ELECTRICAL ACTUATOR HAVING SMART MUSCLE WIRE

[0001] This application claims priority of U.S. Provisional Patent Application No. 60/501,279 filed Sep. 9, 2003, PCT/US0410/29420 filed Sep. 9, 2004 and U.S. patent application Ser. No. 10/548,972 filed Sep. 13, 2005.

TECHNICAL FIELD OF INVENTION

[0002] This invention relates generally to actuators and more particularly to electrical actuators for operating a mechanical device.

BACKGROUND OF INVENTION

[0003] Mechanical devices, such as power operated automotive closure latches for doors, tail gates and the like, that can be unlatched, unlocked and locked are already known. These mechanical devices closure latches generally include a "power unit" comprising an electric motor or solenoid that operates a plurality of mechanical components including all kinds of gears, springs, slides and levers, that in turn operate the unlatching lever or lock lever of the closure latch. Such power units which depend on an electric motor or solenoid, have one or more of the following drawbacks. The power unit is complex and costly, and/or is sensitive to environmental conditions, and/or is noisy, and/or is subject to wear and/or requires substantial space.

SUMMARY OF THE INVENTION

[0004] This invention provides a "power unit" that is in the form of an electrical actuator that is characterized by applying electrical power directly to a smart muscle wire. The electrical actuator overcomes one or more of the drawbacks of the prior art noted above, particularly with respect to reducing complexity and cost by reducing the number of mechanical components required for the power unit.

[0005] Applying electrical current directly to the smart muscle wire produces an output motion for the electrical actuator while eliminating the need for either an electric motor or a solenoid. The smart wire is looped around a drive member that is engaged with a moveable member, fixed at both ends to electrical terminals, and contains one or more coils between the electrical terminals and the drive member. The electrical actuator uses a smart wire to produce an output motion of a moveable member, for example a slide or a lever. The smart wire may be coiled to increase the length of the wire, the coil can either be wrapped around a reel in a helical fashion or moveably disposed in flexible tubing for support. Direct electrical current applied to the smart wire results in heating and contraction of the wire. Subsequent removal of electrical current allows the wire to cool and return to its original size and shape. The force and stroke of the electrical actuator can be tailored to meet specific requirements by changing wire diameter and length. Further features and advantages of the invention will appear more clearly on a reading of the following detail description of the preferred embodiment of the invention, which is given by way of non-limiting example only and with reference to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0006] This invention will be further described with reference to the accompanying drawings in which:

[0007] FIG. **1** is a schematic diagram for explaining a characteristic of a smart muscle wire;

[0008] FIG. **2** is a stress strain curve of an example of a smart muscle wire;

[0009] FIG. **3** is a schematic drawing of an electrical actuator of the invention characterized by a smart muscle wire;

[0010] FIG. **3** is an enlarged section of a portion of FIG. **3**;

[0011] FIG. **5** is a schematic drawing of still another electrical actuator of the invention characterized by a smart muscle wire;

[0012] FIG. **5** is a section taken substantially along the line A-A of FIG. **5** looking in the direction of the arrows.

DETAILED DESCRIPTION OF INVENTION

[0013] Referring now to the schematic diagram of FIG. **1**, a coiled wire **10** made of a smart muscle material is illustrated. Smart muscle material, which is also known as a memory material, is characterized by a shape change responsive to heating and a return to its original shape upon cooling.

[0014] An example of a suitable muscle or memory material for the invention is nickel-titanium (NiTi) alloy which expands when heated and contracts when cooled. A wire made of nickel-titanium alloy is represented in FIG. **1** functioning as the coiled wire **10** (of solid round cross section) that supports a weight **12**. The electrical resistance of the metallic alloy wire **10** is high so that the wire is heated by applying electric current directly to the wire. The metallic alloy wire expands and contracts between its Martensite and Austentite (phase) transformation which is achieved by heating the wire **10** while it is under the fixed load of weight W. As the metallic alloy wire **10** heats up, wire **10** contracts and raises the weight **12** as indicated by the three left hand figures and the upward slanting heating arrow **14** of FIG. **1**. Then as wire **10** cools down, wire **10** expands back to its original shape as indicated by the three right hand figures and the downward slanting cooling arrow **16**.

[0015] FIG. **2** illustrates the typical loading and unloading that is, the heating and cooling behavior of superelastic nickel titanium (NiTi) alloy. When the material is loaded, the percentage of deformation strain is low initially, that is up to about 1%. The percentage of deformation is then very high increasing up to about 6½% with very little increase in stress. The percentage of deformation strain is then low again. This behavior is shown in the upper curve **20** of FIG. **2**. The lower curve **22** shows the behavior of the alloy as the load is removed and the stress returns to zero.

[0016] Referring now to FIG. **3**, a schematic drawing of an electric actuator **130** of the invention is illustrated. Actuator **130** is designed to operate an unlatching lever of a closure latch (not shown). Consequently electrical actuator **130** is a one-way version **132** (for operating the typical unlatching lever of a closure latch or the like) that reduces the space requirements required to gain a mechanical advantage. Basi-