The moving end of transducer T**1** is connected to the flexible spline FS. The output of the actuator is the circular spline CS. This design allows transducer T**1** to be integrated inside the rotor R of transducer **72**.

[**0139**] Implementation 2

[**0140**] FIG. **17***b* illustrates a second possible design of rotational differential actuator using a hollow shaft harmonic drive as illustrated in FIG. **16** wherein transducer T**1** is a rotational damper **1703**.

[**0141**] In FIG. **17***b*, transducer T**2** comprises a rotor R connected to the wave generator WG of the harmonic drive. The moving end of transducer T**1** is connected to the flexible spline FS. The output of the actuator is the circular spline CS. This design allows transducer T**1** to be integrated around the stator **1701** of transducer **72**.

[**0142**] Implementation 3

[**0143**] FIG. **17***c* illustrates a third possible design of rotational differential actuator using a hollow shaft harmonic drive as illustrated in FIG. **16** wherein transducer T**1** is a limited angle torque motor **1704**.

[**0144**] As illustrated in FIG. **17***c*, transducer T**2** comprises a rotor R connected to the wave generator WG of the harmonic drive. The moving end of transducer T**1** is connected to the circular spline CS. The output of the actuator is the flexible spline FS. This design allows transducer T**1** to be integrated around the stator **1701** of transducer **72**.

[**0145**] Rotational Differential Elastic Actuator (DEA)

[**0146**] Referring to FIGS. **18** and **19**, a rotational differential elastic actuator (DEA) according to a non-restrictive illustrative embodiment of the present invention will be described. The DEA of FIGS. **18** and **19** generally follows implementation 1 described hereinabove and comprises a transducer T**1** of above category 1 formed by a passive mechanical torsion spring **8**.

[**0147**] The DEA includes:

[**0148**] a transducer T**2** formed of a frameless brushless motor composed of a rotor **1** and stator **2**,

[**0149**] a mechanical differential in the form of a hollow shaft harmonic drive composed of a wave generator **4**, a flexible spline **5** and a circular spline **6**; and

[**0150**] a transducer T**1** formed by a passive mechanical torsion spring **8**.

[**0151**] The rotor **1** of the motor is mounted to a shaft **3**, itself mounted to the wave generator **4** via fasteners such as **71**. The stator **2** is fixedly mounted to a housing **14** of the motor. The shaft **3** is rotatably connected to the housing **14** via bearings **16** mounted to a ring **15** itself mounted to the housing **14** through fasteners such as **72**.

[**0152**] A first end **7** of the torsion spring **8** is secured to the flexible spline **5** via fasteners such as **73**. The first end **7** of the torsion spring **8** is also secured to a ring **9**. A second end **17** of the spring **8** is mounted to a ring **18**. The ring **18** is rotatably mounted to the housing **14** via a bearing **26** which is designed to prevent radial and axial movement of this ring **18**. Indeed, bearing **26** absorbs both axial and radial reactions developed at the end **17** of the spring **8** when it transmits a torque to an external load (not shown).

[**0153**] More specifically, the end **17** of the torsion spring **8** is mounted to the circular ring **18** through **2** locking elements **20** and **25**. Circular rings **21** and **22** combined with fasteners **23** (only one being shown) generate an axially oriented pressure applied to locking elements **20** and **25**. Resulting friction forces applied to surfaces **19** and **24** enable transmission of torque from the end **17** of the spring **8** to the ring **18**.

[**0154**] The circular spline **6** is mounted to an output shaft **11** via fasteners such as **74**. The output shaft **11** is rotatably mounted to the housing **14** via bearings **12** and **13**. Bearings **10** are also interposed between the output shaft **11** and the ring **9**.

[**0155**] The housing **14** is fixed with respect to the ground by means of a bracket **27**. A force/torque sensor **29** includes a first end **28** mounted to the bracket **27** via spherical bearing **57** (FIG. **19**). The ring **18** includes an outwardly protruding plate member **31** to which a second end **30** of the force/torque sensor **29** is mounted through a spherical bearing **58** (see FIG. **19**). Spherical bearings **57** and **58** ensure that only tension and compression efforts are transmitted to force/torque sensor **29**.

[**0156**] As can be seen from FIG. **19**, a rotary position sensor **59** measures the angular position of the output shaft **11**. For that purpose, a pinion gear **61** is mounted on an input shaft of this sensor **59**, and the gear **61** is driven by an annular internal gear **62**, which is directly mounted and centered on the output shaft **11**. The angular position measured is supplied to the controller **33** to monitor the angular position of the output shaft **11**.

[**0157**] A controller **33** receives force/torque data from the force/torque sensor **29** and angular position data from the rotary position sensor **59** and controls the rotation of the rotor **1** by controlling the electrical energy supplied to the stator **2**. A force/torque set point **35** required by the system's user is also supplied to the controller **33**. Such a controller **33** is well known to those of ordinary skill in the art and for that reason will not be further discussed.

[**0158**] When a voltage is applied to a winding of stator **2** by the controller **33**, the rotor **1** and associated shaft **3** begin to rotate and actuate the wave generator **4** of the harmonic drive.

[**0159**] In operation, when an external torque load **32** is applied to output shaft **11** while no voltage is applied to the winding of the stator **2**, the output shaft **11** rotates and drives circular spline **6** and flexible spline **5**. Flexible spline **5** then drives the end **7** of the torsion spring **8** which axially deforms in a reversible manner. The end **17** is immobilized because of the high rigidity of the force/torque sensor **29**. While the end **7** continues to deviate from its initial angular position which is detected by the angular position sensor **59**, a mechanical reaction torque starts to raise inside the torsion spring **8**. The process continues until a force equilibrium is achieved between the external load **32** applied to output shaft **11** and an internal mechanical reaction torque built inside torsion spring **8**. Electric signals produced by force/torque sensor **29** and supplied to the controller **33** are a direct measurement of the external applied load **32**.

[**0160**] To unload the system and decrease applied torque **32** to zero, the wave generator **4** needs to be rotated by rotor **1** in the appropriate direction so angular deviation of the end