



- [54] **TAPERED MULTILAYER LUMINAIRE DEVICES**
- [75] Inventors: **Roland Winston; Benjamin A. Jacobson, both of Chicago; Robert L. Holman, Naperville; Neil A. Gitkind, Chicago, all of Ill.**
- [73] Assignee: **NiOptics Corporation, Evanston, Ill.**
- [21] Appl. No.: **29,883**
- [22] Filed: **Mar. 11, 1993**

| | | | |
|-----------|---------|-------------------------|---------|
| 4,649,462 | 3/1987 | Dobrowolski et al. | 362/2 |
| 4,706,173 | 11/1987 | Hamada et al. | 362/341 |
| 4,729,068 | 3/1988 | Ohe | 362/31 |
| 4,735,495 | 4/1988 | Henkes | 362/310 |
| 4,737,896 | 4/1988 | Mochizulki et al. | 362/301 |
| 4,747,223 | 5/1988 | Bonds | 40/219 |
| 4,765,718 | 8/1988 | Henkes | 359/49 |
| 4,799,050 | 1/1989 | Prine et al. | 340/765 |
| 4,799,137 | 1/1989 | Abo | 362/309 |
| 4,832,458 | 5/1989 | Ferguson | 350/338 |

(List continued on next page.)

Related U.S. Application Data

- [63] Continuation-in-part of Ser. No. 855,838, Mar. 23, 1992, Pat. No. 5,237,641.
- [51] Int. Cl.⁵ **G02B 6/26**
- [52] U.S. Cl. **385/146; 385/43; 385/901; 385/129; 385/131**
- [58] Field of Search **385/43, 129, 130, 131, 385/140, 146, 147, 901, 31; 359/599, 833, 834**

References Cited

U.S. PATENT DOCUMENTS

| | | | |
|-----------|---------|--------------------------|-----------|
| 2,347,665 | 5/1944 | Christensen et al. | 362/31 |
| 2,712,593 | 7/1955 | Merchant | 362/27 |
| 3,617,109 | 11/1971 | Tlen | 385/43 |
| 3,752,974 | 8/1973 | Baker et al. | 240/1 |
| 3,832,028 | 8/1974 | Kapron | 385/43 |
| 3,980,392 | 9/1976 | Aunacher | 385/43 |
| 4,059,916 | 11/1977 | Tachihara et al. | 40/130 |
| 4,111,538 | 9/1978 | Sheridon | 353/122 |
| 4,114,592 | 9/1978 | Winston | 126/270 |
| 4,161,015 | 7/1979 | Dey et al. | 362/263 |
| 4,176,908 | 12/1979 | Wagner | 350/96.15 |
| 4,212,048 | 7/1980 | Castleberry | 362/19 |
| 4,240,692 | 12/1980 | Winston | 350/96.10 |
| 4,257,084 | 3/1981 | Reynolds | 362/31 |
| 4,277,817 | 7/1981 | Hehr | 362/31 |
| 4,323,951 | 4/1982 | Pasco | 362/27 |
| 4,373,282 | 2/1983 | Wragg | 40/546 |
| 4,420,796 | 12/1983 | Mori | 362/32 |
| 4,453,200 | 6/1984 | Troka et al. | 362/31 |
| 4,528,617 | 7/1985 | Blackington | 362/32 |
| 4,547,043 | 10/1985 | Penz | 362/32 |
| 4,573,766 | 3/1986 | Bournsy, Jr. et al. | 350/345 |
| 4,618,216 | 10/1986 | Suzawa | 359/49 |
| 4,648,690 | 3/1987 | Obe | 350/321 |

OTHER PUBLICATIONS

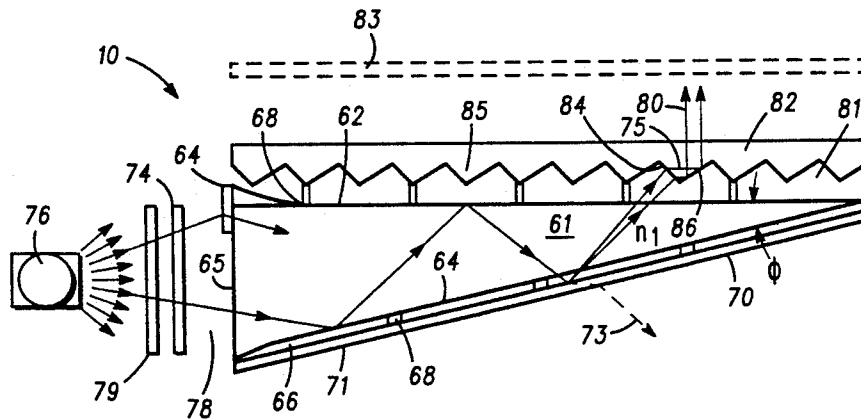
- "Flat Panel Backlight Reflecting Device," R. L. Garwin and R. T. Hodgson, *IBM Technical Disclosure Bulletin*, vol. 31, No. 2, Jul. 1988, pp. 190-191.
- "Dielectric Totally Internally Reflecting Concentrators" Xisohui, Ming, Roland Winston and Joseph O'Gallagher, *Applied Optics*, vol. 26, Jan. 15, 1987, pp. 300-305.

Primary Examiner—John D. Lee
Assistant Examiner—Phan Thi Heartney
Attorney, Agent, or Firm—Reinhart, Boerner, Van Deuren, Norris & Rieselbach

[57] ABSTRACT

An optical device for collecting light and selectively outputting or concentrating the light. A wedge layer has an optical index of refraction n_1 , and top, bottom and side surfaces intersecting to define an angle of inclination d . A back surface spans the top, bottom and side surface. A first layer is coupled to the bottom surface of the layer and has an index of refraction n_2 . The first layer index n_2 causes light input through the back surface of the layer to be preferentially output into the first layer. A second layer is coupled to the bottom of the first layer and selectively causes output of light into ambient. Additional layers, such as an air gap, can be provided adjacent to the wedge shaped layer. The wedge shaped layer can also have a variable index of refraction $n(x,y,z)$.

69 Claims, 23 Drawing Sheets



U.S. PATENT DOCUMENTS

| | | | |
|-----------|---------|-------------------|-----------|
| 4,838,661 | 6/1989 | McKee et al. | 350/345 |
| 4,842,378 | 6/1989 | Flasck et al. | 350/345 |
| 4,907,044 | 3/1990 | Schellborn et al. | 357/17 |
| 4,907,132 | 3/1990 | Parker | 362/32 |
| 4,914,553 | 4/1990 | Hamada et al. | 362/321 |
| 4,915,479 | 4/1990 | Clarke | 358/345 |
| 4,936,659 | 6/1990 | Anderson et al. | 359/49 |
| 4,950,059 | 8/1990 | Roberts | 362/32 |
| 4,958,915 | 9/1990 | Okada et al. | 350/345 |
| 4,965,876 | 10/1990 | Foldi et al. | 362/247 |
| 4,974,122 | 11/1990 | Shaw | 362/31 |
| 4,974,353 | 12/1990 | Norfolk | 40/447 |
| 4,985,809 | 1/1991 | Matsui et al. | 362/31 |
| 4,989,933 | 2/1991 | Duguay | 350/96.10 |
| 4,992,916 | 2/1991 | Henkes | 362/255 |
| 4,998,188 | 3/1991 | Degelmann | 362/147 |
| 5,019,808 | 5/1991 | Prince et al. | 340/765 |
| 5,039,207 | 8/1991 | Green | 359/49 |
| 5,040,098 | 8/1991 | Tanaka et al. | 362/31 |
| 5,040,878 | 8/1991 | Eichenlaub | 350/345 |
| 5,044,734 | 9/1991 | Sperl et al. | 359/49 |
| 5,046,805 | 9/1991 | Simon | 385/31 |

| | | | |
|-----------|---------|------------------|------------|
| 5,046,829 | 9/1991 | Worp | 359/49 |
| 5,050,946 | 9/1991 | Hathaway et al. | 385/33 |
| 5,051,551 | 9/1991 | Doyle | 250/341 |
| 5,053,765 | 10/1991 | Sonehara et al. | 340/815.31 |
| 5,083,120 | 1/1992 | Nelson | 340/784 |
| 5,101,325 | 3/1992 | Davenport et al. | 362/31 |
| 5,128,783 | 7/1992 | Abileah et al. | 359/49 |
| 5,128,787 | 7/1992 | Blonder | 359/70 |
| 5,128,846 | 7/1992 | Mills et al. | 362/224 |

OTHER PUBLICATIONS

"Optics of Two-Stage Photovoltaic Concentrators with Dielectric Second Stages", Xisohul, Ning, Roland Winston and Joseph O'Gallagher, *Applied Optics*, vol. 26, Apr. 1, 1987, pp. 1207-1212.

"New Backlighting Technologies for LCDs", Hathaway et al., *Society for Information Display Digest*, vol. 22, May 1991, pp. 751-754. "Parts that Glow", A. Bhumenfeld and S. Jones, *Machine Design*, Jul. 1985, pp. 1-11. "Directional Diffuser Lens Array for Backlit LCDs", R. I. McCartney and D. Syroid, *Japan Display*, pp. 259-262 (1992).

Fig. 1

— PRIOR ART —

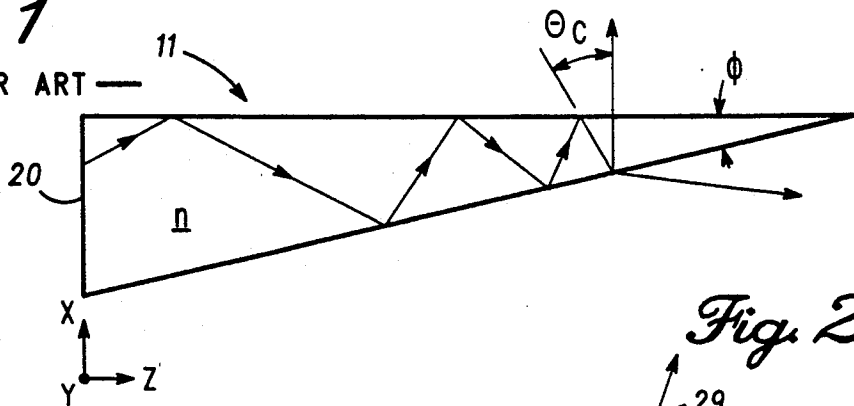


Fig. 2A

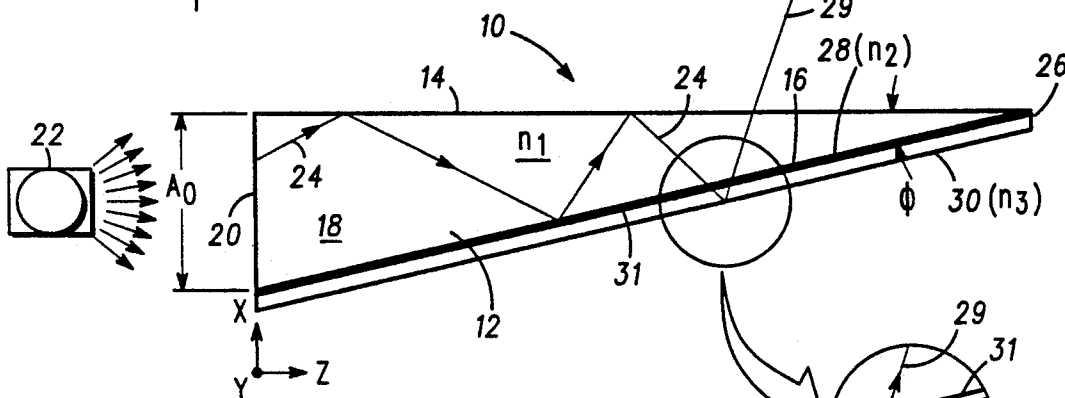


Fig. 2B

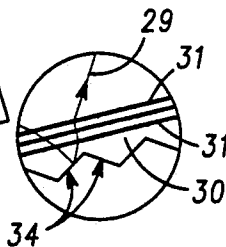


Fig. 2C

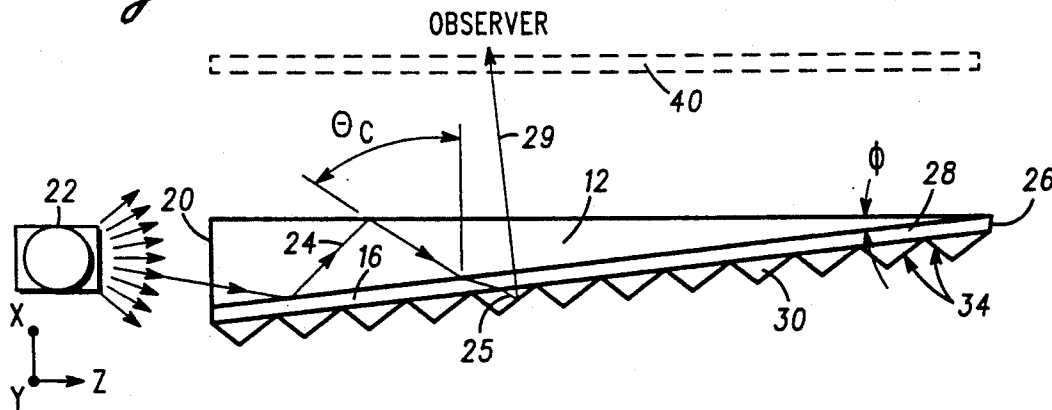
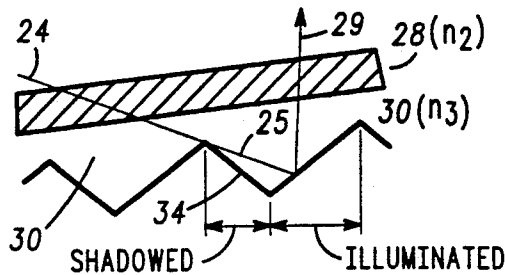


Fig. 2D



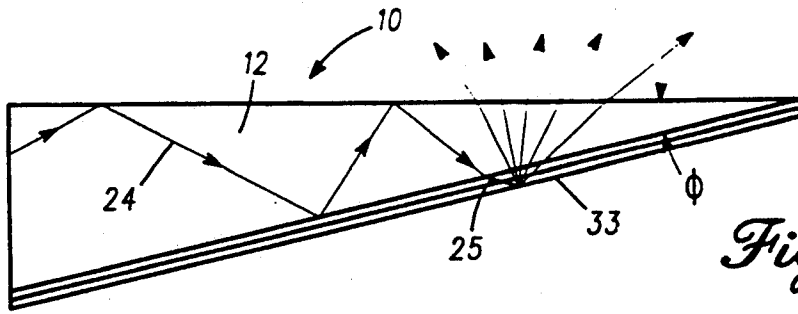


Fig. 2E

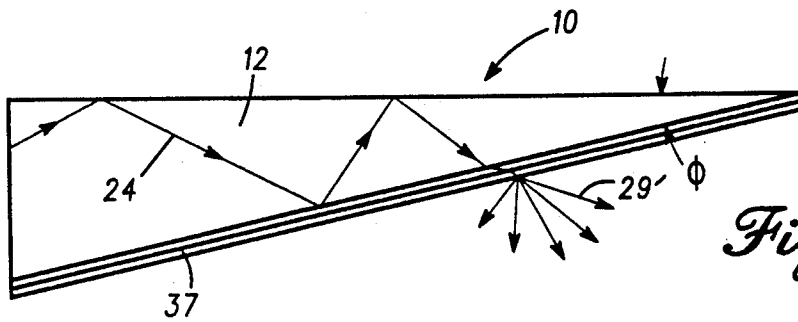


Fig. 2F

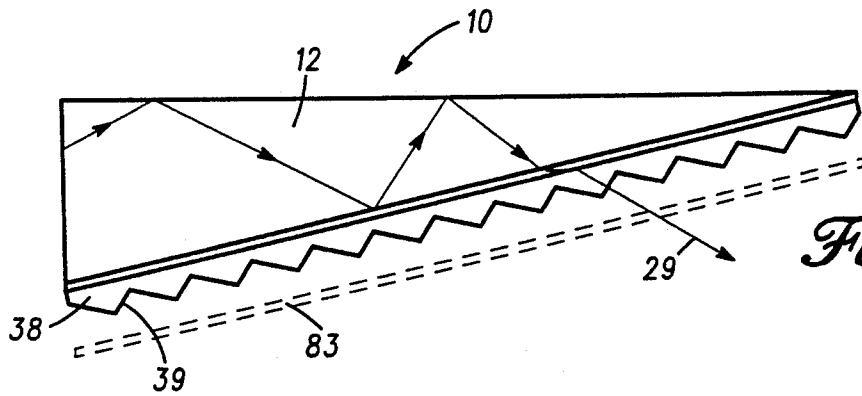


Fig. 2G

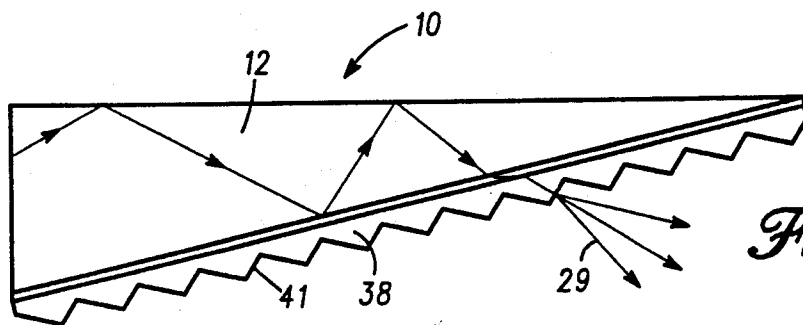


Fig. 2H

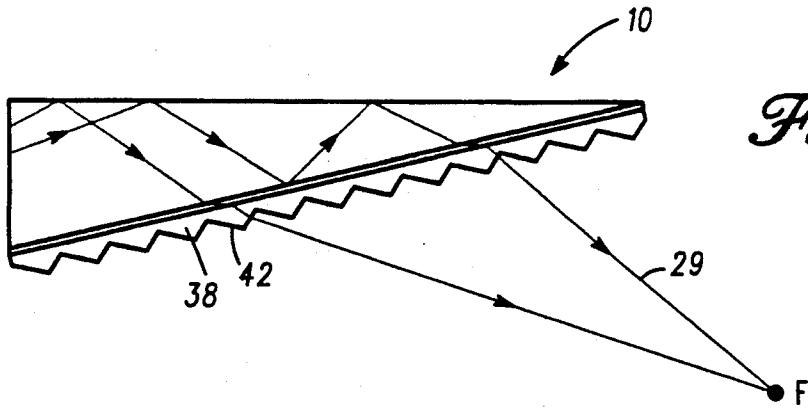


Fig. 2I

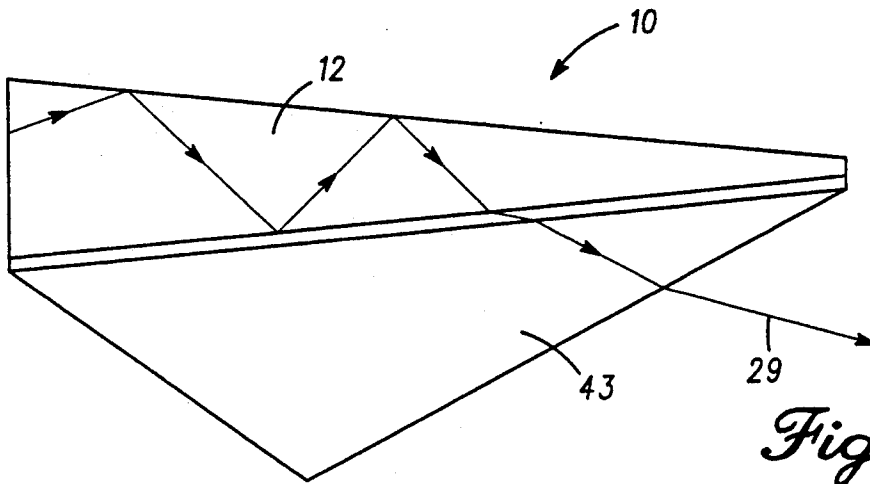


Fig. 2J

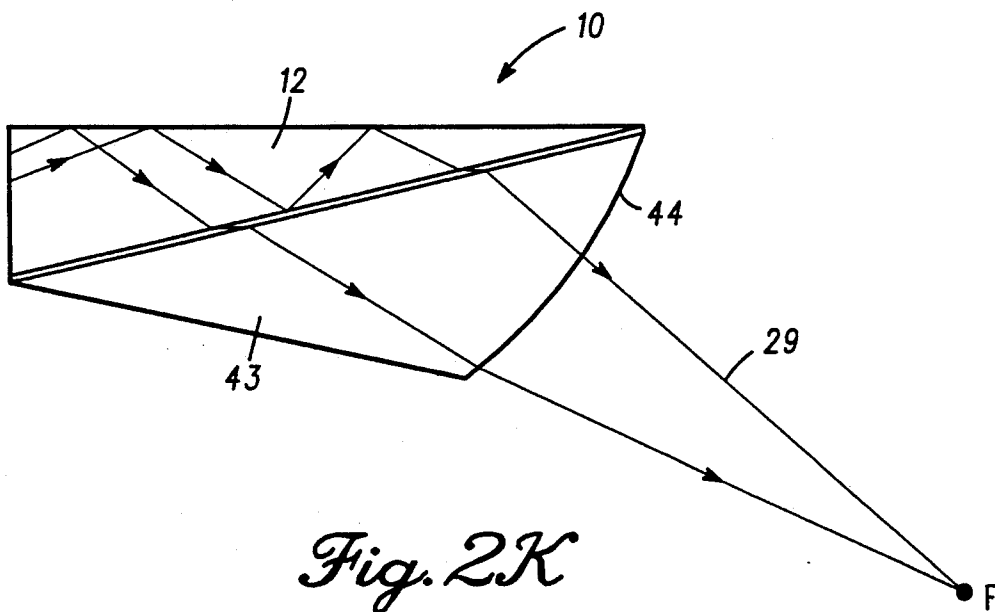


Fig. 2K

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.