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

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(54) **LIGHT SOURCE USING EMITTING PARTICLES TO PROVIDE VISIBLE LIGHT**

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 301 days.

(21) Appl. No.: **10/606,551**

(22) Filed: **Jun. 26, 2003**

**Related U.S. Application Data**

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(51) **Int. Cl.**  
**H01J 1/62** (2006.01)  
**H05B 33/00** (2006.01)

(52) **U.S. Cl.** ..... **313/512**; 445/23

(58) **Field of Classification Search** ..... 313/512;  
257/98-100, 103

See application file for complete search history.

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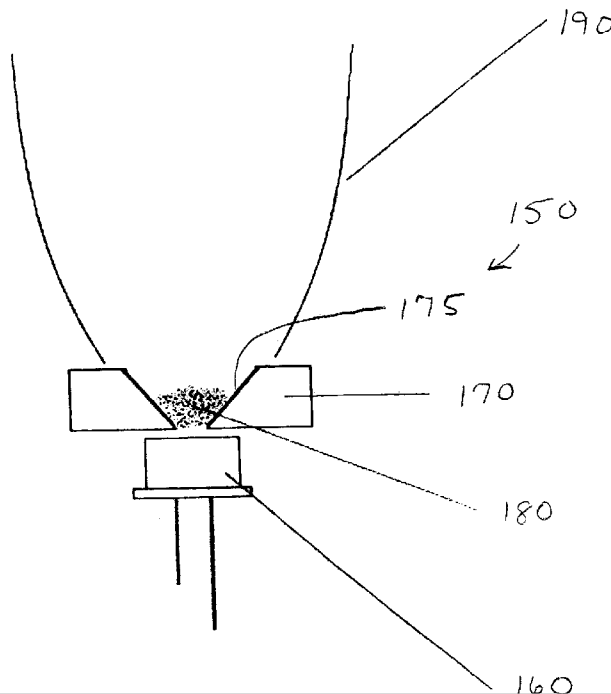
*Primary Examiner*—Joseph Williams

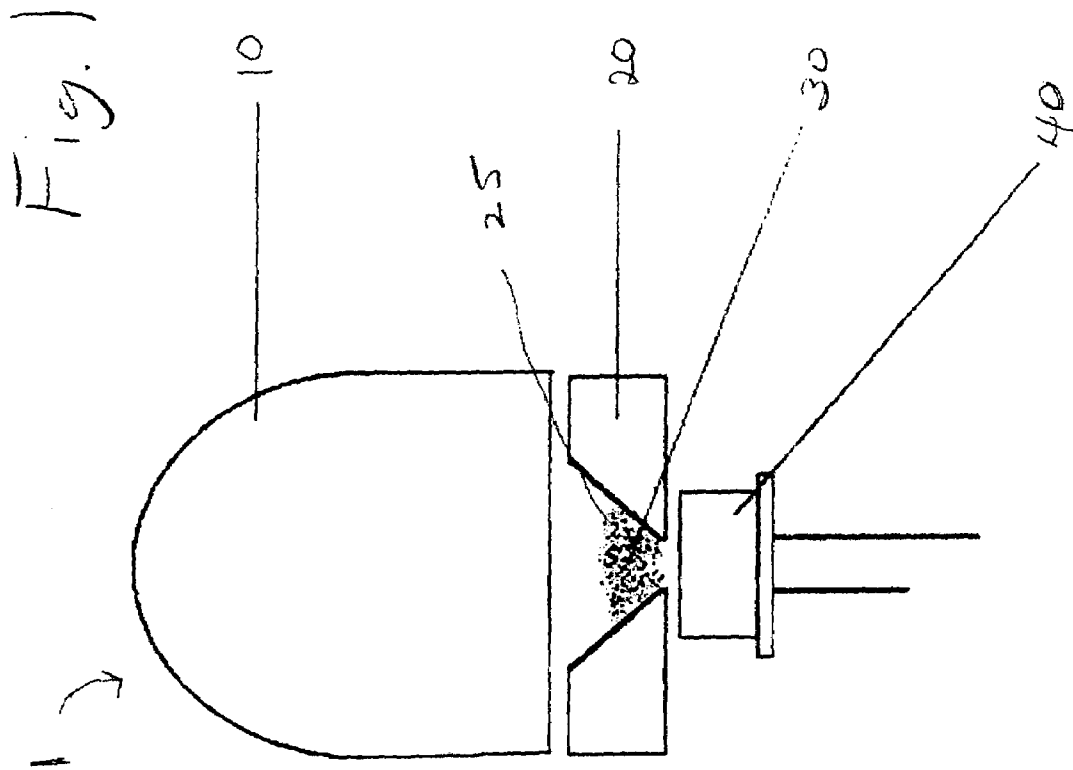
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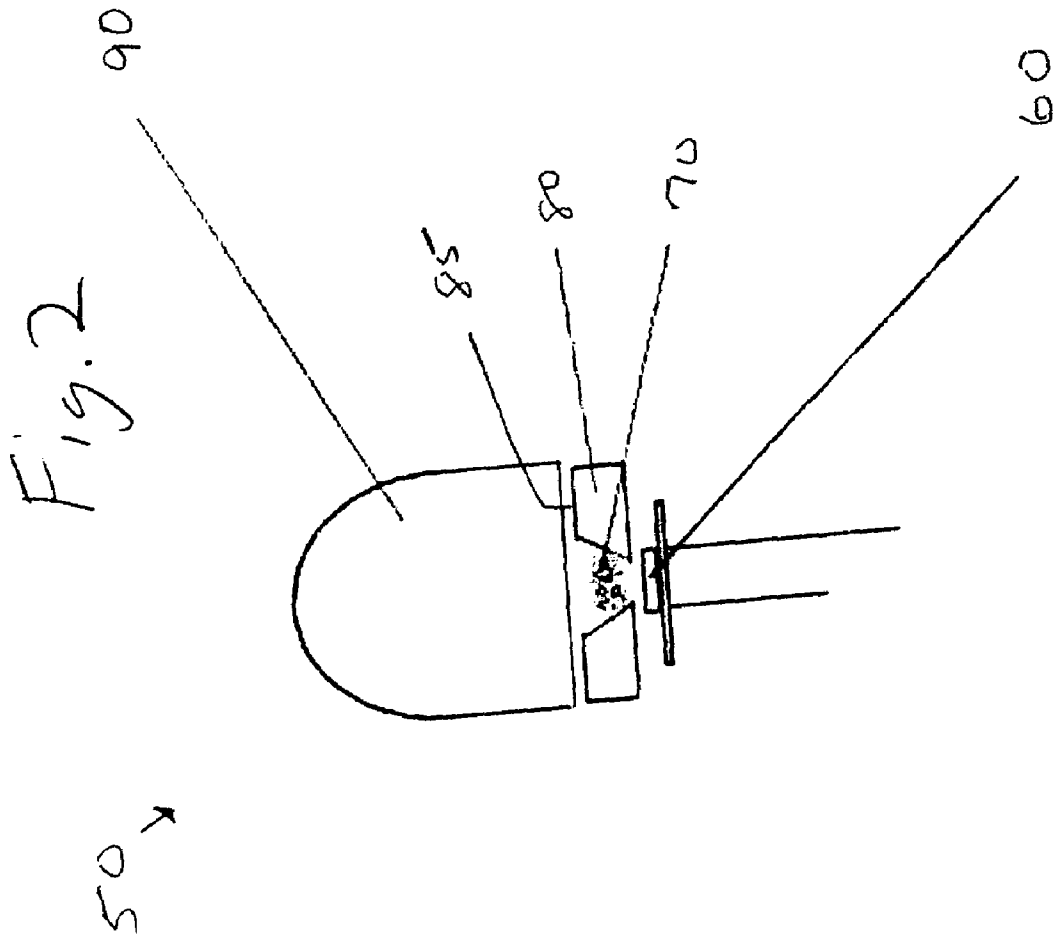
(57) **ABSTRACT**

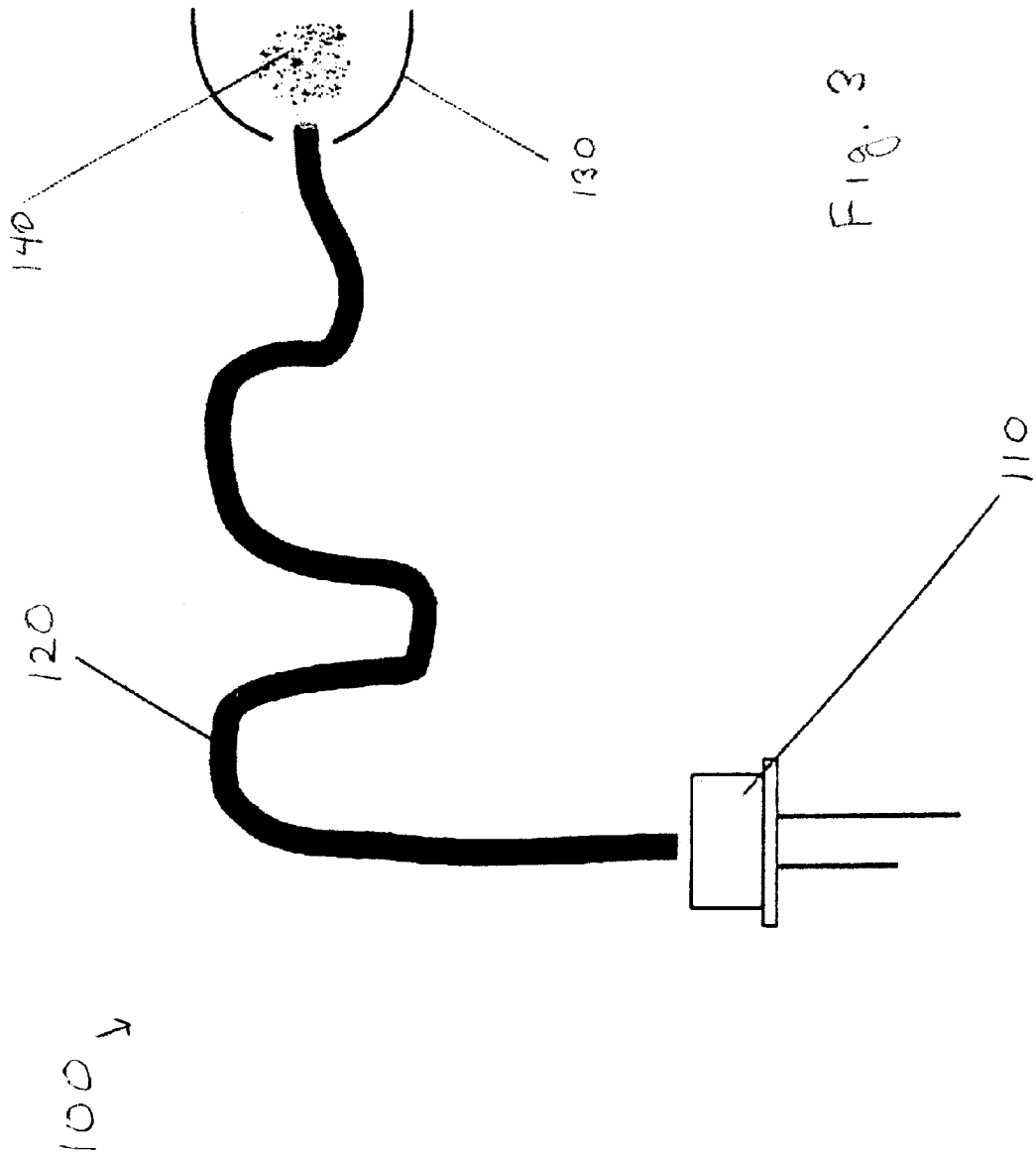
Upconversion methods and devices that converts near-infrared light to the visible spectrum using a rare-earth-doped crystalline host for use as general and decorative lighting. The pseudo-monochromatic output of the processes can be specified by altering the amount and type of rare-earth material used and by selection of an appropriate host. Using rare-earth materials such as ytterbium-erbium or ytterbium-thulium can produce red, green and blue emissions, where the additive mixture of these colors yields a high-quality white light. The materials can be adjusted to achieve white light with any color temperature and high color-rendering index (CRI) for any general and decorative lighting applications both indoors and outdoors.

**29 Claims, 11 Drawing Sheets**









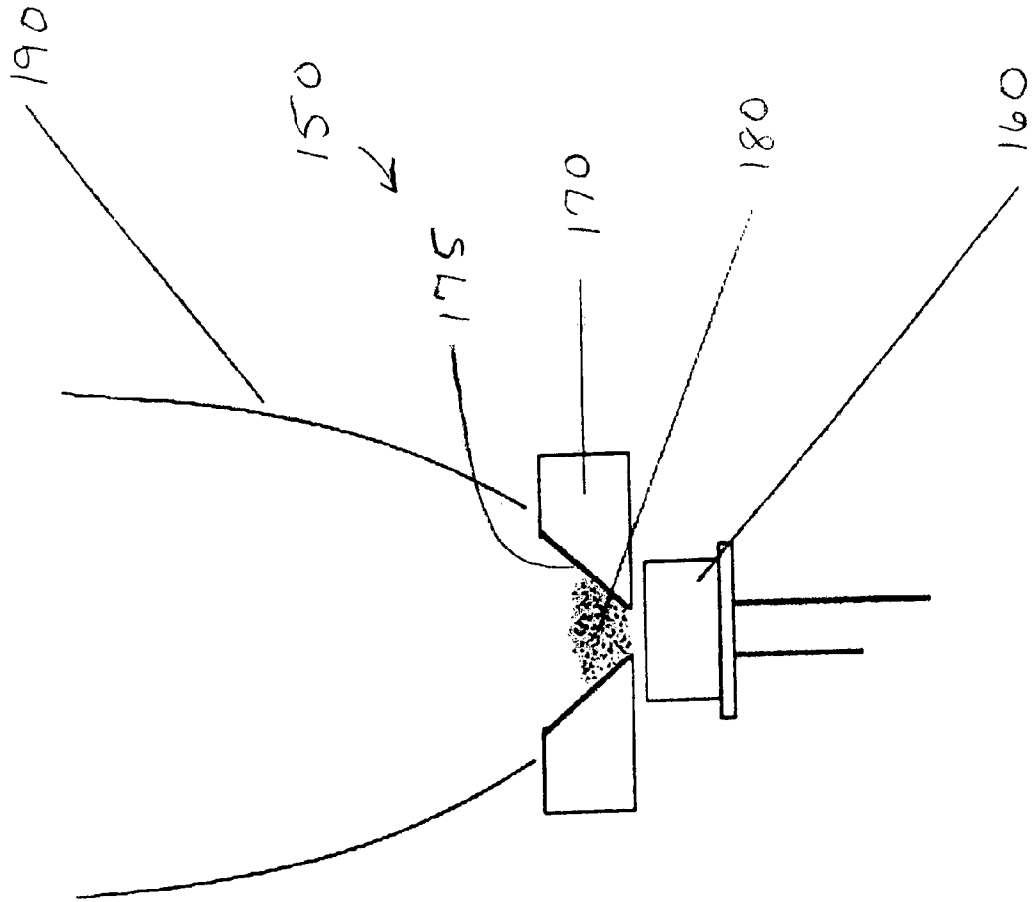


Fig. 4

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