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(54) FLEXIBLE EXERCISE DEVICE

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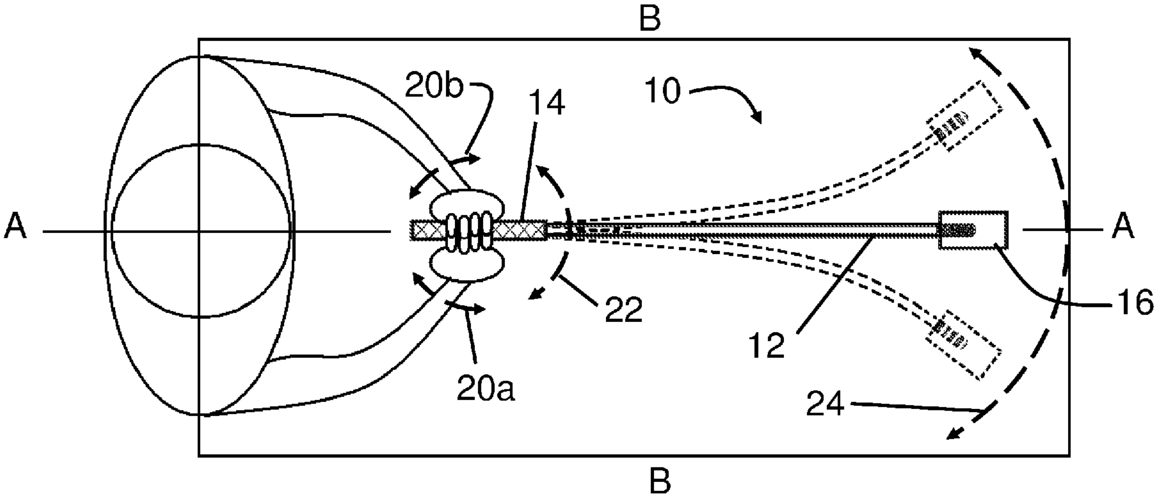
(57) ABSTRACT

A flexible exercise device includes a resilient portion connected between a handle and an excitation mass. The resilient member is tuned such that the spring rate of the resilient portion, in combination with the excitation mass, cooperate to provide a natural frequency that is below a user excitation frequency. The flexible exercise device provides a force feedback input into targeted muscle groups that influence a swing speed of a sports implement, such as a baseball bat.



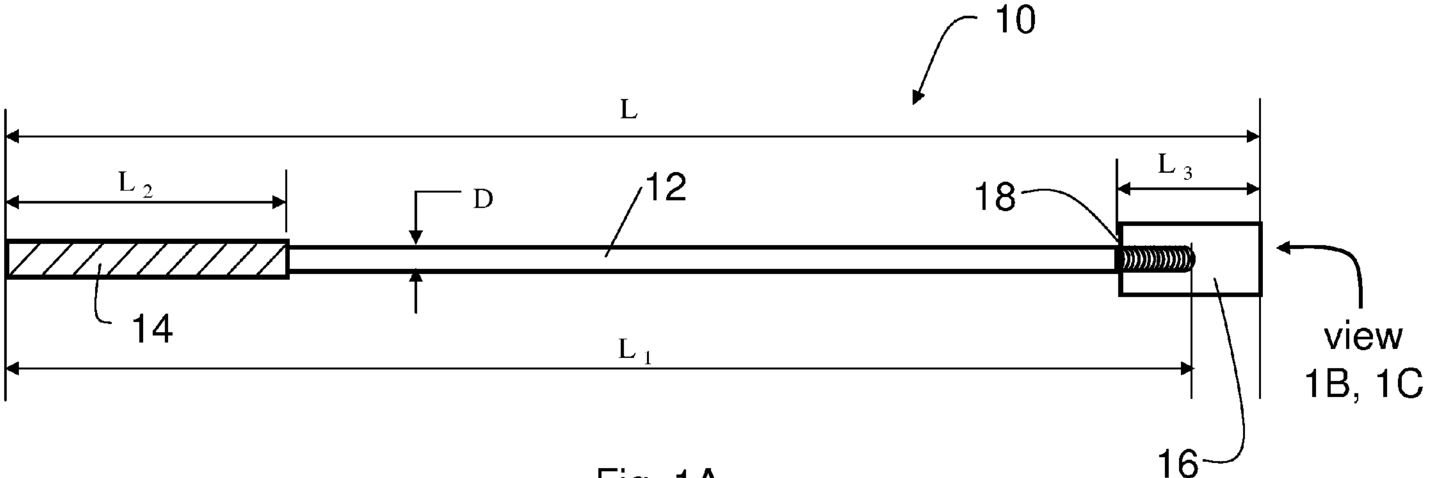


Fig. 1A

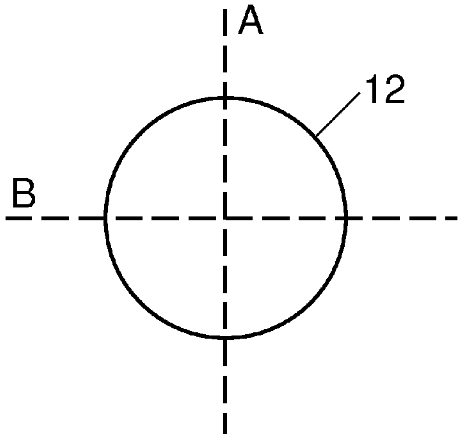


Fig. 1B

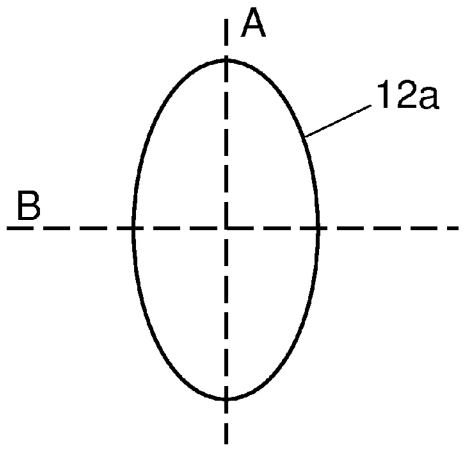


Fig. 1C

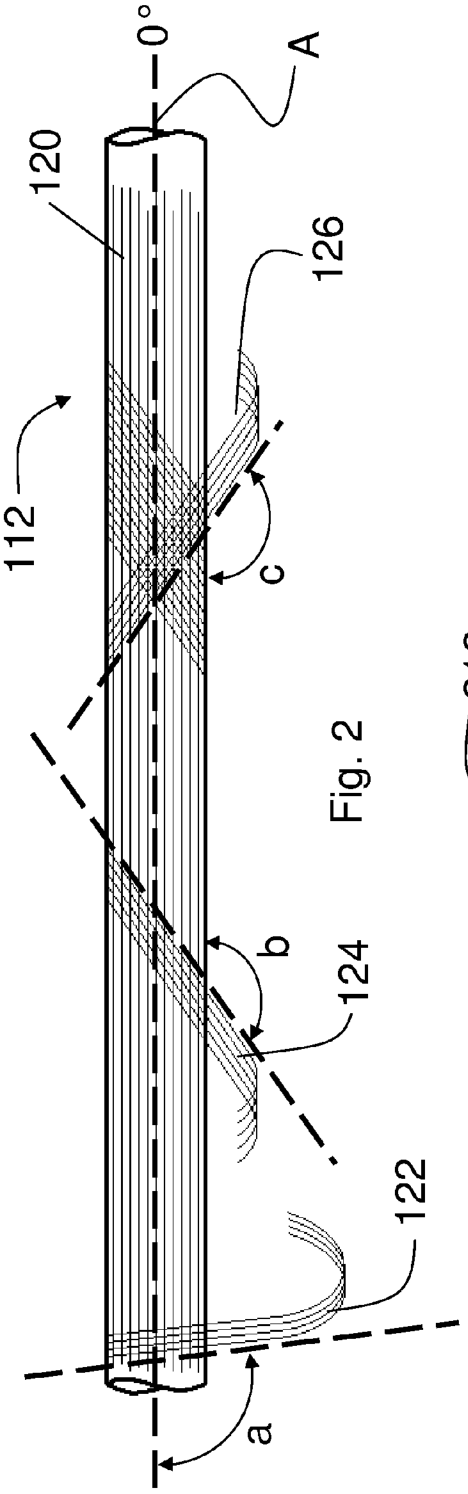


Fig. 2

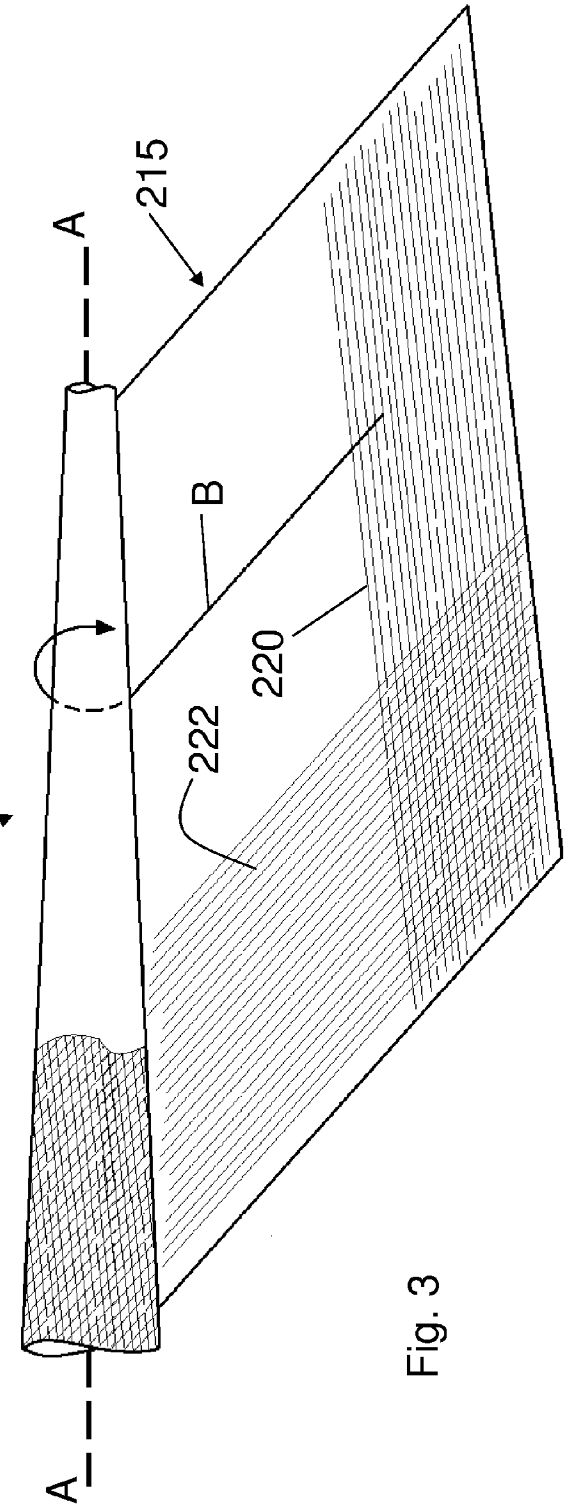


Fig. 3

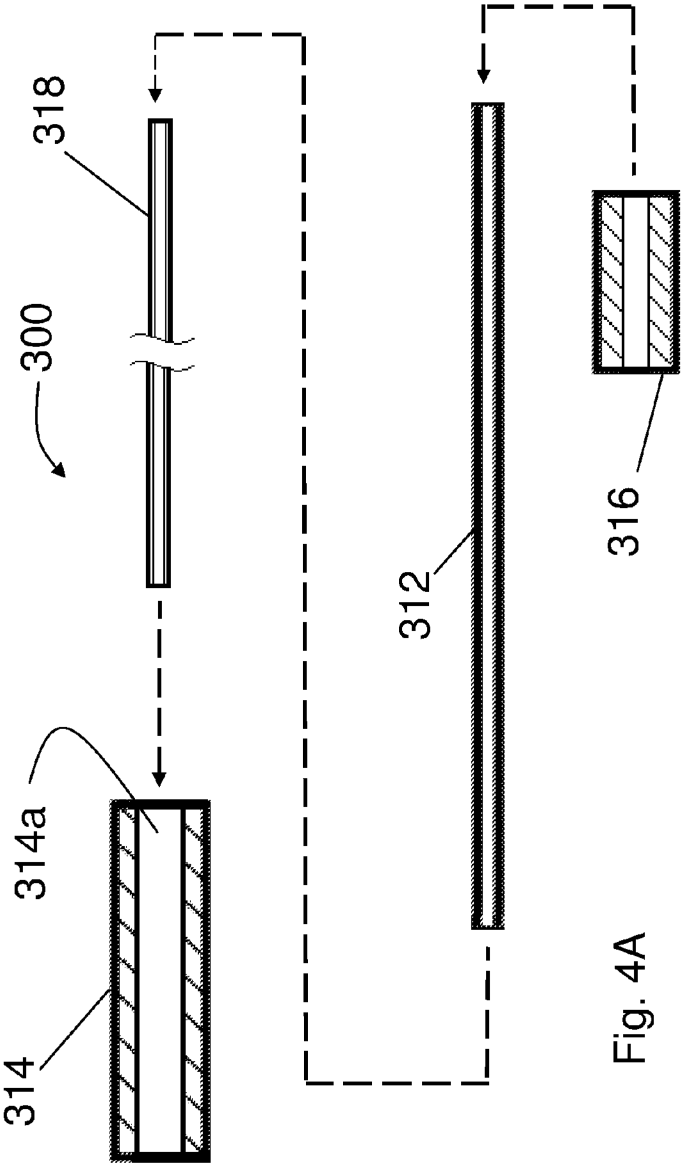


Fig. 4A

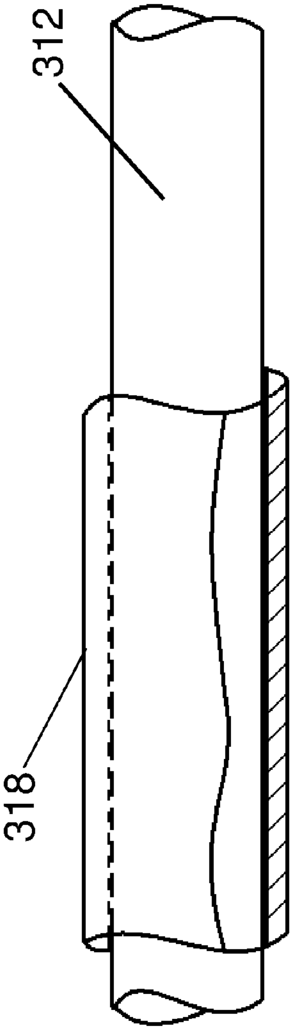


Fig. 4B

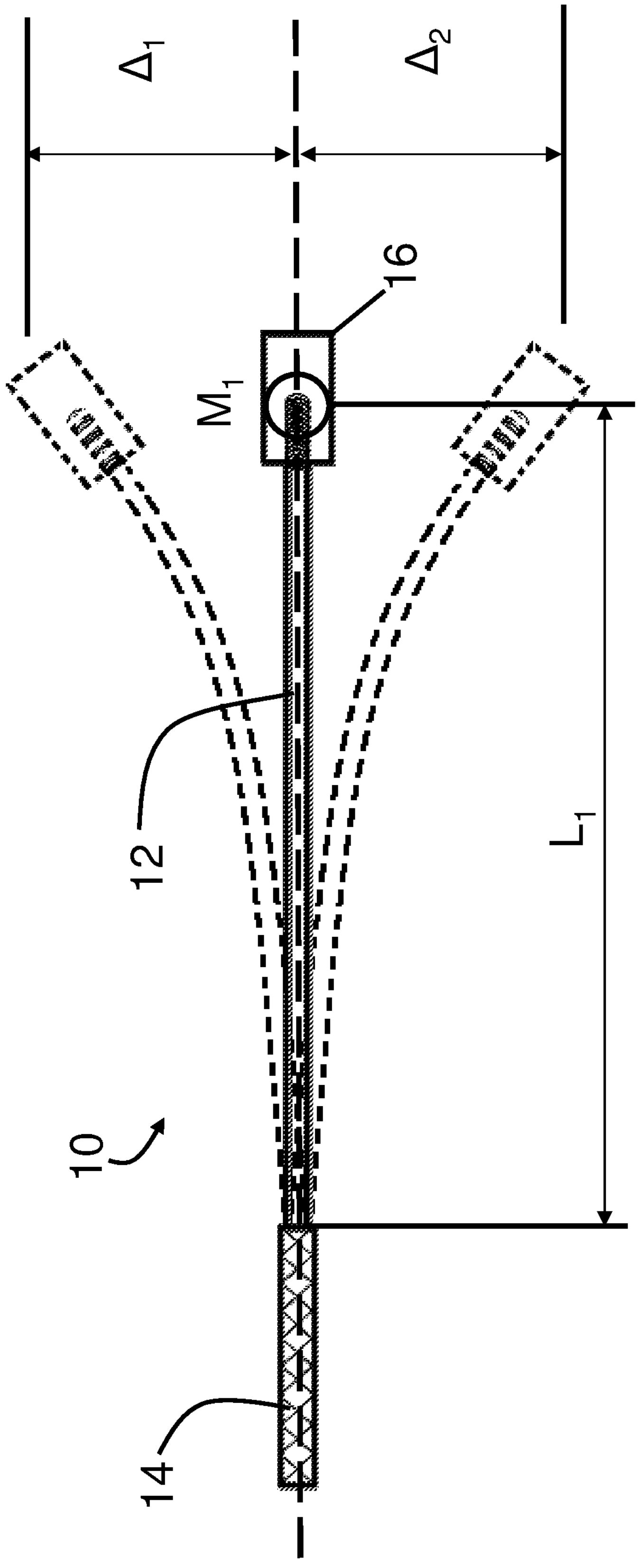


Fig. 5

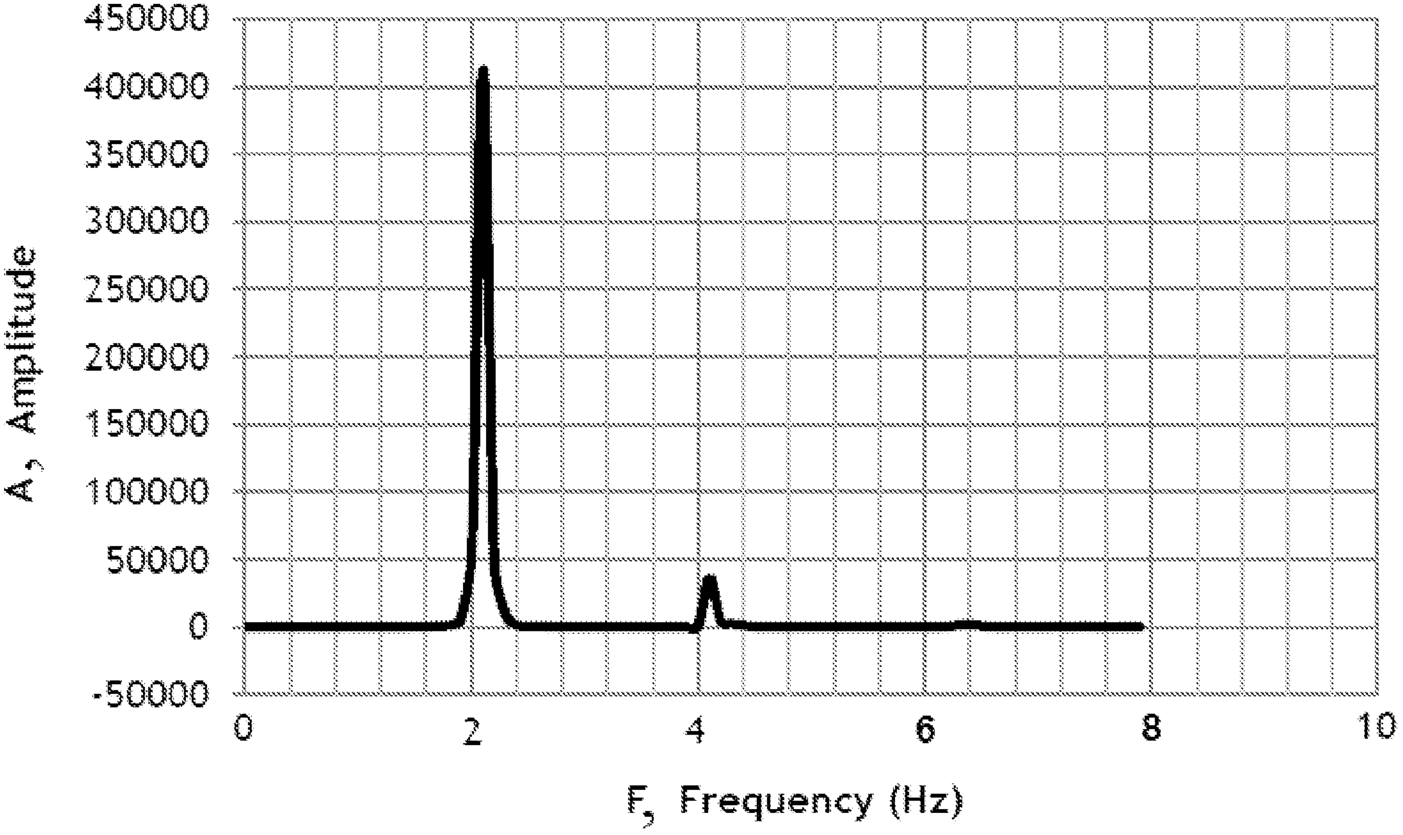

450000
400000
350000
300000
250000
200000
150000
100000
50000
0
-50000
A, Amplitude
0
2
4
6
8
10
F, Frequency (Hz)

Fig. 6

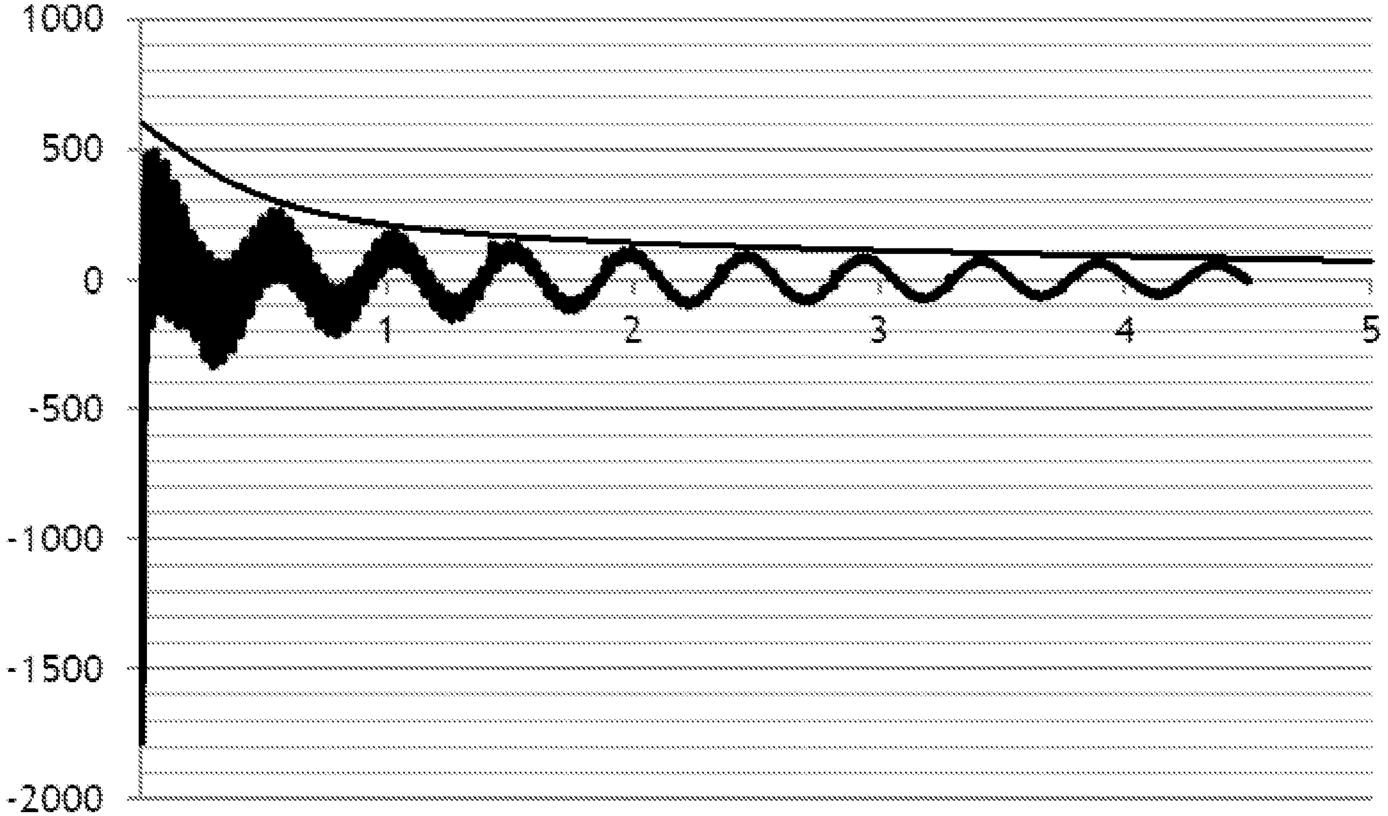


Fig. 7

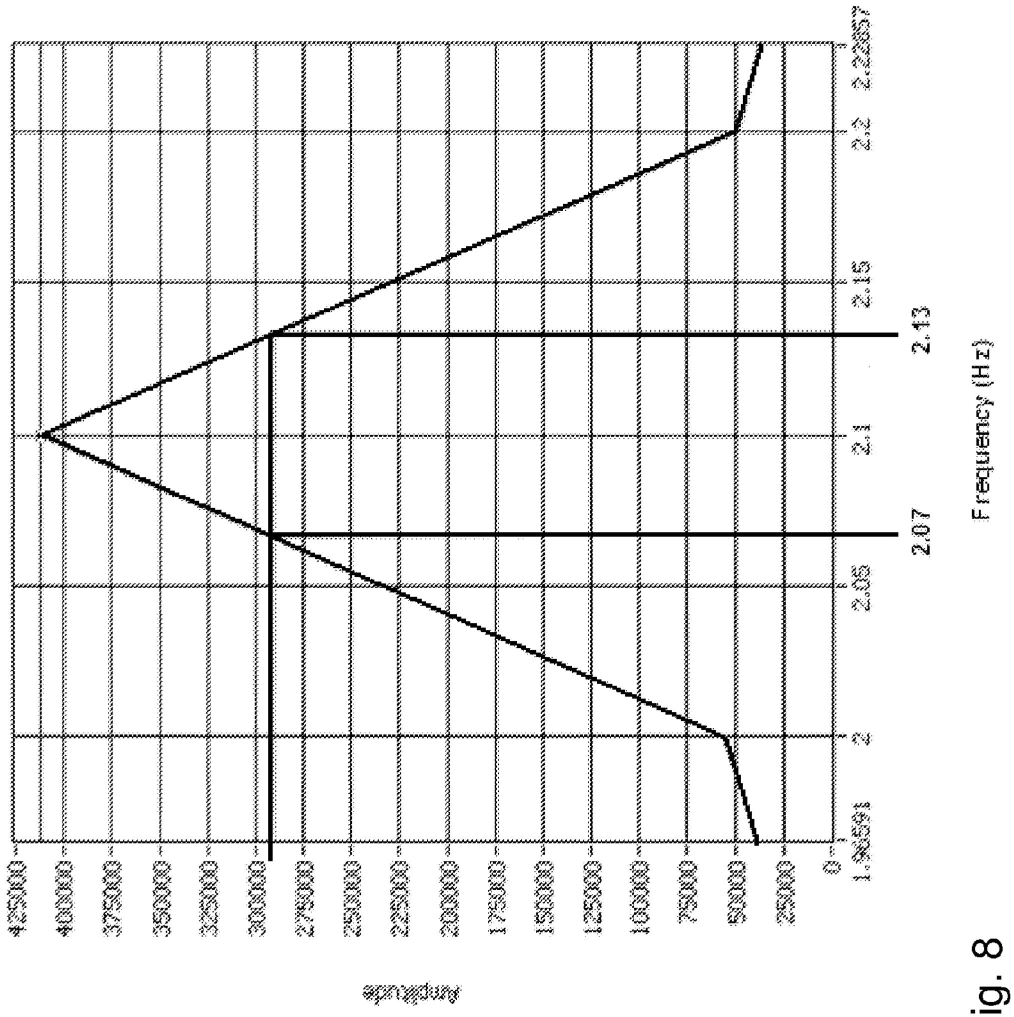

Amplitude
425000
400000
375000
350000
325000
300000
275000
250000
225000
200000
175000
150000
125000
100000
75000
50000
25000
0
1.96591
2
2.05
2.07
2.1
2.13
2.15
2.2
2.22857
Frequency (Hz)

Fig. 8

Specimen No.	Excitation condition	Natural Frequency	Damping Ratio
1	Free Vibration	2.10 Hz (13.19 rad/s)	0.0140
1	Impact	2.08 Hz (13.09 rad/s)	0.0153
2	Free Vibration	1.93 Hz (12.12 rad/s)	0.0229
2	Impact	1.95 Hz (12.28 rad/s)	0.0173
3	Free Vibration	2.26 Hz (14.20 rad/s)	0.0318
3	Impact	2.24 Hz (14.09 rad/s)	0.0292
4	Free Vibration	1.79 Hz (11.22 rad/s)	0.0162
4	Impact	1.80 Hz (11.30 rad/s)	0.0153

Fig. 9A

Specimen No.	Ave. free vibration Natural Frequency	Ave. Damping Ratio free vibration	Ave. Damping ratio impact response
1	2.08 Hz	0.0169	0.0305
2	1.95 Hz	0.01155	0.02447
3	2.24 Hz	0.0128	0.0225
4	1.80 Hz	0.0064	0.0127

Fig. 9B

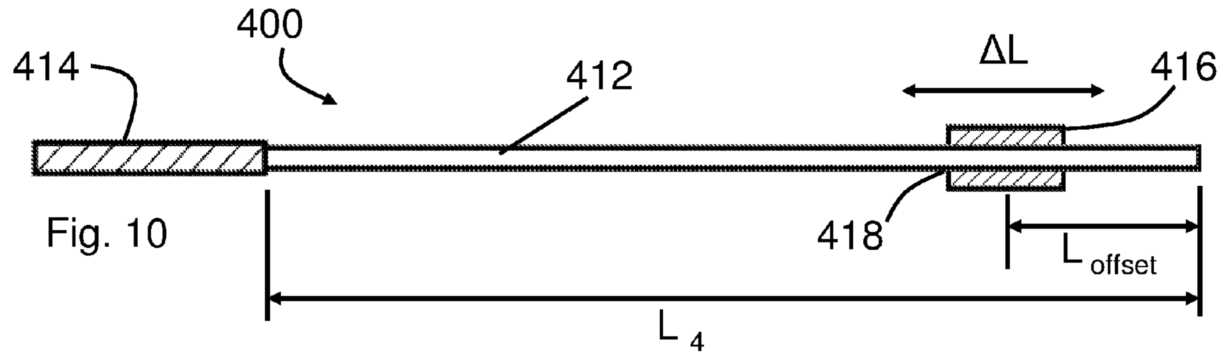


Fig. 10

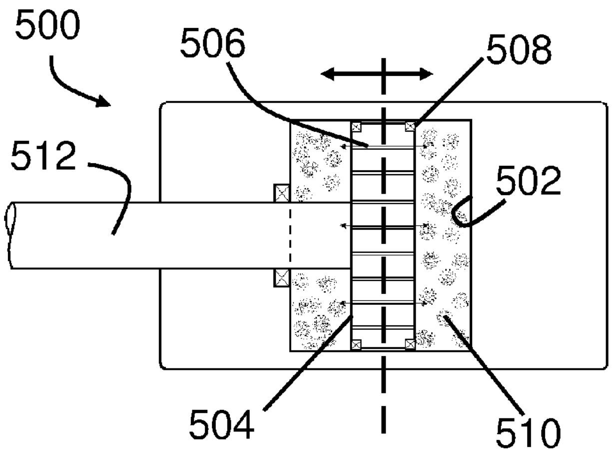


Fig. 11A

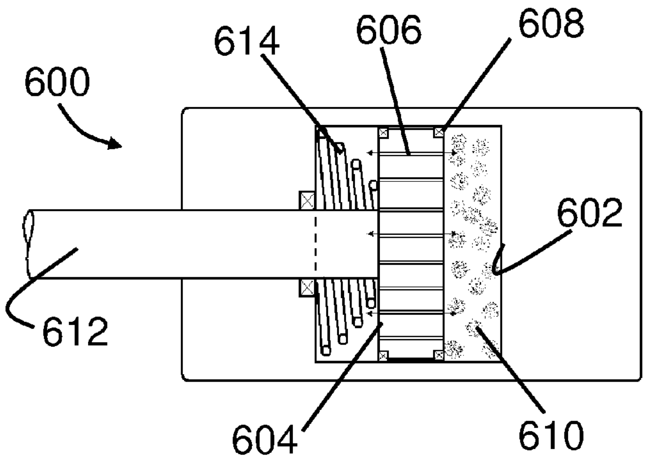


Fig. 11B

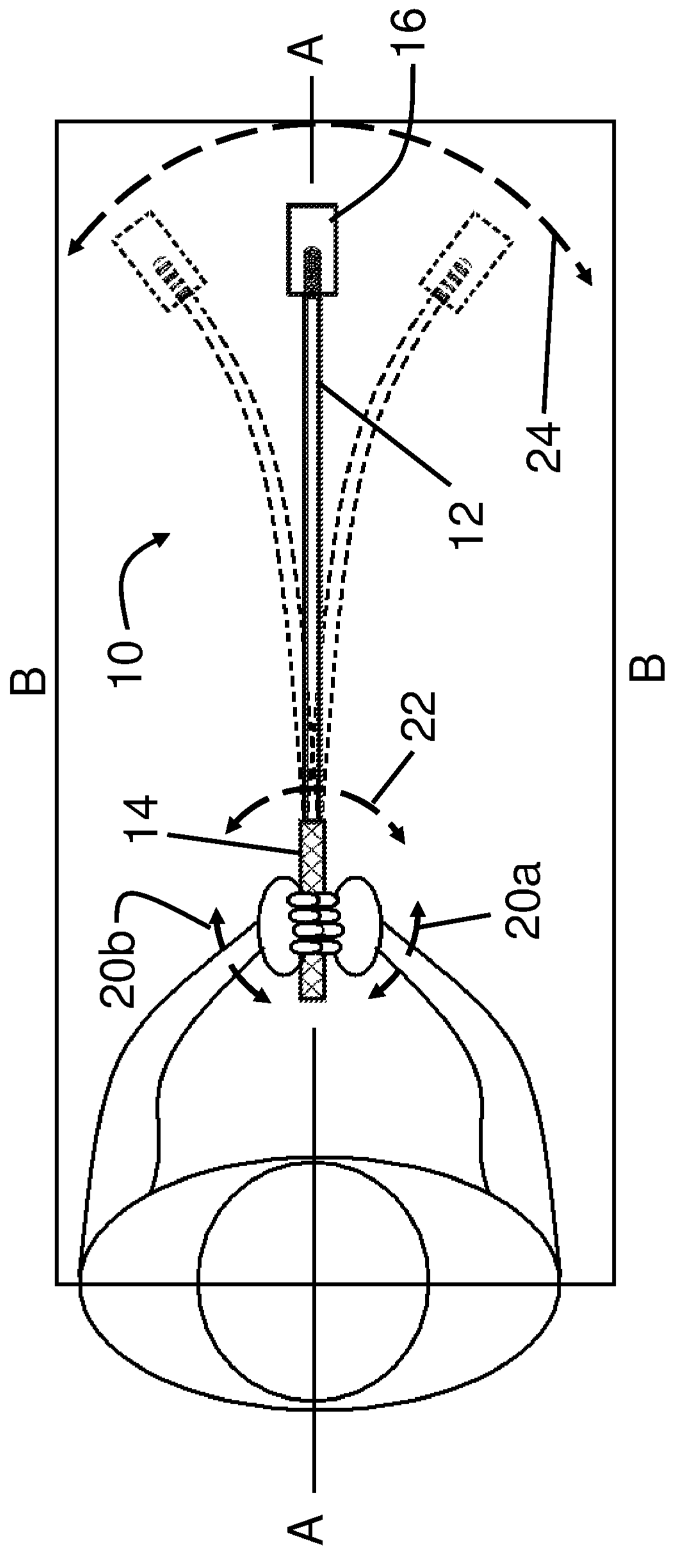


Fig. 12

FLEXIBLE EXERCISE DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/621,329, filed Apr. 6, 2012, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] This invention relates in general to a flexible exercise device. In particular, this invention relates to a user-excited, frequency-responsive, structure that provides a force feedback input to exercise muscle groups to improve swing acceleration of sports implements.

[0003] Exercise devices provide various types of force inputs to muscle groups to provide resistance or strength training. Often, these devices use springs or other load/deflection responsive mechanisms to create a force that is resisted by a user to strengthen and tone muscles. The typical excitation of these devices by a user is below the structure's first natural frequency, relying the spring's stiffness to provide resistance that is proportional to the deflection of the user. Other exercise devices utilize resilient members, such as flexible rod, loaded in torsion or bending. The resilient members provide resistance as the device is deflected, but the user's excitation cadence is below the structure's resonance.

[0004] Other flexible devices are configured to improve the structure and path of a user's swing relative to the user, the ball, or the ground. These devices are not provided to exercise muscle groups but instead permit a user to develop muscle memory in order to engrain a particular swing path or style. Thus, the excitation frequency of the device is not a consideration in the design of the device or implementation of the workout routine.

[0005] Thus, it would be desirable to provide a muscle development tool that creates strength and muscle tone quickly and easily. It would further be desirable to provide a frequency responsive exercise device that improves the swing speed and acceleration that a user can impart to a sports swing implement, such as a baseball bat, softball bat, tennis racquet, hockey stick, golf club, and the like.

SUMMARY OF THE INVENTION

[0006] This invention relates to a flexible exercise device configured to increase muscle tone, speed response, and strength. The flexible exercise device described herein includes a frequency and damping ratio configured for strength training rather than swing tempo training.

[0007] In one aspect of the invention, a flexible exercise device includes a resilient portion connected between a handle and an excitation mass. The resilient member is tuned such that the spring rate of the resilient portion, in combination with the excitation mass, cooperate to provide a natural frequency that is below a user excitation frequency. The flexible exercise device providing a force feedback input into targeted muscle groups that influence a swing speed of a sports implement, such as a baseball bat.

[0008] In one embodiment, a flexible exercise device includes a handle, a spring portion, and an excitation mass configured such that a natural frequency of at least the spring portion and the excitation mass is lower than a user excitation frequency.

[0009] In another embodiment, a flexible exercise device having a spring portion and an excitation mass configured to respond to a user excitation in a post-resonance frequency range such that a therapeutic effect is generated at the end of an oscillatory cycle. The therapeutic effect being a function of the velocity profile of the excitation mass where the excitation mass reverses direction as part of the oscillatory motion of a user forcing function that excites the structure.

[0010] In another embodiment, a flexible exercise device have a spring portion and an excitation mass that cooperate to have a natural frequency above a use excitation frequency. The spring portion is formed from a polymer rod having a length in a range of about 35 inches to about 40 inches and a diameter of about 0.25 inches. The natural frequency is in a range of about 1.7 hertz to about 2.3 hertz and a damping ratio is in a range of about 0.006 to about 0.017. In a variation of this embodiment, the spring portion may include a first resilient element and a second resilient element where the first resilient element is the polymer rod formed from a fiberglass material and the second resilient element is a polymer sleeve coaxially disposed over the first resilient element and having a durometer in a range of about 60 to 80 Shore A. The first and second resilient elements cooperate with the excitation mass to produce a cantilevered first natural frequency of about 2.0 hertz and the excitation mass is about 5.5 ounces.

[0011] Various aspects of this invention will become apparent to those skilled in the art from the following detailed description of the preferred embodiment, when read in light of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1**A is an elevational view of a flexible exercise device.

[0013] FIG. **1**B is a schematic illustration of a cross sectional shape of a resilient portion of the flexible exercise device of FIG. **1**A.

[0014] FIG. **1**C is a schematic illustration of an alternative cross sectional shape of another embodiment of a resilient portion of a flexible exercise device, similar to FIG. **1**A.

[0015] FIG. **2** is a schematic illustration of an embodiment of a spring portion of the flexible exercise device of FIG. **1**.

[0016] FIG. **3** is a schematic illustration of another embodiment of a spring portion of the flexible exercise device of FIG. **1**.

[0017] FIG. **4**A is a schematic illustration of an exploded view of an embodiment of a flexible exercise device.

[0018] FIG. **4**B is a schematic illustration of an embodiment of a two stage resilient spring portion of the flexible exercise device of FIG. **4**A.

[0019] FIG. **5** is a schematic illustration of a cantilever-mounted flexible exercise device, showing a deflected test configuration.

[0020] FIG. **6** is a plot of a frequency response function of a flexible exercise device, similar to the device of FIG. **5**.

[0021] FIG. **7** is a plot of acceleration amplitude vs. time and a vibration decay over time for the tested flexible exercise device, similar to FIG. **5**.

[0022] FIG. **8** is a graphical estimation of damping ratio of the tested embodiment of a flexible exercise device, similar to FIG. **5**.

[0023] FIG. **9**A is a table of natural frequency and damping ratio results of four tested embodiments of flexible exercise devices, similar to FIG. **5**.

[0024] FIG. **9**B is another table, similar to FIG. **9**A, summarizing free vibration testing data.

[0025] FIG. **10** is a schematic illustration, in partial cross section, of an embodiment of a flexible exercise device having a moveable weight.

[0026] FIG. **11**A is a schematic illustration, in partial cross section, of an embodiment of a damped-oscillation moveable weight for a flexible exercise device.

[0027] FIG. **11**B is a schematic illustration, in cross section of another embodiment of a damped-oscillation moveable weight for a flexible exercise device.

[0028] FIG. **12** is a schematic, plan view of a user and the flexible exercise device during use.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0029] Referring now to the drawings, there is illustrated in FIG. **1** an embodiment of a flexible exercise device, shown generally at **10**. The flexible exercise device **10** includes a spring section **12**, a handle **14**, and an excitation mass **16**. The flexible exercise device **10** defines an overall length, L, from a distal end of the handle **14** to a proximal end of the excitation mass **16**. The spring section **12** is shown in FIGS. **1**A and **1**B as a round solid rod having a length, L_1 and a diameter, D. In other embodiments, the spring section **12** may have other cross sectional shapes. In other embodiments, the cross sectional shape of the spring section **12** may be asymmetrical and exhibit two different spring rates relative to the cross section. For example, as shown in FIG. **1**C, the cross sectional shape of a spring section **12*a*** may be elliptical and exhibit greater stiffness in the major diameter plane, A and lower stiffness in the minor diameter plane, B. As shown in FIG. **8**, the plane A is generally oriented parallel to the height of the user. Plane B represents the plane of exercise in which the exercise device oscillates and is oriented at an angle to plane A, such as a 90 degree angle. Typically, the relative angle between planes A and B are based on a comfortable position of the user's forearms, bent at the elbows, relative to the user's upper arm. Thus, in one use orientation of the asymmetrical cross section embodiment of the exercise device of FIG. **1**C, the orientation of the spring section **12*a*** may be such that the lower stiffness orientation of plane B is in the plane of exercise that is generally parallel to a plane of a user's shoulders. The higher stiffness orientation of plane A is such that the excitation of the device **10** remains generally in the exercise plane. In alternative embodiments, the planar stiffness differences may be formed into fiber layup orientations rather than asymmetric cross sections, if desired.

[0030] In one specific embodiment, the overall length, L_1 of the spring section **12** may be in the range of 30-40 inches and the diameter, D may be in the range of ⅛ (0.125) inches to ½ (0.5) inches and is dependent on material properties. In another embodiment, L_1 is approximately 38 inches and D is approximately 0.25 inches, though the diameter and length may be varied to achieve a desired stiffness characteristic. The handle **14** has a length, L_2, and in the illustrated embodiment, L_2 is approximately 10 inches, though other lengths may be provided. An effective spring length of spring section **12** is estimated at approximately 28 inches (i.e. L_1-L_2). This effective spring length, along with the spring material properties, determines the spring stiffness, k, which provides a force input to the user during exercise training, as will be described in detail below. The force input to the user is also a function of the weight of the mass **16** and its position along the spring section relative to the handle **14**, which is generally in the range of 4-6 ounces. In one embodiment, the mass **16** is 5.2 ounces. The weight of the excitation mass **16** may be increased or decreased to change the natural frequency of the exercise device to match the user's physical requirements. In the illustrated embodiment of FIG. **1**, the excitation mass **16** is attached to the spring portion **12** by a threaded section **18**. However, the mass **16** may be attached by any other means such as, for example, adhesive bonding, set screws, bolts, jam nuts, and the like. In the illustrated embodiment, the mass **16** has a length L_3 and is attached a fixed distance away from the handle **14**. The mass **16** may be formed of any suitable material and may be covered in a soft medium, such as a foam or neoprene, to minimize damage or injury from incidental contact. The handle **14** may be provided as any grip promoting arrangement such as, for example, a bonded foam sleeve, leather wrapped section, knurled section of the spring **12**, plastic molded section (formed and contoured or straight and smooth).

[0031] In one embodiment, the spring portion **12** may be a molded or extruded polymer material, such as Delrin (e.g. Delrin 570) by DuPont. Alternatively, the spring portion **12** may be made from any material or in any configuration that exhibits a spring rate in the ranges described herein, such as a metal or a fibrous composite material. As shown in FIG. **2**, a spring section **112** may be formed as a fibrous composite material formed from filaments or fibers, such as fiber glass, aramid fiber, carbon fiber, and the like, in a resin matrix. In the embodiment of FIG. **2**, the spring section **112** is formed relative to a longitudinal axis, A that establishes a generally 0 (zero) degree axis of orientation. Winding angles of other layers are expressed in degrees relative to this 0 degree longitudinal axis. A fiber orientation of fibers **120** may be generally parallel to axis A. These fibers may be applied to form the spring **112** by any suitable process such as, for example, pultrusion, extrusion, filament winding, weaving, or as a hand lay-up process. A layer of fibers **122** may be formed over the fibers **120** in a relative angular fiber orientation, shown as angle "a," that is between 90 degrees and approximately 85 degrees relative to axis A. The fibers **122** may also be applied by high volume production processes, such as pultrusion. The fibers **120** are oriented to provide a generally tensile and flexural strength capability. The fibers **122** are applied to provide hoop strength to the longitudinal fibers **120** of the spring structure. The structural stiffness of the spring portion **112** may be varied by apply fibers **124** and **126** at an off-axis winding angle. Such an angle may be, for example, a ±45 degree angle relative to the axis, A. The fibers **124** may be wound of otherwise applied onto surface of the spring layers or a mandrel at an angle, "b" relative to the axis A. In one embodiment, the angle "b" may be approximately 45 degrees to the axis A. It should be understood that other angles may be used to achieve different stiffness properties from the spring portion **112**. For example, as the fiber angle "b" becomes larger, i.e., the fibers **124** are oriented more toward the hoop direction, the fiber properties contribute less to the flexural stiffness while the resin or binding agent properties become more dominant. The fibers **126** may be oriented at an angle "c" that is generally at the same angle as angle "b", such as 45 degrees to axis A and generally perpendicular to fibers **124**. It should also be understood that fibers **126** may be applied at any desired angle, whether or not the same as angle "b".

[0032] Referring now to FIG. **3**, another method may be used to form a spring **212** where one or more sheets **215** of pre-woven fibers impregnated with a resin or binder, i.e., prepreg material, may be rolled or formed into the shape of the spring **212**. The prepreg material **215** may be a woven mat having a first fiber **220** oriented in a first direction and a second fiber **222** oriented in a second direction relative to the first fiber **220**. As shown in FIG. **3**, the first fibers **220** are generally perpendicular to the second fibers **222**, though other angles between fibers **220** and **222** may be provided. The fibers **220** and **222** are woven together, similar to a woven sheet or cloth, and may be oriented at any desired angle relative to an axis, such as axis A in FIG. **2**. The sheet **215** is then rolled, typically over a shaped mandrel, in a direction shown by arrow "B". In the embodiment shown in FIG. **3** the shape of the spring element is generally conical (and either hollow or solid), but other shapes and profiles may be used. The spring **212** may then be processed using heat, vacuum, pressure, and/or mechanical compression to conform the material to the desired shaped mandrel and provide a curing of the resin.

[0033] Referring now to FIGS. **4**A and **4**B, there is illustrated an exploded view of an embodiment of a flexible exercise device **300**. The flexible exercise device **300** includes a first flexible or resilient element **312** that connects a handle **314** to an excitation mass **316**. The handle **314** has a bore **314*a*** extending at least partially down the center length thereof. The first resilient element **312** may be solid or hollow, straight or tapered, and formed of any suitable material. Disposed over the first resilient element **312** is a second resilient element **318**, shown as a polymer tubular sheath. The second resilient element **318** may be formed as a tubular plastic sleeve member having an outer diameter pressed inside the handle bore **314*a*** and an inner diameter that accepts the outer diameter of the first resilient element **312**. The first and second resilient elements **312** and **318** are illustrated as being disposed in a coaxial orientation. The second element **318** may be configured as a series of discrete elements disposed about the circumference of the first element **312**, if desired. The first and second resilient elements **312** and **318** may be positioned such that each element cooperates as a parallel-functioning multiple spring portion, where each is subjected to generally the same deflection.

[0034] The first and second resilient elements **312** and **318**, and also the handle **314**, may be secured together by any means, such as adhesive bonding, chemical welding, ultrasonic welding, mechanical fasteners, or a mechanical press fit, or any combination thereof. The second element **318** may be provided in different durometers and associated press fits with the first element **312**. The second resilient element may be, for example, a plastic or polymer tube such as may be formed from nylon, polyester, polyvinyl chloride, polyurethane and the like. In one embodiment, the second element **318** has a durometer in the range of approximately 60-80 Shore A, and more specifically in a range of 72-74 Shore A. In another embodiment the durometer of the second element **318** may be in a range of 80-100 Shore A.

[0035] In certain embodiments, adjusting the amount of press fit or interference fit between the first and second resilient elements **312** and **318** changes both the resulting spring stiffness and the amount of damping. As the press fit between the first and second resilient elements **312** and **318** is reduced, a controlled amount of relative movement occurs at the interface therebetween. The relative movement, in the presence of a compressive load, provides a frictional force component resulting in damping applied to the device **300**. Also, as the press fit relationship is reduced or eliminated, the resilient elements are subjected to different deflections, due in part to the different lengths of each element during deflection (such a deflection is illustrated in FIG. **5**), the contribution of spring rate times deflection differs.

[0036] In an alternative embodiment, the first and second resilient elements **312** and **318** may be bonded together by an adhesive, a chemical or thermal weld, or a mechanical connection. As the fit relationship between the first and second resilient elements **312** and **318** is increased, the relative differences in deflection are reduced such that both elements are subjected to the same deflection and the length of the second resilient element **318** is stretched more compared to the first resilient element **318**. This deflection/strain configuration results in less frictional damping, more material damping and more spring rate contribution of the second resilient element **318** to the overall response of the structure. In another embodiment of a flexible exercise device, a plastic sleeve, similar to the second resilient element **318** may be limited to the interface region between the handle **314** and the first resilient element **312**. The plastic tubing may be nylon, polyester, polyvinyl chloride, polyurethane and the like. The plastic sleeve, in this configuration acts as a shock absorber between the handle and the resilient element to provide cushioning to the user's hands.

[0037] Referring now to FIG. **5**, there is illustrated a deflection mode shape of the flexible exercise device **10**. The deflected mode shape is illustrated as a deflected cantilever beam approximating a half order mode shape exhibiting a single node point at the handle **14**. Tests conducted using various embodiments of the illustrated embodiment fix the handle **14** of the flexible exercise device **10** relative to the spring portion **12**. In one test condition, the handle **14** is held in a generally horizontal attitude. The spring portion **12** and the excitation mass **16** extend in a generally horizontal direction and have a static deflection of the spring portion **12** caused by the excitation mass **16**. Alternatively, the flexible exercise device **10** may be fixtured at any other relative orientation, such as a vertical orientation. For tests conducted using a free vibration excitation, the spring portion **12** and mass **16** are deflected an amount of delta$_1$, Δ_1, and released, allowing the device **10** to vibrate freely. The spring deflection may be within the plane of orientation or at a relative angle thereto. As shown in FIG. **7**, the spring portion **12** and mass **16** oscillate in a generally sinusoidal pattern with generally decreasing amplitudes of vibration. Alternatively, the spring may be deflected by an amount of delta$_2$, Δ_2. The deflection amounts delta$_1$, Δ_1 and delta$_2$, Δ_2, may be the same or different. Referring back to the embodiment of the flexible exercise device **10** of FIG. **1**, described above, the deflected amount Δ_1 may be between 18 and 22 inches. More particularly, for a deflection of 20 inches, a load of approximately 6 lbs. is required. The resultant spring rate ($k=F/\Delta$) of the spring **12** is about 0.3 lbs. per inch. Other spring rates may be used in combination with other mass weights to provide a desired natural frequency characteristic.

[0038] The various tested embodiments were also evaluated using a force-transducing hammer and an accelerometer as inputs to a Fast Fourier Transformer (FFT) vibration analyzer. A frequency plot vs. amplitude from the testing is shown in FIG. **6** and a vibration amplitude sweep showing the time rate of decay is shown in FIG. **7**. FIG. **8** is an enlarged plot of the frequency response function from one of the test trials. The graph of FIG. **8** is marked to determine damping ratio. The various embodiments of the flexible exercise device are configured to exhibit a lightly damped, natural frequency of about 2 Hz. As shown in the Tables of FIGS. **9**A and **9**B, four embodiments of the flexible exercise device exhibit natural frequencies and damping ratios that are in a range of 1.5 Hz. to 3 Hz and about 0.006 to about 0.018, respectively. Table **9**A identifies the four test specimens and test results for a first battery of tests using both a free vibration excitation and impact hammer excited response testing. Free vibration excitation uses an accelerometer and a single force input to cause deflection and oscillation of the structure, resulting in measurement of the vibratory forcing function. Impact response testing uses a force transducing hammer that inputs a known forcing function and an accelerometer measures the oscillatory output to determine the natural frequency response of the structure.

[0039] The tabulated test results of specimens tested are generally configured as described hereafter. Specimen 1 is configured with parallel spring arrangement having a first resilient element that is an approximately 0.25 inch diameter pultruded fiberglass rod having a Young's modulus of about 6×10^6 psi. One example of such a pultruded rod is an Extren® rod manufactured by Strongwell Corporation, Bristol, Va. A second resilient element that is part of the parallel spring arrangement is a coaxially oriented polyurethane sleeve is fitted over the rod to form the two spring portion, similar to the embodiment of FIGS. **4**A and **4**B. The polyurethane sleeve has a durometer of approximately 73 Shore A. The excitation mass is approximately 4 ounces and the specimen length, L is about 38.5 inches. Specimen 2 is configured as a parallel spring arrangement with a first resilient element of 0.25 inch diameter pultruded fiberglass rod, similar to Specimen 1. The second spring element is a polyurethane sleeve having a durometer of 85 Shore A and an excitation mass of about 5.0 oz. The length L of Specimen 2 is approximately 37.5 inches. Specimen 3 is also configured as a parallel spring arrangement having the same first resilient element of a 0.25 inch O.D. fiberglass rod. The second resilient element is a urethane sleeve having a durometer of 64 Shore A. The excitation mass is about 4.0 oz. and the length, L is about 37.5 inches. Specimen 4 is configured as a single spring portion configured as a pultruded fiberglass rod without an outer sleeve. The handle length, L2 of four tested specimens are generally equal.

[0040] The embodiments of the flexible exercise device described above are tunable to accommodate the force input and muscle development requirements of various users, from the novice to the professional athlete. By varying the length of the spring portion 12, the spring rate and natural frequency may be varied. As one of the length of the spring portion increases or the weight of the excitation mass increases, the natural frequency decreases. As the diameter of the spring portion increases, the stiffness of the spring portion increases as does the natural frequency of the flexible exercise device. An increase in spring stiffness may be counteracted by increasing the weight proportionally so that the natural frequency remains the same. The higher the stiffness and the mass increase, the exercise energy levels go up, thus becoming tailored for a stronger user.

[0041] Referring now to FIG. **10**, there is illustrated an embodiment of a flexible exercise device, shown generally at **400**, having a spring portion **412** that terminates in a handle **414** fixed at a distal end of the spring portion **412**. The spring portion **412** includes a moveable weight **416** generally positioned at a proximal end of the spring portion **412**. The moveable weight **416** is adjustable along a length L_4 of the spring portion **412**. The moveable weight **416** may be moved by a distance ΔL such that the center of the weight is generally positioned at a distance L_{offset} from the proximal end of the spring portion **412**. In one embodiment, the moveable weight **416** includes a bore **418** that is configured and sized relative to the outer diameter of the spring portion **412** to permit the weight to be axially displaced along the spring portion, yet sized so as not to exhibit relative movement with the spring portion in the plane of oscillation when put in use. The bore **418** may include a mechanical retaining device, such as a set screw, ball and detents, collet and jamb nut, or other suitable structure to fix the desired position of the weight relative to the spring portion **412**. In one embodiment, the mass of weight **416** may be a fixed value or, alternatively, the weight can be adjustable such that the mass value is increased or decreased to adjust the natural frequency. The resulting movement of the weight **416** and/or altering of the mass provides the ability to adjust the mass spring system and configure the exercise device **400** as a stiffer or more compliant structure. Generally, the further away the weight is moved from the handle **414**, the lower the natural frequency response. Also, the larger the mass value at a given location, the lower the natural frequency becomes.

[0042] Referring now to FIGS. **11**A and **11**B, there are illustrated alternative weight structures that include a moving weight with damping. As shown in FIG. **11**A, a moveable weight **500** includes a fluid filled chamber **502** and a moving piston **504** disposed within the chamber. The piston **504** is fixed to a proximal end of a spring portion **512** that is similar to the various spring portion embodiments described herein. The piston **504** may include one or more passages **506** that extend through the length of the piston **504** and may also include one or more seals, such as o-rings **508**, though such is not required. The passages **506** are sized to permit a fluid **510** to pass through as the weight is slowly moved relative to the piston **504**. As the weight **500** and the piston **502** move at higher velocities relative to each other, the fluid is sheared as it flows through the passages **506**, producing a damping effect similar to a shock absorber. The fluid **510** may be any suitable martial, such as a water, latex, or oil based material, a thixotropic paste, a compressed gas, or other shear-able medium. The fluid **510** may be provided on one side or both sides of the piston **504**. The fluid on one side may also be a compressible and expansible medium. The fluid may also responsive to an energy field, such as a magneto-rheological fluid, electro-rheological fluid, piezo-ceramic material, and the like.

[0043] FIG. **11**B illustrates a similar, alternative embodiment of a moveable weight **600**. The moveable weight **600** includes a chamber **602** and a piston **604** disposed within the chamber **602**. The piston **604** may include at least one passage **606** and at least one seal **608**, similar to those described above. The chamber **602** is filed, at least on one side of the piston **604**, with a fluid **610**. The piston **604** is attached to a spring portion **612**, similar to the spring elements described above. A resilient member **614**, illustrated as a coil spring, is disposed on the other side of the piston **604**. The resilient member **614** is illustrated as a compression coil spring that acts against the force of weight **600** caused by centripetal acceleration during oscillation.

[0044] Referring now to FIG. **12**, there is illustrated the flexible exercise device **10** being oscillated by a user in accordance with a general method of use to develop specific muscle groups in the hands, wrists, forearms, triceps, shoulders and chest areas. In operation, the user grips the handle, either with one hand or both. As shown in FIG. **12**, the user grips the handle **14** with both hands. The user articulates the wrists back and forth, as shown by deflections **20***a* and **20***b*, in an out-of-phase motion. The out-of-phase motion of the user's wrists compresses certain muscle groups in one hand while extending or stretching the same muscle groups of the other hand. The excitation oscillations of the user are inputted at a rate above the natural frequency of the spring/mass system of the flexible exercise device **10**, such as about 2.5 Hz. The excitation oscillations **20***a* and **20***b* cause the spring portion **12** to oscillate within the plane B with a handle deflection **22**.

[0045] The energy of the excitation oscillations of the user transmits down the length of the spring portion **12** and oscillates the excitation mass **16** with a mass deflection **24**. The excitations of the mass **16**, operating in a post-first resonance condition, transmit a multiplied force input into the handle **14**, which is then resisted and counteracted by the user. The resistance force is counteracted as the excitation mass decelerates to a zero velocity and changes direction. Thus, the flexible spring portion amplifies at least one of deflection and the acceleration of the excitation mass that is imparted by the user.

[0046] The various embodiments of the flexible exercise device produce a therapeutic effect that builds muscle tone and structure. The operation of the flexible exercise device in a post-resonance condition (i.e., above the first natural frequency of the cantilever structure) creates both isolation of forces that can cause muscle strain and a therapeutic resistance that promotes muscle mass and tone. The post-resonance operation reduces the forces on muscles during the swinging motion as the force transmissibility of the stiffness input of the spring portion is reduced. The therapeutic resistance that excites the muscles happens at the ends of travel where the velocity profile of the excitation mass slows to a sub-resonance condition and passes through a zero velocity, at least in the exercise plane of excitation. There is a response lag between when the user's hands change direction of the excitation imparted to the device and when the excitation mass goes to a zero velocity and changes direction. The resistance of this rebounding force is supplied by the user's forearm, triceps, and upper torso muscles. The rate of force input, because of the post-resonance operation, causes the muscle groups to be exercised rapidly. Though the deflections of the muscles are relatively low, compared to similar muscle exercises using free weights or weight resistance machines, the excitation frequency is significantly higher. Thus, the energy input of the muscle groups has the benefits of a low impact regiment like those of isometric exercising, yet rapid repetition rates greater than those of resistance machines. This combination of low muscle deflection and high repetition rate creates a low impact workout where the targeted muscle groups are loaded and relaxed in rapid succession.

[0047] The principle and mode of operation of this invention have been explained and illustrated in its preferred embodiment. However, it must be understood that this invention may be practiced otherwise than as specifically explained and illustrated without departing from its spirit or scope.

What is claimed is:

1. A flexible exercise device having a handle, a spring portion, and an excitation mass configured such that a natural frequency of at least the spring portion and the excitation mass is lower than a user excitation frequency.

2. The flexible exercise device of claim **1** wherein the natural frequency is about 2 hertz.

3. The flexible exercise device of claim **1** wherein the spring portion is a flexible rod having a length in a range of about 35 inches to about 40 inches and having a mass of about 4 ounces to about 6 ounces.

4. The flexible exercise device of claim **1** wherein the spring portion is configured as a polymer rod having a lightly damped frequency response.

5. The flexible exercise device of claim **4** wherein the spring portion is a fiberglass rod having a damping ratio in a range of about 0.011 to about 0.013.

6. The flexible exercise device of claim **4** wherein the spring portion is a parallel spring having a first resilient element and a second resilient element.

7. The flexible exercise device of claim **6** wherein the second resilient element is coaxially mounted relative to the first resilient element.

8. The flexible exercise device of claim **6** wherein the second resilient element is a polymer sleeve that is coaxially mounted to the first resilient element.

9. The flexible exercise device of claim **8** wherein the second resilient element has a durometer in a range of about 60 Shore A to about 80 Shore A.

10. A flexible exercise device having a spring portion and an excitation mass configured to respond to a user excitation in a post-resonance frequency range such that a therapeutic effect is generated at the end of an oscillatory cycle.

11. The flexible exercise device of claim **10** wherein an isolation effect occurs in the middle of the oscillatory cycle.

12. The flexible exercise device of claim **12** wherein the spring portion and the excitation mass have a natural frequency of about 2 hertz and the excitation mass is in a range of about 4 ounces to about 6 ounces.

13. The flexible exercise device of claim **10** wherein the spring portion includes a first resilient element and a second resilient element coaxially disposed about the first resilient element.

14. The flexible exercise device of claim **10** wherein the excitation mass is configured to be moved along the spring portion to adjust a natural frequency of the spring portion and excitation mass to the post-resonance frequency range.

15. The flexible exercise device of claim **10** wherein the excitation mass moves relative to the spring portion during user excitation and includes a damping component.

16. The flexible exercise device of claim **10** wherein the spring portion is an e-glass fiberglass rod having a diameter in a range of about 0.25 inches to about 0.375 inches.

17. A flexible exercise device having a spring portion and an excitation mass that cooperate to have a natural frequency above a use excitation frequency, the spring portion being formed from a polymer rod having a length in a range of about 35 inches to about 40 inches and a diameter of about 0.25 inches.

18. The flexible exercise device of claim **17** wherein the natural frequency is in a range of about 1.7 hertz to about 2.3 hertz and a damping ratio in a range of about 0.006 to about 0.017.

19. The flexible exercise device of claim **17** the spring portion includes a first resilient element and a second resilient element, the first resilient element being the polymer rod formed from a fiberglass material and the second resilient element being a polymer sleeve coaxially disposed over the first resilient element, the coaxial sleeve having a durometer in a range of about 60 to 80 Shore A.

20. The flexible exercise device of claim **19** wherein the first and second resilient elements cooperate with the excitation mass to produce a cantilevered first natural frequency of about 2.0 hertz and the excitation mass is about 5.5 ounces.

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