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(54) **ACTUATING DEVICE WITH MULTIPLE STABLE POSITIONS**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

2,624,531	1/1953	Stalker	244/17.13
2,642,143	6/1953	Miller	170/160.25
2,716,460	8/1955	Young	170/160.1
3,042,371	7/1962	Fanti	253/78
3,930,626	1/1976	Croswell, Jr.	244/44
4,953,098	8/1990	Fischer, Jr. et al.	364/508
5,114,104	5/1992	Cincotta et al.	244/219
5,150,864	9/1992	Roglin et al.	244/219
5,224,826	7/1993	Hall et al.	416/4
5,242,130	9/1993	Mouille et al.	244/17.13
5,366,176	11/1994	Loewy et al.	244/75 R
5,529,458	6/1996	Humpherson	416/20 R
5,588,800	12/1996	Charles et al.	416/24
5,626,312	5/1997	Head	244/75 R
5,662,294	9/1997	Maclean et al.	244/219
5,752,672	5/1998	McKillip, Jr.	244/75 R
5,839,698 *	11/1998	Moppert	244/215
5,887,828 *	3/1999	Appa	244/215
5,895,015 *	4/1999	Saiz	244/90 R

OTHER PUBLICATIONS

Chopra, I., "Development of a Smart Rotor," 19th European Rotorcraft Forum, Associazione Industrie Aerospaziali, Cernobbio (Como), Italy, Sep. 14, 1993, pp. N6–0 to N6–18.

(List continued on next page.)

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(57) **ABSTRACT**

A mechanical actuating device for moving an aerodynamic or hydrodynamic surface includes at least one flexure member confined in an elastically deformed condition. The flexure member is movable against the force generated by its elastic deformation to move the device into one of a plurality of stable positions, in which the device, and therefore the aerodynamic or hydrodynamic surface, are held by the force generated by elastic deformation of the flexure member. Since the flexure member is always elastically deformed, it "snaps" between discrete, stable positions and is held firmly in each. In another embodiment more flexure members can be used to provide additional stable positions. In one application, the actuating device is used as a trailing edge tab for a helicopter or tiltrotor blade to reduce 1/rev vibrations. The device can be actuated manually or electrically using shape-memory alloy wires to snap the flexure members into their various stable positions.

16 Claims, 4 Drawing Sheets