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CLAIMS:

1. A rotary elastic actuator comprising:

first and second flywheels, mounted about an axis for rotation relative to each other;

a pair of linear elastic elements, each having opposing ends, one of said opposing ends of each of said linear elastic elements mounted to said first flywheel; the other one of said opposing ends of each of said linear elastic elements mounted to said second flywheel;

said pair of linear elastic elements mounted to bias said first and second flywheels towards an angular equilibrium position relative to each other about said axis of rotation and to exert a net torque about said axis and toward said position of equilibrium, as said flywheelss are rotated angular distances in either direction away from said angular equilibrium position.
2. The actuator of claim 1, further comprising a motor operatively connected to said first flywheel for rotating said first flywheel.
3. The actuator of claim 2, further comprising a sensor for generating signals indicative of angular positions of said first and second flywheels, and a controller operatively connected to said motor and said sensor for controlling the output of said motor based on said signals.
4. The actuator of any one of claims 1 to 3, further comprising additional pairs of linear elastic elements.
5. The actuator of any one of claims 1 to 4, wherein each one of said linear elastic elements is a linear spring.
6. The actuator of claim 5, wherein said linear springs are all of the same natural length and stiffness.

7. The actuator of claim 6, further comprising additional pairs of linear elastic elements, each of said additional pairs mounted to bias said first and second flywheels towards said angular equilibrium position relative to each other about said axis of rotation and to exert a torque toward said position of equilibrium, as said flywheels are rotated angular distances in either direction away from said angular equilibrium position.
8. The actuator of claim 7, wherein said pair of linear springs and said additional pairs of linear springs are circumferentially disposed about said axis.
9. The actuator of claim 3, wherein said sensor comprises two optical position sensors.
10. The actuator of claim 9, wherein one of said two optical position sensors is disposed to sense the angular position of said second flywheel and the other one of said optical position sensors is disposed to sense the angular position of said first flywheel.
11. The actuator of claim 10, wherein each of said optical position sensors comprises an encoder for converting a sensed angular position into a signal indicative of said sensed angular position.
12. The actuator of claim 10 or claim 11, wherein said motor is controlled to generate a constant torque based on the difference between said angular positions of said first and second flywheels.
13. The actuator of claim 12, wherein said controller comprises an inner loop proportional-integral-derivative (PID) control circuit.
14. The actuator of claim 12, wherein said controller comprises a proportional-integral-derivative control circuit.

15. The actuator of any one of claims 10 to 14, wherein said controller controls said motor based on a desired output position and said difference between said angular positions.
16. The actuator of any one of claims 10 to 14, wherein said controller controls said motor based on a desired output torque and said difference between said angular positions.
17. The actuator of claim 15 or 16, wherein said controller controls said motor based further on a measured output torque computed from said difference between said angular positions.
18. The actuator of claim 16 or 17, wherein said controller controls said motor based further on a rate of change of said difference between said angular positions.
19. The actuator of any one of claims 10 to 18, wherein said controller controls said motor exert near constant torque on said second flywheel.
20. The actuator of any one of claims 10 to 19, wherein said controller controls said motor to rotate said second flywheel to a desired angular position.
21. The actuator of any one of claims 1 to 20, further comprising a gearbox operatively connected to said motor, and comprising a coupler operatively connected to said gearbox and said first flywheel, said gearbox and coupler capable of transmitting a rotational motion of a drive shaft of said motor to a rotational motion of said first flywheel.
22. The actuator of claim 21, further comprising an input shaft, said input shaft operatively connected to said coupler and said flywheel so as to transmit a rotational motion of said coupler to a rotational motion of said flywheel.
23. The actuator of claim 22, further comprising an output shaft, said output shaft operatively connected to said second flywheel and a load to be rotationally

moved so as to transmit a rotational motion of said second flywheel to a rotational motion of said load.

24. The actuator of claim 23, further comprising a centering shaft, said input and output shafts are rotatably coupled to said centering shaft such that said input and output shafts are axially aligned and rotatable relative to each other.

25. The actuator of claim 1, wherein each of said first and second flywheel comprises a plurality of sliders mounted on said each flywheel, each end of each one of said elastic elements mounted on one of said sliders, each of said sliders slidable in a radial direction during assembly such that the extended lengths of said elastic elements can be adjusted, said sliders fixed on said each flywheel during use.

26. A rotary elastic actuator comprising:

first and second flywheels, mounted about an axis for rotation relative to each other;

a pair of linear elastic elements, each having opposing ends, one of said opposing ends of each of said linear elastic elements mounted to said first flywheel; the other one of said opposing ends of each of said linear elastic elements mounted to said second flywheel;

said pair of linear elastic elements mounted to bias said first and second flywheels towards an angular equilibrium position relative to each other about said axis of rotation and to exert a net torque about said axis and toward said position of equilibrium, as said flywheels are rotated angular distances in either direction away from said angular equilibrium position;

a motor operatively connected to said first flywheel for rotating said first flywheel;

a sensor for generating signals indicative of angular positions of said first and second flywheels; and

a controller operatively connected to said motor and said sensor for controlling the output of said motor based on said signals.

27. A rotary elastic coupling comprising:

a first rotating member mounted for rotation about an axis of rotation;

a second rotating member mounted about said axis of rotation, said first rotating member being mounted in a generally opposite relation to said second rotating member;

first and second linear elastic elements connected between said first and second rotating members,

said first linear elastic element being connected between said first and second rotating members to exert forces on said first and second rotating members creating a torque transmitted to said first rotating member in a first rotational direction about said axis of rotation, and a torque transmitted to said second rotating member in a second direction opposite to said first direction about said axis of rotation;

said second linear elastic element connected between said first and second rotating members to exert forces on said first and second rotating members creating a torque transmitted to said first rotating member in said second rotational direction about said first axis of rotation, and a torque transmitted to said second rotating member in said first direction about said axis of rotation;

said first and second rotating members being biased towards an equilibrium position relative to each other by said first and second linear elastic elements, and said coupling operable to elastically transmit a load between said first and second rotating member through said first and second linear elastic elements as one of said first and second rotating members is rotated relative to the other of said first and second rotating members, as said load is applied to said one rotating member.

28. A method of controlling torque provided through a rotary elastic actuator, said rotary elastic actuator comprising:

first and second flywheels, mounted about an axis for rotation relative to each other;

a motor coupled to rotate said first flywheel about said axis;

a pair of linear elastic elements, each having opposing ends, one of said opposing ends of each of said linear elastic elements mounted to said first flywheel; the other one of said opposing ends of each of said linear elastic elements mounted to said second flywheel;

said pair of linear elastic elements mounted to bias said first and second flywheels towards an angular equilibrium position relative to each other about said axis of rotation and to exert a net torque about said axis and toward said position of equilibrium, as said flywheels are rotated angular distances in either direction away from said angular equilibrium position;

said method comprising:

measuring relative angular displacement between said first and second flywheels;

controlling said motor based on said measured angular displacement.

29. The method of claim 28, wherein said controlling further comprises estimating torque provided through said coupling based on said angular displacement.

30. The method of claim 29, wherein said controlling comprises controlling said motor to provide constant torque.