A physiotherapy device for human beings having two parallel measuring channels for indicating the muscle tension in two selected muscles. The device computes and displays the absolute value of each measurement of muscle tension, the arithmetic difference between each measurement and the ratio between each measurement. In operation, the patient observes his own muscle tension readings and responds accordingly in a biological feedback.

10 Claims, 1 Drawing Figure
DIFFERENTIAL/RATIO METRIC ELECTROMYOGRAPHIC BIO-FEEDBACK MONITOR

BACKGROUND OF THE INVENTION

1. Field of the Invention
This invention relates to devices for performing physical therapy on human beings, and more particularly to devices for performing human muscle rehabilitation therapy.

2. Description of the Prior Art
In recent years there has been a substantial amount of research being conducted in the area of bio-feedback systems. The general concept of a bio-feedback system includes the steps of electronically measuring some physiological activity of a patient, translating these measurements into signals readily observable by the patient, and then having the patient attempt to control his physiological activity by responding to the observed signals. In a bio-feedback system the patient actually becomes part of the signal transmission circuit. He generates the signals by his own bodily activity, observes the measured signals either visually, audibly or tactually, and then in the manner of a feedback loop tries to control his bodily activity as indicated by the signals.

Currently, most of the bio-feedback research and experimentation is directed to the study of the brainwaves that are generated in the human mind. The human brain waves are recorded on an electroencephalograph (EEG) and displayed to the patient through various electrical circuits. A further discussion of how these measurements are performed and the devices used to record electroencephalographic activity is contained in the U.S. Patent Application entitled "BIOLOGICAL FEEDBACK SYSTEMS", Ser. No. 299,774, filed Oct. 24, 1972 by James A. Freeman now abandoned.

In the area of physical therapy and human muscle rehabilitation, bio-feedback systems have been used with some success. It has been found experimentally that the tension of a muscle is proportional to the electrical activity of the neuron fibers within that muscle. This electrical activity can be measured by two electrodes placed on the skin of the patient proximate to the muscle. The electrodes produce very weak signals that must be greatly amplified. The amplified signals are then fed to an indicator that displays to the patient the relative tension of the muscle being measured. The patient tries to control the muscle by responding to the signals displayed on the indicator and thereby learns through the feedback to voluntarily relax or to tense the muscle.

Heretofore, these prior art systems have incorporated only a single feedback loop and have been found to be inadequate to treat cases of severe muscle disorder. In the case of severe muscle disorder, the process of learning to tense or relax a disabled muscle is accompanied by an undesirable, simultaneous tensing or relaxing of other body muscles. For example, the lifting of a human arm requires a simultaneous contraction of the biceps and along with a lengthening of the triceps. The problem, heretofore, has been how to measure simultaneously two interacting muscles and how to display the amount of interaction therebetween.

SUMMARY OF THE INVENTION
The differential/ratiometric electromyographic bio-feedback monitor is a two-channel bio-feedback system providing simultaneous measurement and feedback information on more than one muscle of a patient at one time. In the system a plurality of electrodes are connected to the various muscles being studied to measure the relative tension of each. The system displays to the patient the absolute value of each measured muscle tension signal, the difference between each muscle tension signal, and the quotient of the muscle tension signals.

The primary object of the present invention is to display to the patient the measured values of the differences and ratios of the tension of selected muscles so that the patient can gain independent control of those muscles which do not interact with each other and can gain complimentary control of those muscles which should normally interact.

Additional objects and features of the present invention will appear from the following description in which the preferred embodiment of the invention has been set forth in detail in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWING
FIG. 1 is a diagrammatic view of a differential/ratiometric electromyographic bio-feedback monitor according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT
Referring to FIG. 1, reference numeral 12 indicates a patient undergoing biological feedback physiotherapy while lifting a ball 14 in his left hand. Attached to the biceps of his upper left arm are two electrodes 16 and attached to the triceps of his upper left arm are two similar electrodes 18. Each set of electrodes is placed in proximity to the muscle desired to be monitored; in FIG. 1 the electrodes 16 are measuring the left biceps and the electrodes 18 are measuring the left triceps. Each pair of electrodes measures a small electrical potential, called an electromyographic signal, generated by the neuron fibers within the muscle being measured. Each set of electrodes is connected to a separate high gain amplifier 20. The electrical potential measured by each pair of electrodes is in the range of microvolts, so a high gain amplifier is required in order to provide a usable signal.

The output of each high gain amplifier 20 is connected to a potentiometer 22 for adjusting the magnitude of the output of each high gain amplifier. Since each muscle being measured by the bio-feedback system produces a signal of a different magnitude, the potentiometers are used to adjust the relative magnitudes of the signals and to give a weighting factor to each muscle. The output of each potentiometer 22 is connected to a rectifier 24 that converts the signal into a direct current signal level proportional to the absolute value of the measured electromyographic activity.

Referring to FIG. 1, the electromyographic bio-feedback system includes two parallel measuring channels, each having a high gain amplifier 20, a potentiometer 22 and a rectifier 24. Each channel separately and independently measures the electromyographic activity of a selected muscle. For the purposes of identification, the electromyographic activity of the bicep muscle is measured by channel A, and the electromyographic ac-
tivity of the tricep muscle is measured by channel B. The duplicate components of channel A contained in channel B are identified by corresponding primed reference numerals.

The outputs of the two measuring channels A, B are displayed on an indicator console 26 observable by the patient 12. The output from the rectifier 24 of channel A is connected directly to an absolute value indicator 28 and also to a differential amplifier 30 and an electronic divider 32. The absolute value indicator 28 is a meter on the indicator console 26 displaying the relative value of the muscle tensions measured by channel A. The rectifier 24 of channel B is connected directly to an absolute value indicator 34 and also to the differential amplifier 30 and the electronic divider 32. The absolute value indicator 34 is identical with the absolute value indicator 28 and displays the relative value of the muscle tension measured by channel B. The differential amplifier 30 is a conventional differential amplifier that generates an output proportional to the arithmetic difference between the inputs from channel A and from channel B. The output of the differential amplifier 30 is connected to a difference indicator 36 which visually indicates the absolute value of the quantity (A - B) to the patient. The electronic divider 32 is a conventional electronic dividing circuit that generates an output proportional to the ratio of the inputs from channel A and from channel B. The output of the electronic divider is connected to a ratiometric indicator 40 which visually indicates the quotient (A/B) to the patient.

In operation each pair of electrodes 16, 18 is attached to the skin of the patient proximate to the respective muscle being measured. Thereafter the patient begins his muscle conditioning exercise. As each muscle tenses and relaxes, each set of electrodes measures the electromyographic activity in the respective muscle. The electromyographic signals from each set of electrodes is amplified in the high gain amplifier 20, rectified in the rectifier 24, and displayed on the indicator console 26. As soon as an output is displayed on the indicator console 26, the potentiometers 22 are adjusted to compensate for the varying magnitudes of the electromyographic signals received from the muscles being measured. The indicator console 26 is located in front of the patient 12 so that he may observe the signals visually displayed thereon. As the patient 12 exercises, he tries to control the tension of the muscles in his arm in response to the signals visually displayed on the indicator console 26. The program of muscle conditioning exercises includes directions from a physical therapist expressed in terms of the visual indications displayed on the indicators 28, 34, 36 and 40. These directions incorporate both the absolute value readings as well as the ratiometric and difference readings.

It should be appreciated that the patient 12 can measure simultaneously two interacting muscles and the electromyographic bio-feedback monitor can display the amount of interaction therebetween. The patient can thus gain control of his muscles by observing the visual display and responding thereto. While a specific disclosure and embodiment has been shown herein, it should be realized that many modifications and changes can be made by those skilled in the art without departing from the spirit of the present invention. For example, the visual indicators 28, 34, 36 and 40 can be replaced by a plurality of galvanometers, colored lights, audio oscillators or any other form of audio, visual, tactile or perceptible stimulus. Accordingly, the scope of this invention should be understood in a broader context limited only by the following claims as interpreted in the light of the foregoing example.

I claim:

1. Apparatus for performing biofeedback physical therapy on a human being, comprising means for measuring the relative tension in a first muscle of the human being, means for measuring simultaneously therewith the relative tension in a second muscle of the same human being, means for independently amplifying the tension measurements of the first and second muscles, means for indicating to the human being in real time the instantaneous value of the tension measurements of the first and second muscles so that the human being can control the muscles being measured in response thereto, said indicating means including means for computing an instantaneous ratiometric value from the two tension measurements and means for displaying in real time said ratiometric value to the human being being measured.

2. Apparatus for performing biofeedback physical therapy on a human being, comprising means for measuring the relative tension in a first muscle of the human being, means for measuring simultaneously therewith the relative tension in a second muscle of the same human being, means for independently amplifying the tension measurements of the first and second muscles, means for indicating to the human being in real time the instantaneous value of the tension measurements of the first and second muscles so that the human being can control the muscles being measured in response thereto, said indicating means including means for computing an instantaneous arithmetic difference value from the two tension measurements and means for displaying in real time said value to the human being being measured.

3. Apparatus for performing biofeedback physical therapy on a human being, comprising means for measuring the relative tension in a first muscle of the human being, means for measuring simultaneously therewith the relative tension in a second muscle of the same human being, means for independently amplifying the tension measurements of the first and second muscles, means for indicating to the human being in real time the instantaneous value of the tension measurements of the first and second muscles so that the human being can control the muscles being measured in response thereto, said indicating means including means for computing both a ratiometric value and an arithmetic difference value from the two tension measurements and means for displaying in real time simultaneously said values to the human being being measured.

4. Apparatus for conducting biofeedback physical therapy on human beings by measuring the relative tension of muscles, comprising:
   a. two sets of electrodes, each electrode set being attachable on a human being to provide an output signal indicating the tension of a separate muscle; 
   b. two high gain amplifiers, each amplifier connected to one set of electrodes for amplifying the output signal therefrom; 
   c. two potentiometers, each connected to one of the high gain amplifiers for adjusting the output signal therefrom;
d. two rectifiers, each connected to one of the potentiometers for rectifying the output signal therefrom;

e. a differential amplifier connected to the rectifiers and generating an output signal proportional to the arithmetic difference between the two signals indicating muscle tension;

f. an electronic divider connected to the rectifiers and generating an output signal proportional to the quotient of the two signals indicating muscle tension; and

g. indicator means observable by the human being being measured and selectably connectable to the output of the differential amplifier and to the output of the electronic divider for displaying in real time the instantaneous value of the amount of interaction between the separate muscles.

5. Apparatus of claim 4 wherein the indicator means includes two indicators, one indicator connected to the output of the differential amplifier and the other indicator connected to the output of the electronic divider, permitting the human being being measured to observe simultaneously the amount of interaction between the two muscles displayed on the two indicators.

6. Apparatus for conducting biofeedback physical therapy on human beings by measuring the relative tension of muscles comprising:

a. two sets of electrodes, each electrode set being attachable on a human being to provide an output signal indicating the tension of a separate muscle;

b. two high gain amplifiers, each amplifier connected to one set of electrodes for amplifying the output signal therefrom;

c. two potentiometers, each connected to one of the high gain amplifiers for adjusting the output signal therefrom;

d. two rectifiers, each connected to one of the potentiometers for rectifying the output signal therefrom;

e. two absolute value indicators, each connected to one of the rectifiers for displaying to the human being being measured the absolute value of the muscle tension signal;

f. an electronic divider connected to the rectifiers and generating an output signal proportional to the quotient of the two signals indicating muscle tension; and

g. a ratiometric indicator observable by the human being being measured and connected to the output of the electronic divider for displaying in real time the instantaneous value of the quotient of the two values of the two muscle tension signals.

8. Method of performing biofeedback physical therapy on a human being comprising the steps of measuring the relative tension in a first muscle of the human being, measuring simultaneously therewith the relative tension in a second muscle of the same human being, independently amplifying the tension measurements of the first and second muscles, indicating to the human being in real time the instantaneous value of the tension measurements of the first and second muscles so that the human being can control the muscles being measured in response thereto, and further in which said step of indicating the tension measurements includes computing an instantaneous ratiometric value from the two tension measurements and displaying in real time said ratiometric value to the human being being measured.

9. Method of performing biofeedback physical therapy on a human being, comprising the steps of measuring the relative tension in a first muscle of the human being, measuring simultaneously therewith the relative tension in a second muscle of the same human being, independently amplifying the tension measurements of the first and second muscles, indicating to the human being in real time the instantaneous value of the tension measurements of the first and second muscles so that the human being can control the muscles being measured in response thereto, and further in which said step of indicating the tension measurements includes computing an instantaneous arithmetic difference value from the two tension measurements and displaying in real time said value to the human being being measured.

10. Method of performing biofeedback physical therapy on a human being comprising the steps of measuring the relative tension in a first muscle of the human being, measuring simultaneously therewith the relative tension in a second muscle of the same human being, independently amplifying the tension measurements of the first and second muscles, indicating to the human being in real time the instantaneous value of the tension measurements of the first and second muscles so that the human being can control the muscles being measured in response thereto, and further in which said step of indicating the tension measurements includes computing both a ratiometric value and an arithmetic difference value from the top tension measurements and displaying in real time simultaneously said values to the human being being measured.