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Hoen

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(54) **OPTICAL SWITCHES USING DUAL AXIS MICROMIRRORS**

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(51) **Int. Cl.**⁷ **G02B 6/26**

(52) **U.S. Cl.** **385/17; 385/16; 385/18; 385/19**

(58) **Field of Search** **385/16, 17, 18, 385/19, 20, 25, 31; 359/291, 224, 223, 292**

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,754,185	6/1988	Gabriel et al.	310/309
5,378,954	1/1995	Higuchi et al.	310/309
5,534,740	7/1996	Higuchi et al.	310/309
5,872,880	* 2/1999	Maynard	385/19 X
5,960,133	* 9/1999	Tomlinson	385/18
5,986,381	11/1999	Hoen et al.	310/309

OTHER PUBLICATIONS

Niino, Toshiki et al., "Dual Excitation Multiphase Electrostatic Drive," IEEE, 1995, pp. 1318-1325.

Niino, Toshiki et al., "Development of an Electrostatic Actuator Exceeding 10N Propulsive Force," IEEE, 1992, pp. 122-1127.

Niino, Toshiki et al., "High-Power and High-Efficiency Electrostatic Actuator," IEEE, 1993, pp. 136-241.

Trimmer, W.S.N., "Design Considerations for a Practical Electrostatic Micro-Motor," Sensors and Actuators, 11, 1987, pp. 189-206.

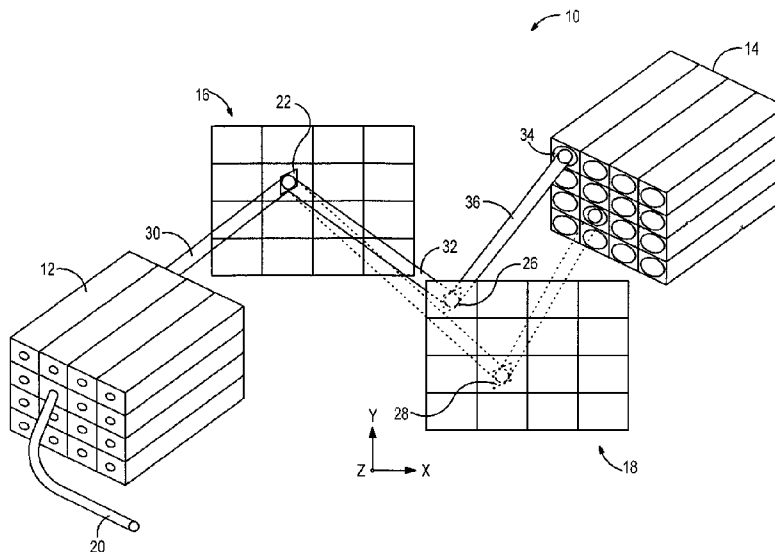
* cited by examiner

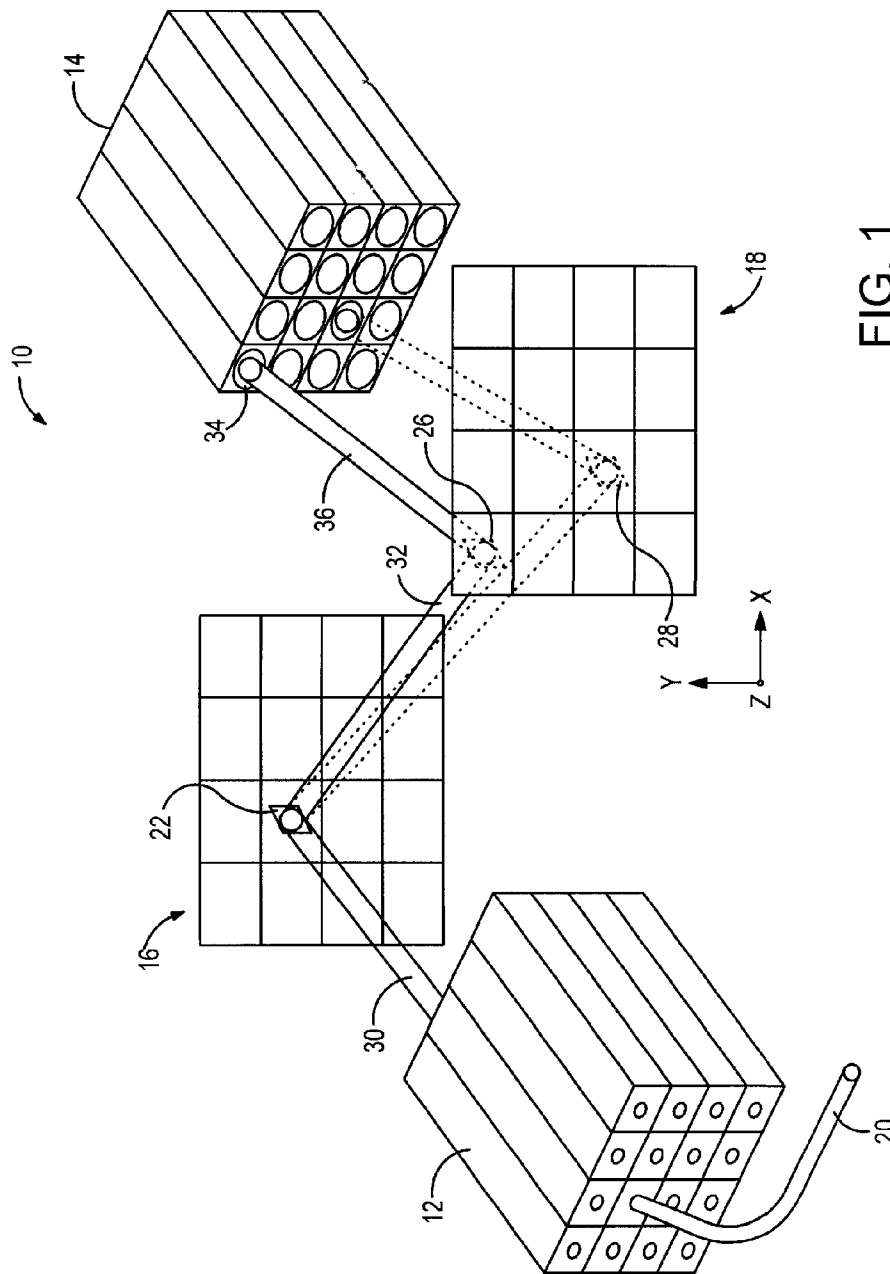
Primary Examiner—Phan T. H. Palmer

(57) **ABSTRACT**

In a first embodiment of an optical switch having at least one dual axis micromirror, the micromirror is manipulated about two generally perpendicular axes by varying voltage patterns along two electrostatic arrangements. The two electrostatic arrangements may be formed to independently drive two movers, or may be formed to control a mover that is displaceable in two directions. The micromirrors and the movers that control the micromirrors may be integrated onto a single substrate. Alternatively, the micromirrors may be formed on a substrate that is attached to the substrate that includes the mover or movers. In a second embodiment of an optical switch in accordance with the invention, the switch includes two collimator arrays and two dual axis micromirror arrays. Each first micromirror in the first micromirror array is dedicated to one of the collimators in the first collimator array. Similarly, each second micromirror of the second micromirror array is dedicated to one of the collimators of the second collimator array. By manipulating a first micromirror, an input signal from the associated first collimator can be reflected to any of the second micromirrors. By manipulating the second micromirror that receives the signal, the signal can be precisely positioned on the second collimator that is associated with the second micromirror.

19 Claims, 12 Drawing Sheets





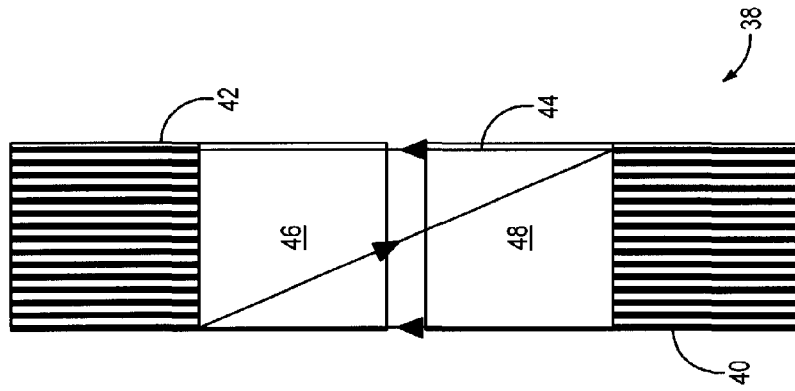


FIG. 3

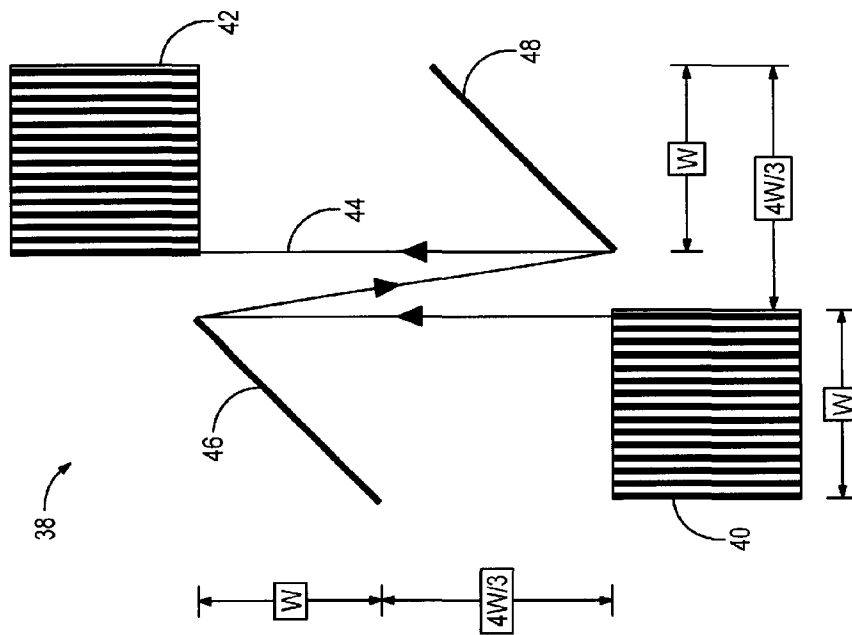


FIG. 2

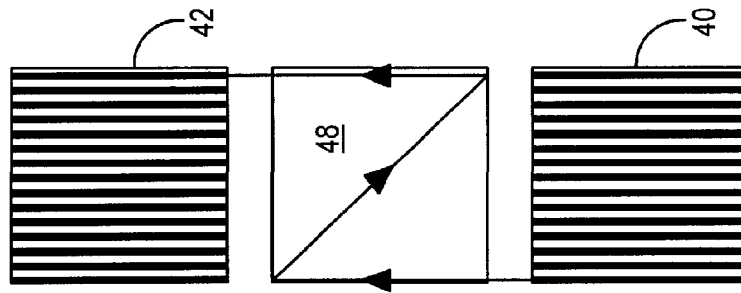


FIG. 5

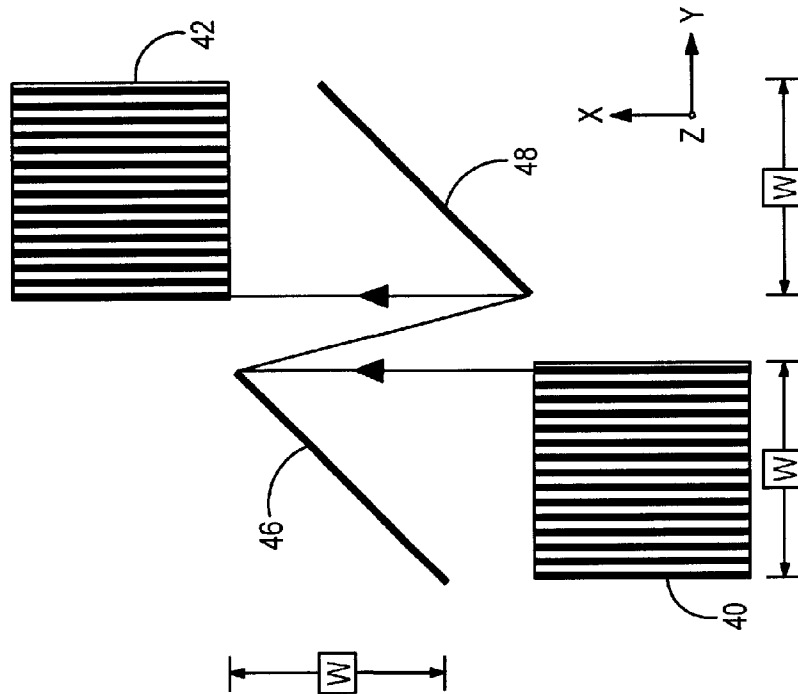


FIG. 4

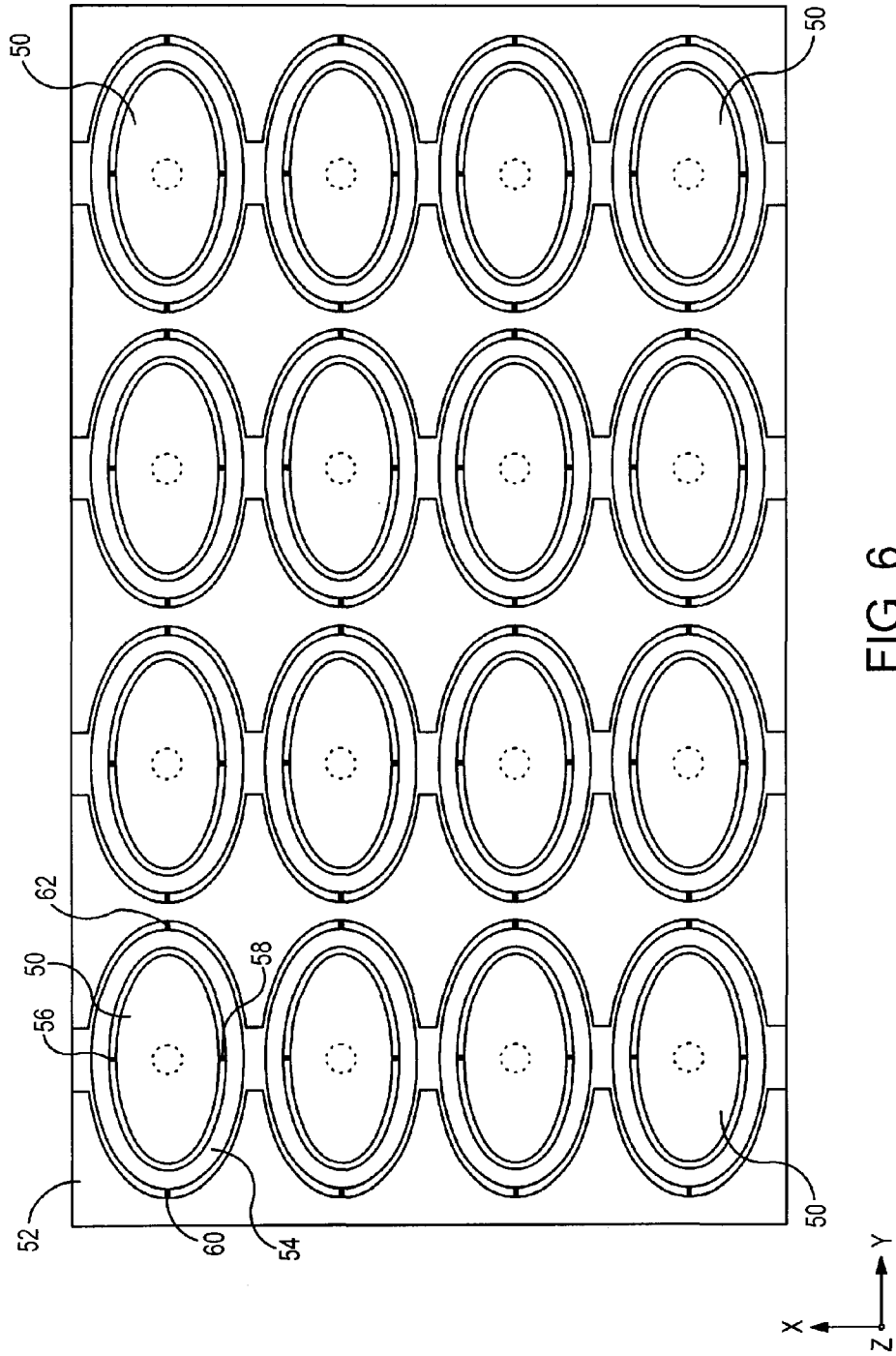


FIG. 6

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