of some of these materials may also be used as the electroactive polymer in transducers.

[0051] Electronic drivers, such as the drivers **112** and **118**, are typically connected to the electrodes of an electroactive polymer transducer. The voltage applied to an electroactive polymer will depend upon specifics of an application. For example a transducer may be driven electrically by modulating an applied voltage about a DC bias voltage. Modulation about a bias voltage improves sensitivity and linearity of the transducer to the applied voltage.

[0052] The deflection of an electroactive polymer can be used in a variety of ways to produce mechanical energy. Generally speaking, electroactive polymer actuators include extenders, bending beams, stacks, and diaphragms. In the binding **152** of the adjustable brace, the linear extension or contraction of the electroactive polymer in response to voltage from a driver is used to increase or decrease the tension in binding. The controller **98** can vary the tension in a binding of one or more of the attaching elements to respond to changing tension in the binding due to muscle contraction and expansion, muscle density, limb position, or another treatment variable captured in a program instruction that is executed by the microcontroller **100**.

[0053] An electroactive polymer can also be used as a sensing transducer for the binding **152** of the brace attaching element **150**. As the electroactive polymer **202** of a transducer is deflected the voltage at the electrodes **204** and **206** changes. The electroactive polymer sensing transducer element **174** is attached to the fabric of the binding **152** so that the transducing element is stretched or compressed by the changing tension in the binding. The voltage at the electrodes of the transducer element **174** can be used to signal a binding tension brace parameter to the controller **98**.

[0054] The adjustable brace **80** includes provisions for bending the bracing element **84** in a direction generally orthogonal to the limb to adjust the fit of the bracing element to a user's limb and to alter the compartmental loading of the braced joint. Referring to **FIG. 6**, the upper **86** and lower **88** levers of the bracing element **84** are connected by a hinge pin **136** facilitating relative rotation of the levers about the pin. A disk **256** attached to the hinge pin **136** on the limb side of the bracing element **84** protects the limb from the moving components of the bracing element and may be used to compress a condyle pad **257** providing lateral stability to the joint. The hinge pin **136** passes through a central aperture in a loading transducer **258** retaining the transducer in rotational engagement with the proximal end to the upper lever **86**. A loading disk **261** with an offset central portion abuts an end of the loading transducer **258** and is restrained to the upper **86** and lower **88** levers by sliding blocks **264** and **265** welded to the levers and engaging the loading disk. When the length of the transducer **258** changes, the distal ends of the upper **86** and lower **88** levers are deflected in the direction of the axis of the hinge pin **136** or substantially normal to the limb. The upper **86** and lower **88** levers may include transverse hinges **260** to reduce the force necessary to deflect the levers. The loading transducer **258** illustrated in **FIG. 6** is a piezoelectric or electro-active polymer transducer having a length that is variable in response to a voltage applied by a driver **116** that is controlled by the controller **98**. The lateral profile of the bracing element can be varied to conform to the user's limb and alter the compartmental loading of the joint. In addition, the brace **80** includes one or more sensing transducers **138**, such as a strain gauge to sense the stress in, and result from, the displacement of a lever of the bracing element **84**. The sensing transducer **138** provides an input signal and feedback to the controller **98** related to the displacement of the levers **86** and **88** by the loading transducer or as a result of external loading. If a prescribed level of displacement or stress is sensed indicating a lateral blow to the limb, the controller **98** can cause the loading transducer **258** to deflect the bracing element to aid in resisting displacement of the brace that might injure the joint.

[0055] A shaft encoder **127** is also attached to the hinge pin to sense changes in the relative angular positions of the upper **86** and lower **88** levers. The controller **98** can vary the force exerted by the attaching elements, the lateral deflection of the brace, or the assistance or resistance of the brace to joint flexing as a function of the angular position of the levers and, therefore, the limb elements. For example, the force exerted by the tensioning structures might be reduced when the foot is raised and the tibia is not in position to apply an injurious load to the joint.

[0056] The adjustable brace **80** also includes a loading transducer to vary the force required for relative rotation of the upper **86** and lower **84** levers about the hinge **136**. As illustrated in **FIG. 3**, an electroactive polymer filament **140** is used to assist joint extension or resist flexion in a first direction. A second electroactive polymer filament **141** reeved on the opposite side of the bracing element joint can apply extension and flexion forces opposing those of the first filament **140**. The electroactive polymer filament **140** is anchored to the upper **86** and lower **88** levers and passes over a leveraging sheave **142** at the hinge **136**. Voltage applied to electrodes of the electroactive polymer filament **140** by the driver **114** in response to signals from the controller **98** causes the length of the filament to change assisting extension or resisting flexion of the joint as desired for a specific treatment regimen. The loading transducer **140** may also be used to assist flexion and resist extension by routing the filament on the opposite side of the sheave **142**.

[0057] Referring the **FIG. 7, a** linear actuator **300** can also be used to in assisting or resisting joint flexing. A piston rod **302** of the linear actuator **300**, attached to the upper lever **86**, is attached to the lower lever **88** of the bracing element **84** by a filament **304**. The filament **304** passes over a sheave **142** at the hinge **136** and an idler **306** that reduces side loading of the piston rod **302**. The linear actuator **300** may be a pneumatic or hydraulic actuator having a valve **308** with flow characteristics controllable by the controller **98**. By controlling the flow into and out of the linear actuator **300** the force required to displace the piston rod **302** can be varied. The controller **98** can vary the force exerted by the actuator **300** as a function of the angular position of the levers **86** and **88** as sensed by the shaft encoder **127**. If a source of pressurized fluid is provided, the actuator **300** can serve as a motor generating a force assisting extension of the joint (or assisting joint flexion by reversing the position of the filament **304** on the sheave **142**).

[0058] An alternative linear loading transducer **300** incorporating a magneto-rheological fluid can be utilized to provide variable resistance under the control of the controller **98**. **FIG. 9** illustrates a linear loading transducer com-