



US006178284B1

(12) **United States Patent**  
**Bergmann et al.**

(10) **Patent No.:** **US 6,178,284 B1**  
(45) **Date of Patent:** **Jan. 23, 2001**

(54) **VARIABLE SINGLE-MODE ATTENUATORS BY SPATIAL INTERFERENCE**

(75) Inventors: **Ernest E. Bergmann**, Fountain Hill Borough, Lehigh County, PA (US); **Joseph E. Ford**, Monmouth; **James A. Walker**, Howell, both of NJ (US)

(73) Assignee: **Lucent Technologies, Inc.**, Murray Hill, NJ (US)

(\* ) Notice: Under 35 U.S.C. 154(b), the term of this patent shall be extended for 0 days.

(21) Appl. No.: **09/163,581**

(22) Filed: **Sep. 30, 1998**

(51) **Int. Cl.**<sup>7</sup> ..... **G02B 26/02**

(52) **U.S. Cl.** ..... **385/140; 359/846; 359/850**

(58) **Field of Search** ..... 385/15, 18, 25, 385/31, 47, 48, 140; 359/298, 302, 318, 846, 847, 850, 851, 855, 856, 857, 865

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

4,516,827	*	5/1985	Lance et al. ....	385/140
4,591,786		5/1986	Koo et al. ....	324/244
4,683,421		7/1987	Miller et al. ....	324/96
4,753,511		6/1988	Bowers et al. ....	350/96.21
4,850,670		7/1989	Mathis et al. ....	350/96.21
4,878,730		11/1989	Wall ..... ..	250/96.21
4,896,938		1/1990	Mathis et al. ....	350/96.21
4,934,785		6/1990	Mathis et al. ....	350/96.21
5,311,614		5/1994	Caron et al. ....	385/140
5,319,733		6/1994	Emmons et al. ....	385/140
5,420,711		5/1995	Snyder ..... ..	359/173
5,432,875		7/1995	Korkowski et al. ....	385/27
5,500,761		3/1996	Goossen et al. ....	359/290
5,518,400		5/1996	Otoide et al. ....	434/4
5,734,778		3/1998	Loughlin et al. ....	385/140
5,745,271		4/1998	Ford et al. ....	359/130
5,781,341		7/1998	Lee ..... ..	359/578
5,796,880		8/1998	Ford et al. ....	385/1
5,900,983	*	5/1999	Ford et al. ....	385/140 X
5,915,063	*	6/1999	Colbourne et al. ....	385/140

**OTHER PUBLICATIONS**

Joseph E. Ford et al., *Micromechanical Fiber-Optic Attenuator with 3 μs Response*, 16 J. Lightwave Tech. 1663-1670 (Sep. 1998).

Raanan A. Miller and Yu-Chong Tai, *Micromachined Electromagnetic Scanning Mirrors*, 36 Optical Engineering 1399-1407 (May 1997).

N. Fukushima et al., *Non-Mechanical Variable Attenuator Module Using Faraday Effect* (No Journal Name or Date Given).

Sunny Bains, *Micromachined Parts Readied for HDTV*, EE Times, 2 pp. (No Date Given).

Optical Attenuator, FDK Corporation (5 pages) (Product Brochure, No Date Given).

Challenging the Outer Edge of Optoelectronics Technology, FDK America, Inc. Aug. 1998 (1 page) *Lightwave*.

R. S. Longhurst, *Multiple Beam Interferometry*, in Geometrical and Physical Optics 153-183 (John Wiley & Sons Inc. ed., 1957), Chapter IX.

C. Marxer et al., *MHz Opto-Mechanical Modulator*, Proc. Transducers (1995), 4 pp.

(List continued on next page.)

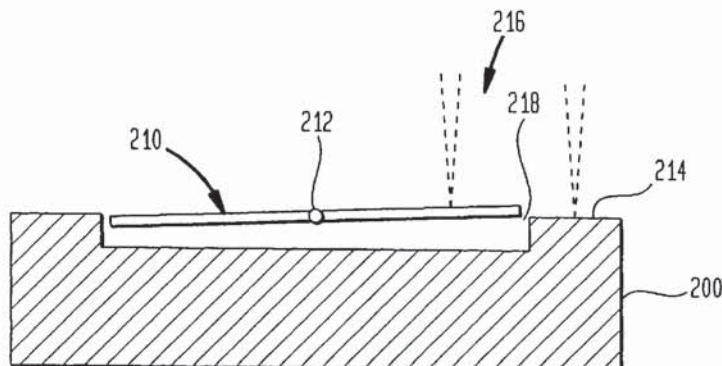
*Primary Examiner*—John D. Lee

(74) *Attorney, Agent, or Firm*—Synnestvedt & Lechner LLP

(57) **ABSTRACT**

An optical attenuator is disclosed that utilizes the concept of destructive and constructive interference to enhance the ability to attenuate the light signal sent between an optical transmitter and an optical receiver. Rather than completely blocking out a portion of the light signal or utilizing a membrane coated with a partially reflecting material, the present invention utilizes a very high reflectivity coating on divided surfaces, and controls the relative distances between each of the divided surfaces and the optical transmitter/receiver.

**22 Claims, 9 Drawing Sheets**



OTHER PUBLICATIONS

K. Aratani, *Process and Design Considerations for Surface Micromachined Beams for a Tuneable Interferometer Array in Silicon*, Proc. IEEE MEMS Workshop 230–235 (1993).

*VCA Series Motorized Attenuator*, Fibercell, Inc. (Preliminary Product Information, 2 pages), Oct. 1997.

\* cited by examiner

FIG. 1

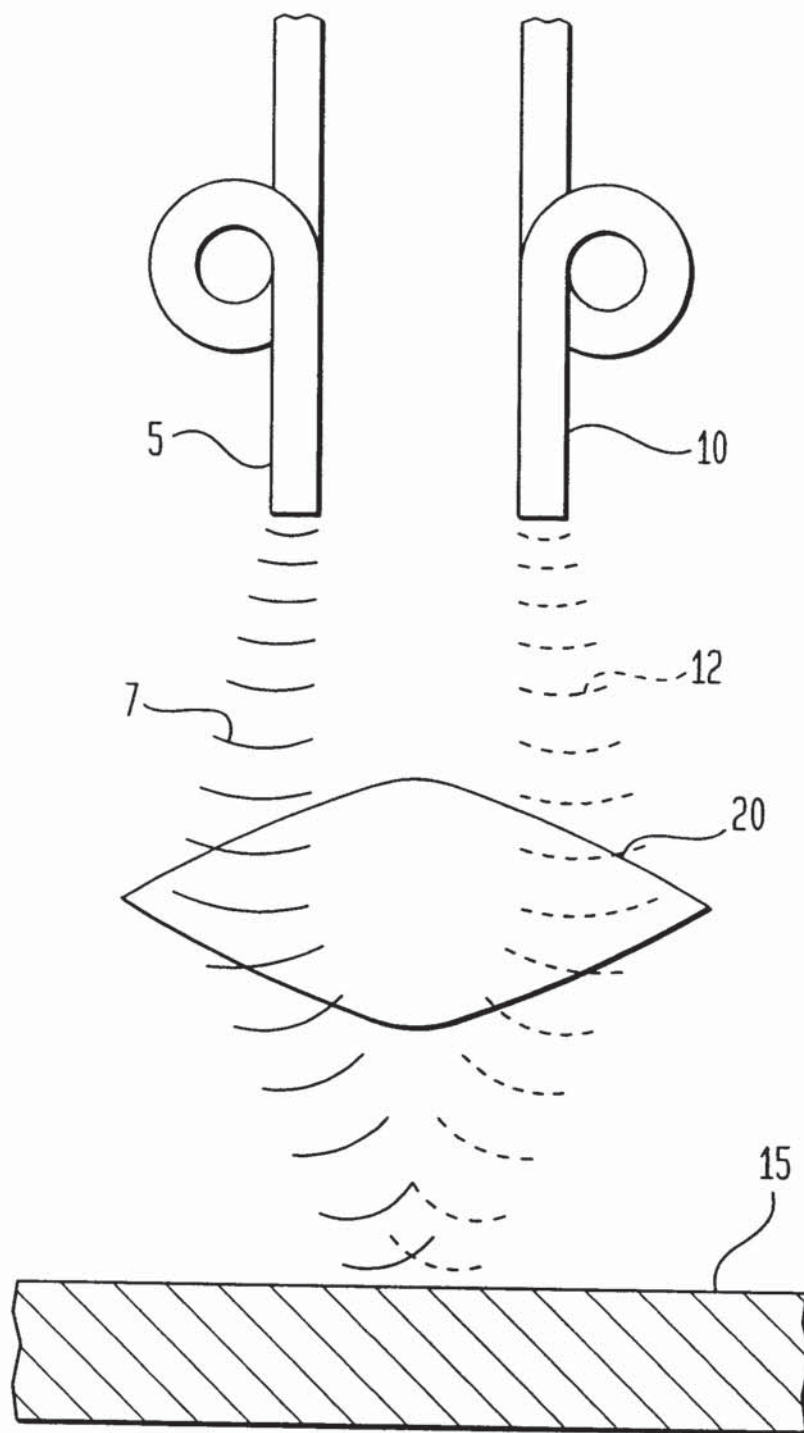


FIG. 2  
(PRIOR ART)

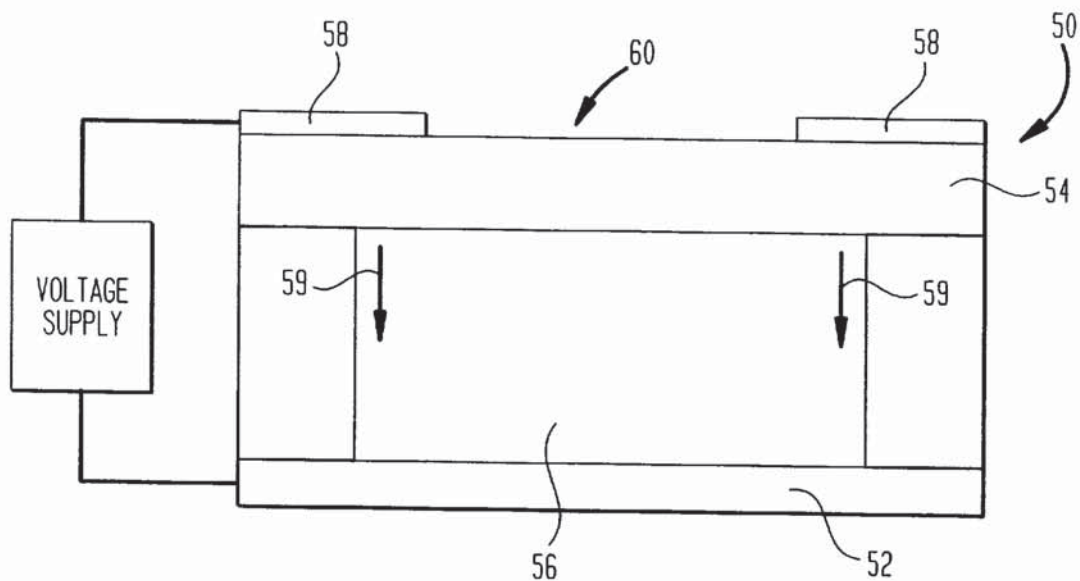


FIG. 3  
(PRIOR ART)

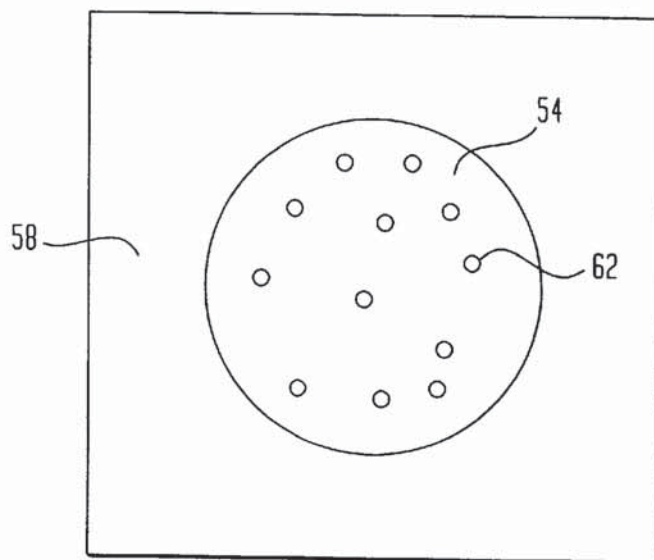


FIG. 4  
(PRIOR ART)

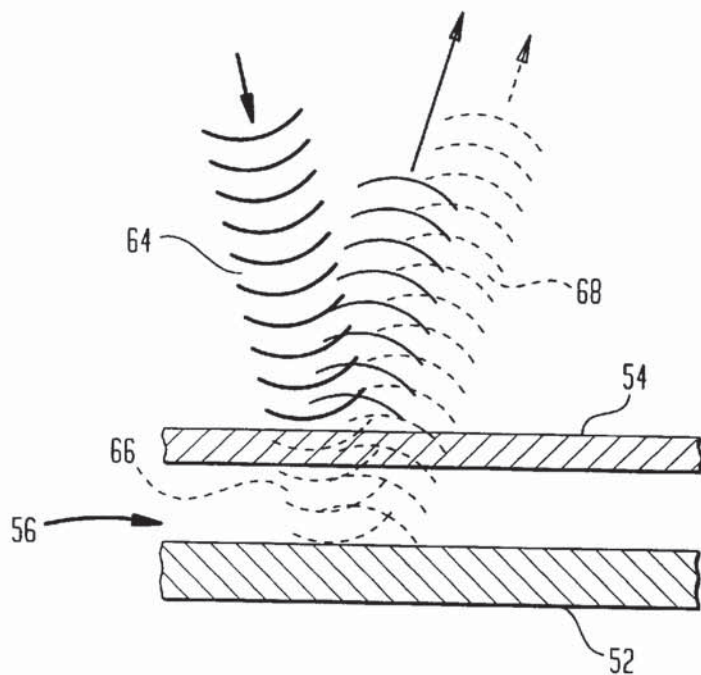
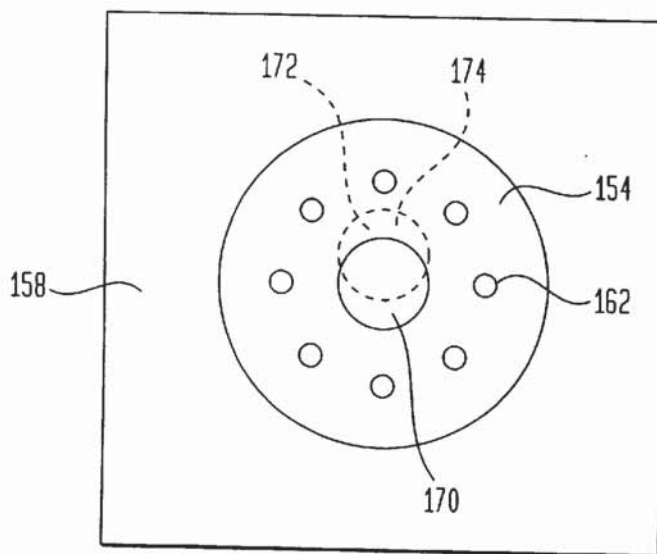


FIG. 5



# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.