 (Fig. 1).

Fig. 4 illustrates another use of switch 40. Here the rod 43 may be of any suitable length, and, mounted on its extremity distant from the switch, is a member 49 which may be conveniently engaged by a moving portion of the body of the patient. The switch may be rigidly fixed in any desired position and the therapeutic prescription may call for a number of timed actuations of the member 49 by the patient. This arrangement is suitable for regulating not only the number and timing but also the range of motion performed during the treatment. Plainly this arrangement is particularly useful in connection with such exercises as repeated flexion or extension of the upper or lower extremities of the body, where member 49 is fixed at a position sufficiently distant from the patient so that he must perform a movement of the prescribed range each time in order to actuate switch 40.

It will also be apparent that the arrangement illustrated in Fig. 4 is suitable for use in connection with underwater exercise by the patient. As is well known in physical medicine the movement of a part of the body is frequently greatly facilitated in the performance of prescribed exercise if the part involved is submerged in warm water. The rod 43 may be of insulating material, such as plastic, whereby the switch 40 may be positioned safely above the surface of the water with the member 49 beneath the surface and convenient to the patient. It will be understood that if member 49 and rod 43 are coupled to button 41 through a lever system (not shown) the exercise movement to be regulated may be other than vertical, and, in fact, may be in any desired direction.

Fig. 5 illustrates a switching arrangement suitable for regulating respiratory movement. The figure shows, in part, a belt 50 which may be adapted to fit around the chest or abdomen of the patient, and which may be adjusted as to effective length in any suitable manner. Mounted on an end 51 of the belt 50 by means of screws 52 is a block 53. Mounted on an opposing end 54 of the belt by means of screws 55 is another block 56. This latter block is slidably mounted on rails 57 extending from and rigidly connecting block 53 to a third block 58 beyond block 56. Blocks 53 and 56 are connected by elastic bands 59 which urge the blocks together. Mounted on block 53 is a switch 60 having an actuating button 61; and mounted on block 58 is another switch 62 having an actuating button 63. The actuating buttons are disposed toward the intermediate block 56 on which are mounted two screws 64 and 65, each adjustable as to effective length and each lockable in position by means of nuts 66, the first screw 64 being aligned so that it may engage button 61 of switch 60 and the second screw 65 being aligned so that it may engage button 63 of switch 62. It will be obvious from the figure that as the patient alternately inhales and exhales switches 60 and 62 will be closed respectively.

Fig. 6 shows a switching arrangement involving a gravity operated switch 67, preferably of the mercury type, mounted in a holder 68 pivotally and lockably mounted by means of a wing screw 69 engaging a tapped bore (not shown) provided in a belt 70. The belt 70 may serve as a cuff or anklet. Fig. 7 shows this switching means in use, the belt here serving as an anklet and being mounted on the leg of the patient. Repeated elevations of the leg from the solid line position to the dot and dash line position of the latter figure operate to close the switch.

The responder or control unit of the present invention may be utilized to regulate the timing of electrical stimulation of muscles and nerves. In Fig. 2 well known means for electrical stimulation are shown diagrammatically. The electrical stimulator is designated 71 and the electrodes to be applied to the patient are indexed 72. The excitation circuit here includes, in series, a bridge rectifier 73, crossed by the coil of a relay 74. As will be apparent, the relay 74 may be substituted for by any of the patient-actuated switching means heretofore described for the purpose of pulsing the indicator or counter 20; and, in order to attain a prescribed count of excitations, the therapist will be obliged to operate the excitation apparatus at intervals no more frequent than those corresponding to the operability frequency of the time delay switch 18.

In Fig. 8 is illustrated diagrammatically a method of using a light beam and photoelectric switching means to accomplish actuation of the responder in accordance with exercise movements. An incendescent light 75 in a housing 76 is excited by a suitable current supplied through lines 77 and 78. An optical lens 79 forms a narrow light beam 80 which is focused on a photoelectric cell 81 mounted in a housing 82. The output of the cell 81 is fed to an electronic relay 85 of a type suitable to be used for photoelectric operation by means of lines 83 and 84. Action of relay 85 is employed to effect pulsing of the responder or control unit through lines 86 and 87 which may be connected to terminals 21 and 22. It will be understood that beam 80 may be positioned as desired so that, during exercise, a portion of the body may be repeatedly moved to block the beam.

It is well known in physiology that currents of small magnitude, known as action currents, are generated within muscles in the presence of attempts to move the muscles even though no visible movement takes place, and that such currents may readily be detected. Therefore these currents may be amplified and employed to pulse the responder whereby repeated efforts to move muscles may be accordingly regulated.

I claim:

1. In an apparatus comprising a time delay circuit for providing current information on intermittent motions composed of starts and stops, three circuits inductively keyed together; a counter in series with a first circuit;

a switch closing in response to muscular activity in series with a second circuit; and a variable time switch in series with a third circuit, said time switch controlling said counter, whereby the time delay circuit constitutes a check upon a desired repetition rate of completed movement.

2. In apparatus of the class described, the combination of claim 1 wherein said first named switch comprises a stationary contact and a cooperating movable contact, the latter having a member attached thereto adapted to be passed through an orifice in a cast and to engage a portion of the human body within said cast whereby flexion of said portion may be utilized to operate said first named switch.

3. In apparatus of the class described, the combination of claim 1 wherein said first named switch is position sensitive and is mounted on a member adapted to be attached to a portion of the human body whereby variation of the angular disposition of said portion may be utilized to operate said first named switch.

4. In apparatus of the class described, the combination of claim 1 wherein said first named switch comprises a

stationary contact and a cooperating movable contact, the latter having a member attached thereto adapted to be engaged by a portion of the human body, said switch being mounted on a support adapted to be positioned relatively to said portion whereby movement of predetermined magnitude of said portion may be utilized to actuate said first named switch.

5. The combination of claim 1 wherein said first named switch is mounted on an elastic belt adapted to be worn around the upper portion of the human body and wherein said switch is adapted to be closed in response to expansion and/or contraction due to respiratory movements of the body.

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