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United States Patent [19]
Lin et al.

[11] **Patent Number:** **5,661,591**
[45] **Date of Patent:** ***Aug. 26, 1997**

- [54] **OPTICAL SWITCH HAVING AN ANALOG BEAM FOR STEERING LIGHT**
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- [73] **Assignee:** **Texas Instruments Incorporated**, Dallas, Tex.
- [*] **Notice:** The term of this patent shall not extend beyond the expiration date of Pat. No. 5,629,794.
- [21] **Appl. No.:** **537,179**
- [22] **Filed:** **Sep. 29, 1995**
- [51] **Int. Cl.⁶** **G02B 26/00**
- [52] **U.S. Cl.** **359/290; 359/214; 359/850**
- [58] **Field of Search** 359/290, 291, 359/212, 213, 214, 846, 847, 848, 849, 850, 851

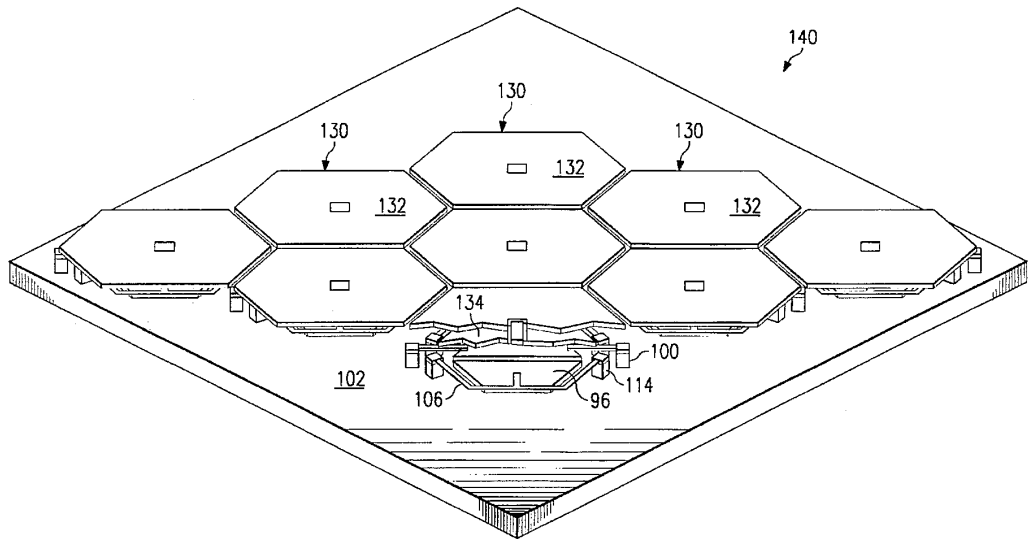
Primary Examiner—Georgia Y. Epps
Assistant Examiner—Dawn-Marie Bey
Attorney, Agent, or Firm—Robert C. Klinger; James C. Kesterson; Richard L. Donaldson

[57] **ABSTRACT**

A spatial light modulator (40,70,80,90,130) operable in the analog mode for light beam steering or scanning applications. A deflectable mirror (42, 72) and which may be hexagonal (92, 132) is supported by a torsion hinge (44,86, 94) ends along a torsion axis. A plurality of flexure hinges (48,82,106) are provided to support the ends of the mirror (42,72,92,132) and provide a restoration force. The combination of the torsion hinges and the flexure hinges realizes a deflectable pixel that is operable in the linear range for a large range of address voltages. The flexure hinges also maintain a flat undeflected state when no address voltage is applied, and prevent the pixel from collapsing. The pixel may be reinforced, such as about its perimeter (74) to ensure mirror flatness and prevent warping, even during extreme deflections of the mirror. The pixel is electrostatically deflected by applying an address voltage to an underlying address electrode (60,96,98). The hexagonal mirrors (92, 132) allow a tightly packed mirror array, and have a closely circular surface area so as to efficiently reflect a light beam of circular cross section, such as a light beam from fiber optics.

- [56] **References Cited**
- U.S. PATENT DOCUMENTS
- 5,489,952 2/1996 Gove et al. 348/771

16 Claims, 9 Drawing Sheets



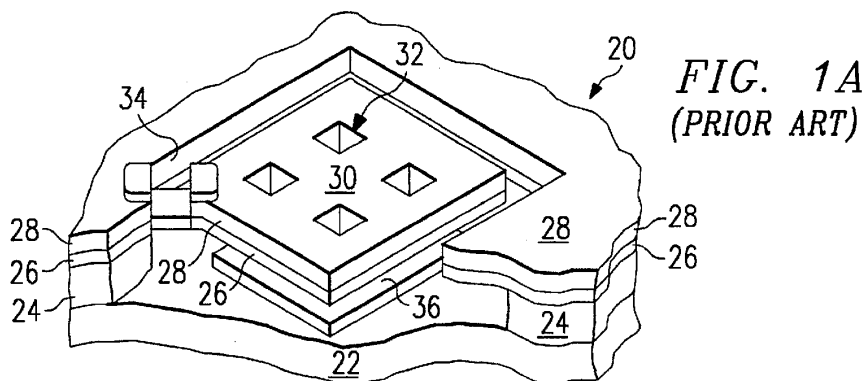


FIG. 1A
(PRIOR ART)

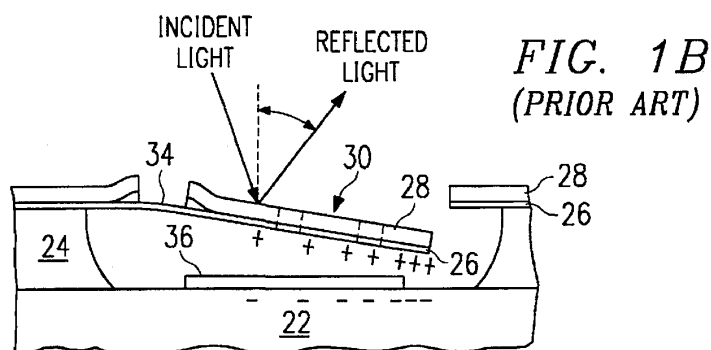


FIG. 1B
(PRIOR ART)

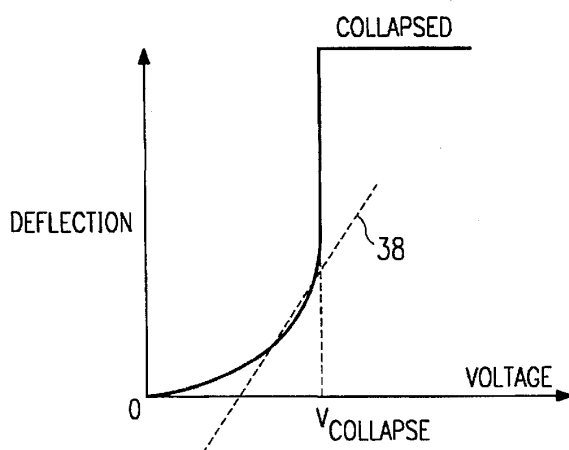
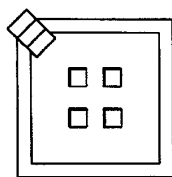
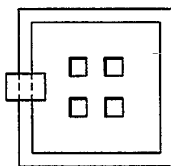


FIG. 1C
(PRIOR ART)



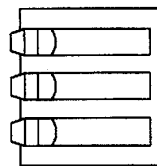
45° FLAP

FIG. 1D



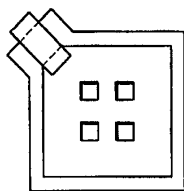
90° FLAP

FIG. 1E



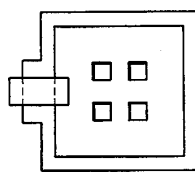
DIVING
BOARDS

FIG. 1F



45° EXTENDED
HINGE

FIG. 1G



90° EXTENDED
HINGE

FIG. 1H

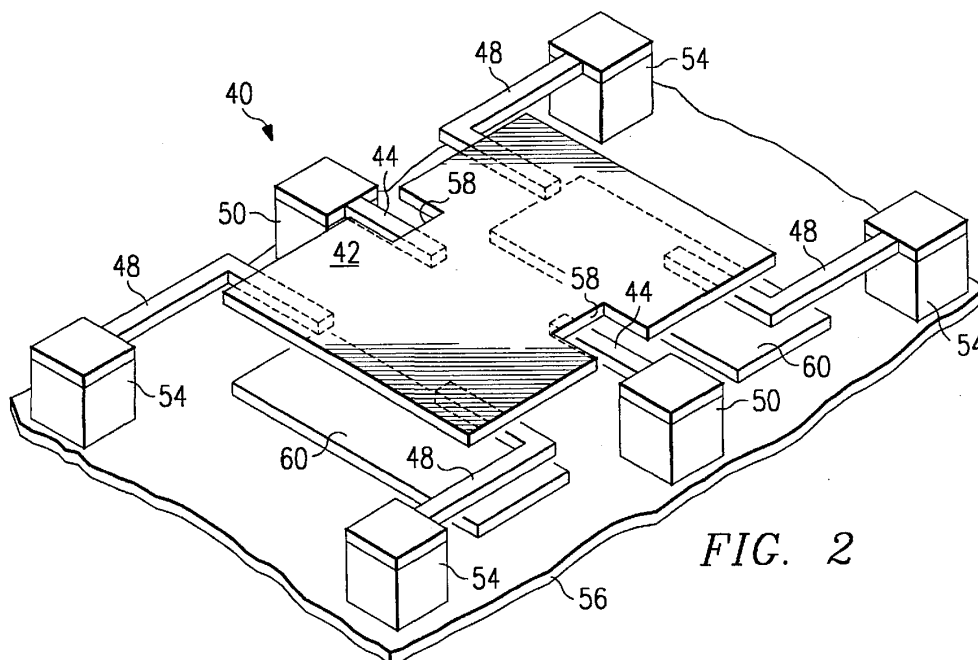


FIG. 2

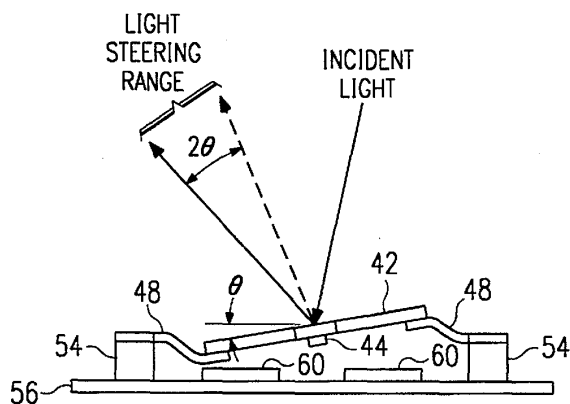


FIG. 3A

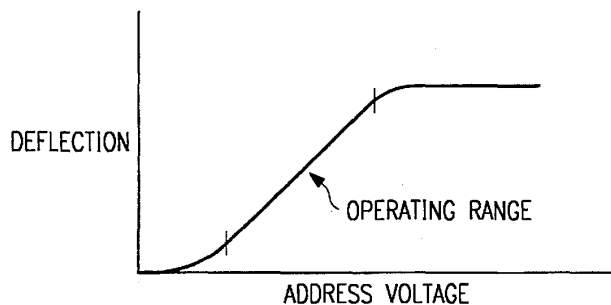


FIG. 3B

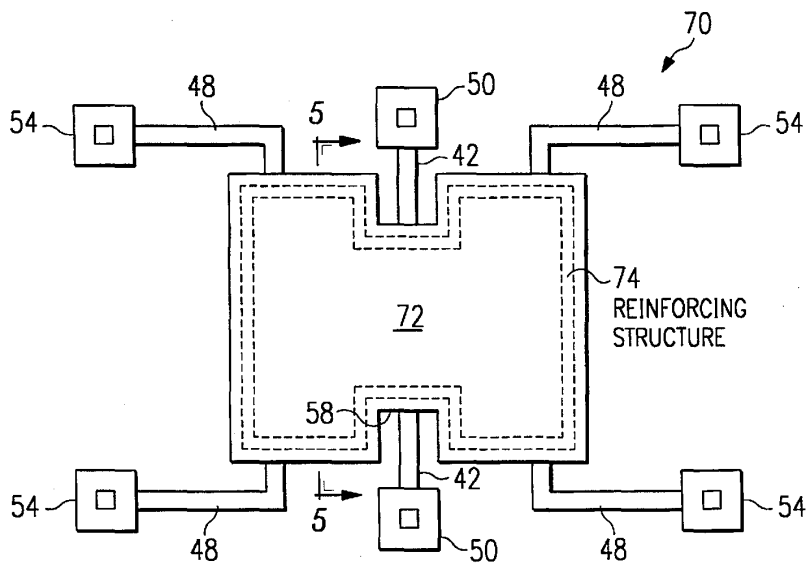


FIG. 4

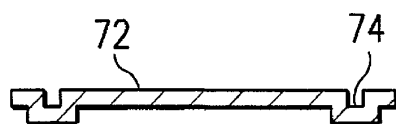


FIG. 5

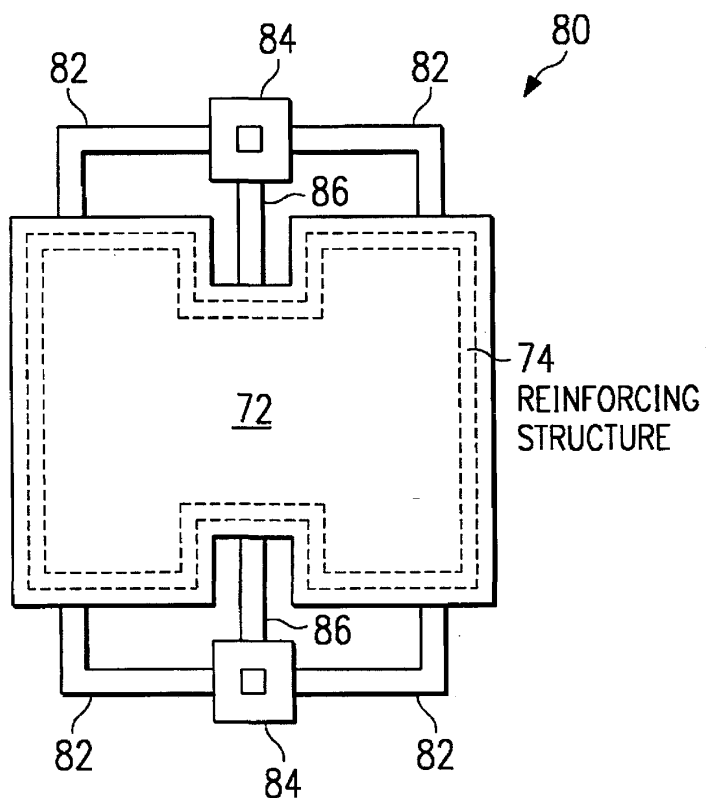


FIG. 6

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