

United States Patent [19]**Takeuchi et al.**[11] **Patent Number:** **5,944,405**[45] **Date of Patent:** ***Aug. 31, 1999**[54] **FLAT LIGHT SOURCE USING LIGHT-DIFFUSING SHEET WITH PROJECTIONS THEREON**[75] Inventors: **Michiko Takeuchi; Toshikazu Nishio; Taiji Ishii**, all of Tokyo-To, Japan[73] Assignee: **Dai Nippon Printing Co., Ltd.**, Japan

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: **08/619,623**[22] PCT Filed: **Aug. 11, 1995**[86] PCT No.: **PCT/JP95/01608**§ 371 Date: **May 30, 1996**§ 102(e) Date: **May 30, 1996**[87] PCT Pub. No.: **WO96/05466**PCT Pub. Date: **Feb. 22, 1996**[30] **Foreign Application Priority Data**

Aug. 12, 1994 [JP] Japan 6-210694

[51] Int. Cl.⁶ **F21V 7/04**[52] U.S. Cl. **362/31; 362/551**

[58] Field of Search 362/26, 31, 551

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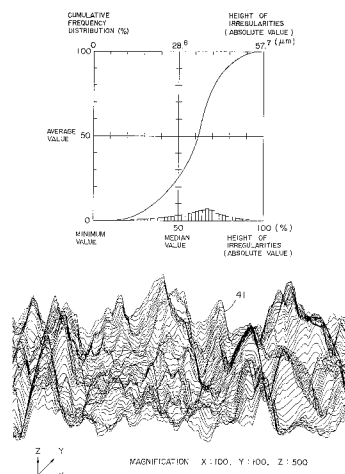
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Primary Examiner—Sandra O'Shea*Assistant Examiner*—Marshall Honeyman*Attorney, Agent, or Firm*—Parkhurst & Wendel LLP[57] **ABSTRACT**

A flat light source used as back-lighting for a liquid crystal display device includes an optically conductive plate (1) having a light reflecting layer (2), and a light source (3). A light-diffusing sheet (8) is provided outside the optically conductive plate (1) opposite to the light reflecting layer (2). A lens sheet (4) is provided outside the light-diffusing sheet (8), with a transmission type of display element (6) provided on the outer side of the lens sheet (4). The light-diffusing sheet (8) is formed of a transparent material free from light-diffusing agent particles and has minute irregularities (41) formed at random on the front surface thereof. The irregularities are of a surface roughness that is at least the wavelength of the light from the light source, but is no more than 100 μm . When the percentage of the cumulative frequency distribution of the heights of the minute irregularities are plotted along the Y-axis and the heights of these minute irregularities are plotted along the X-axis, the cumulative frequency distribution curve has a convex portion oriented towards the lower side of the coordinates and the average value of the heights of the minute irregularities is greater than the median value thereof. Thus, a flat light source is provided which emits highly luminant light uniformly within a predetermined angular range, and which has no local differences in intensity over the surface thereof.

11 Claims, 20 Drawing Sheets

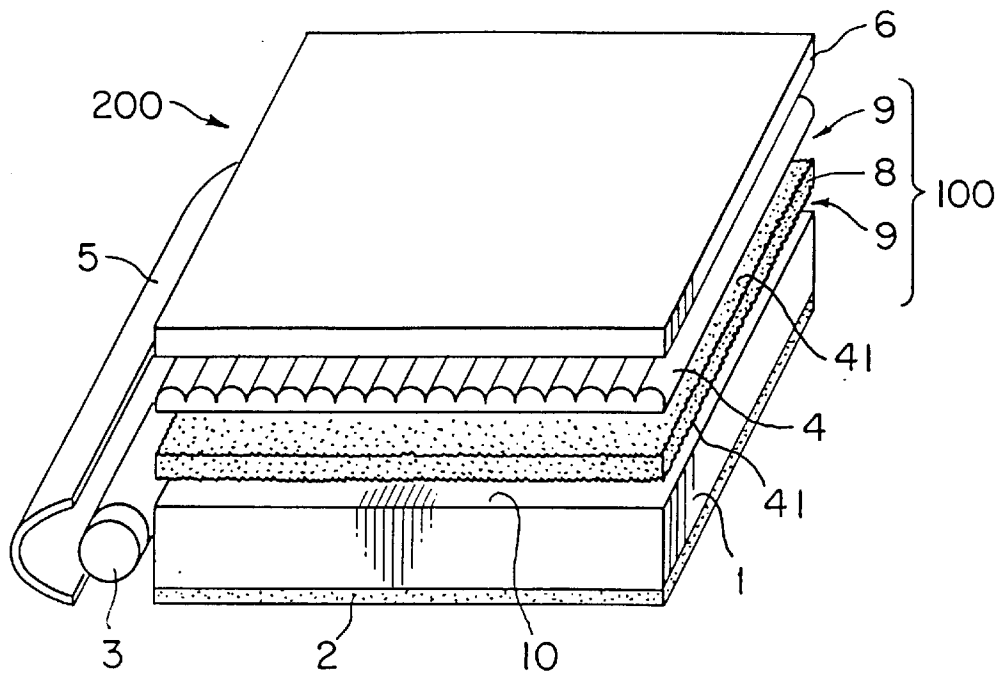


FIG. 1

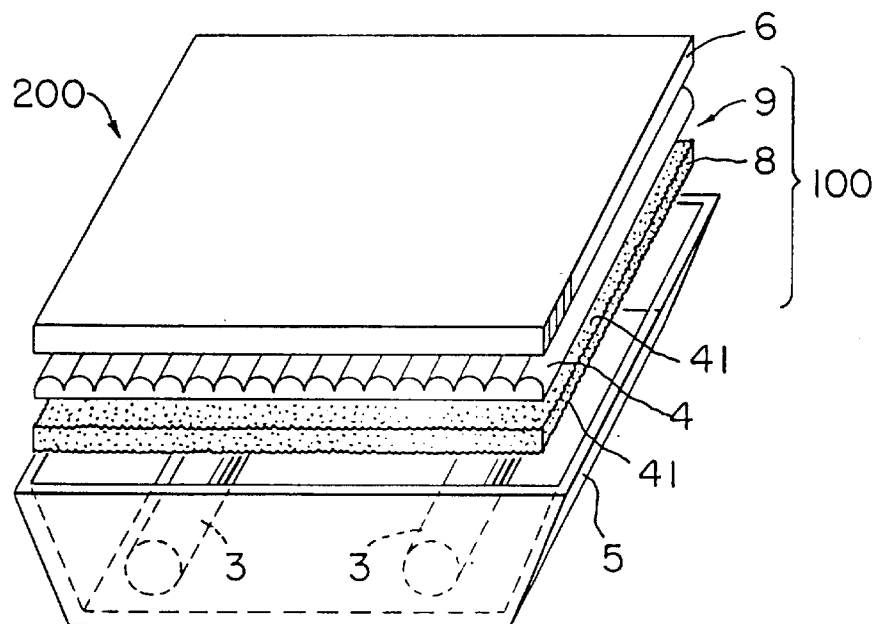


FIG. 2

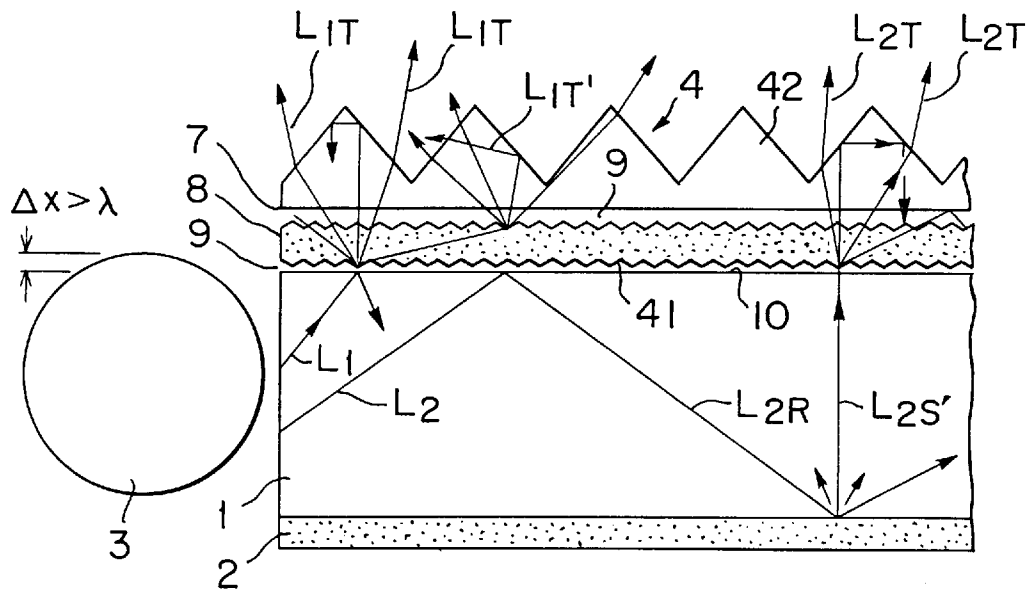


FIG. 3

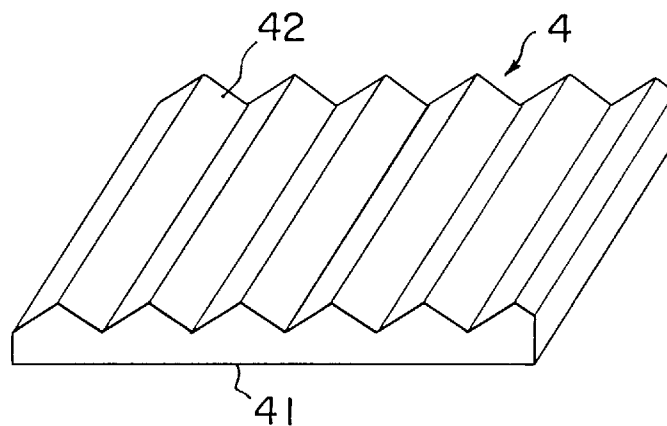


FIG. 4

FIG. 5

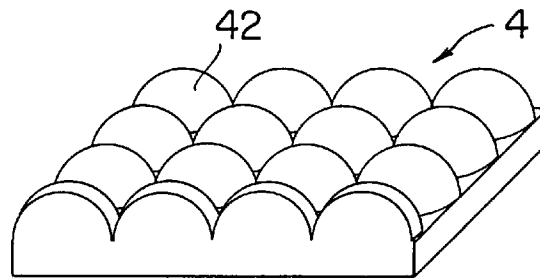


FIG. 6

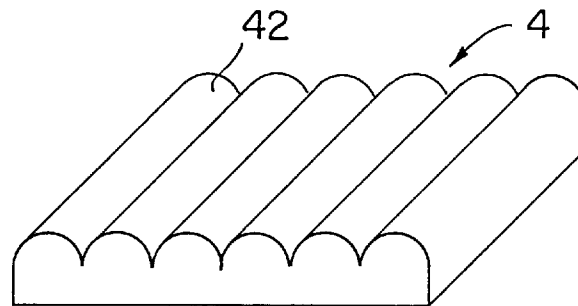


FIG. 7

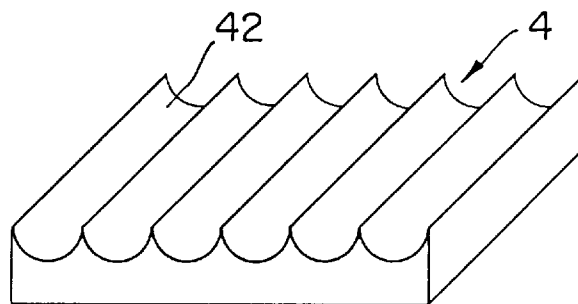
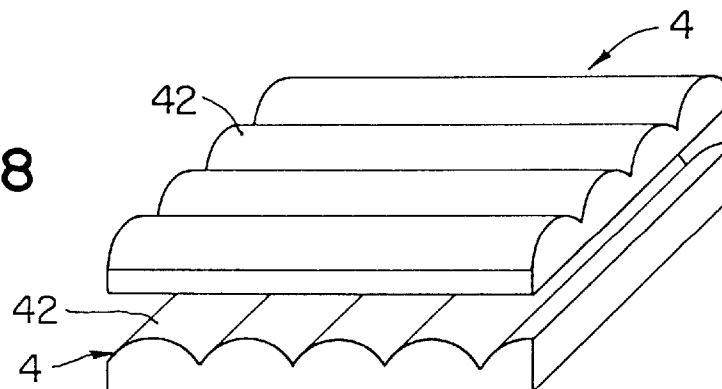


FIG. 8



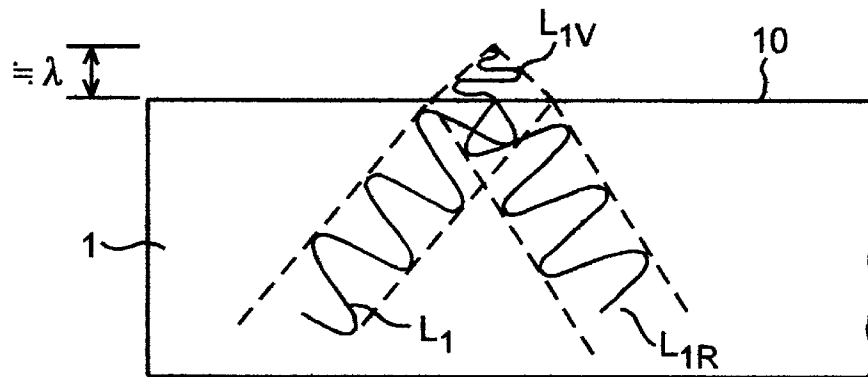


FIG. 9

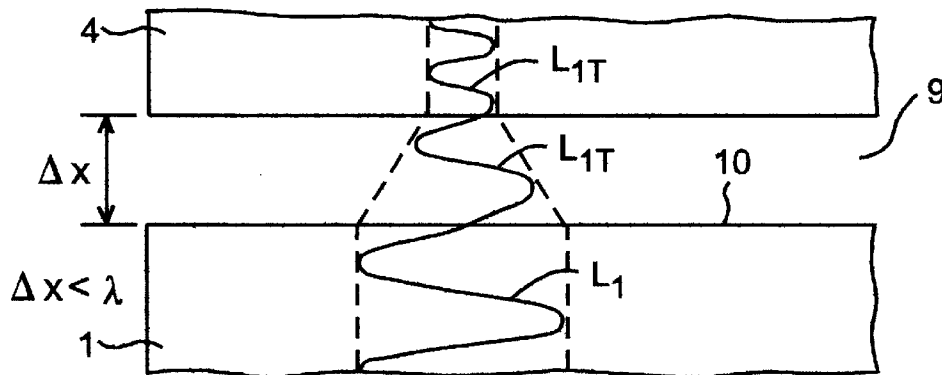


FIG. 10

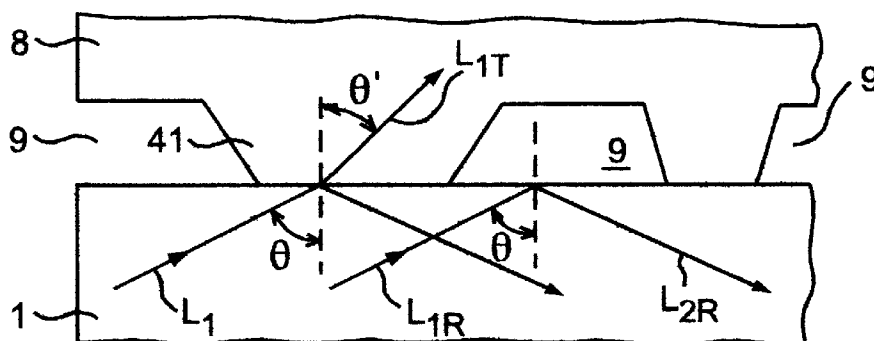


FIG. 11

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