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**Lehman et al.**

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(54) **NON-ATTENUATING METER FOR DETERMINING OPTICAL ENERGY OF LASER LIGHT**

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(58) **Field of Classification Search**  
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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,260,255 A \* 4/1981 Wachs ..... G01J 1/4257 356/222  
4,916,319 A \* 4/1990 Telfair ..... G01J 1/4257 250/365

(Continued)

OTHER PUBLICATIONS

Williams, P., et al., "Portable, high-accuracy, non-absorbing laser power measurement at kilowatt levels by means of radiation pressure", *Optics Express*, 2017, p. 4382-4392, vol. 25 No. 4.

(Continued)

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(57) **ABSTRACT**

A non-attenuating meter determines optical energy of laser light in an absence of optical attenuation of the laser light and includes: a recipient mirror that: receives laser light that propagates in a primary propagation direction; produces profile light; transmits the profile light through the recipient mirror along the primary propagation direction; produces first reflected light from the laser light; and reflects the first reflected light along a secondary propagation direction; a profilometer in optical communication with the recipient mirror and that: receives the profile light from the recipient mirror along the primary propagation direction; and produces a profile signal from the profile light; a sensor mirror in optical communication with the recipient mirror and a passer mirror and that: receives the first reflected light from the recipient mirror along the secondary propagation direction; produces, in a tertiary direction, a sensor force from the first reflected light; communicates the sensor force to a force sensor along the tertiary direction; produces a second reflected light from the first reflected light; and reflects the second reflected light in a tertiary propagation direction; the passer mirror in optical communication with the sensor mirror and that: receives, along the tertiary propagation

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