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(54) **MULTI-LAMP SOLAR SIMULATOR**

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CPC ***F21S 8/006*** (2013.01); ***H05B 37/0218*** (2013.01); *Y02B 20/46* (2013.01)

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USPC 362/1, 2
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,789,989	A	12/1988	Stern et al.	
5,217,285	A *	6/1993	Sopori	362/1
8,016,439	B2	9/2011	Igari	
8,198,821	B2	6/2012	Shimotomai et al.	
8,378,661	B1	2/2013	Cravey	
2007/0206901	A1	9/2007	Bonitatibus et al.	
2012/0206913	A1	8/2012	Jungwirth et al.	

FOREIGN PATENT DOCUMENTS

DE 11 2011 100041 6/2012

OTHER PUBLICATIONS

Extended European Search Report, EP 14 15 5951 (Jul. 16, 2015).

* cited by examiner

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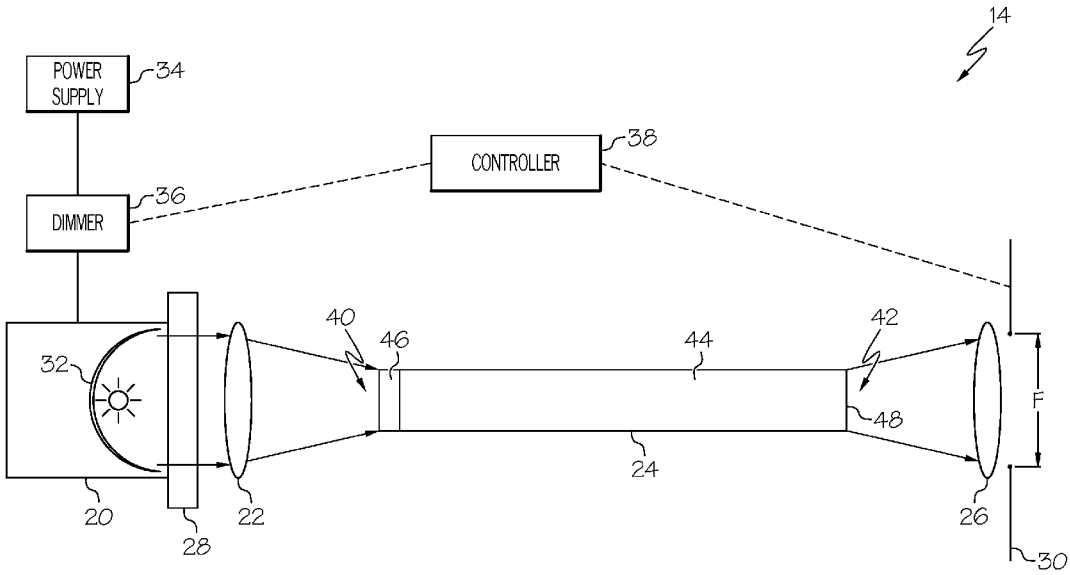
(57) **ABSTRACT**

A solar simulator including an array of lamp modules, wherein each lamp module of the array includes a lamp configured to generate light, a homogenizer having an input end and an output end, a beam divergence lens positioned to focus the light onto the input end of the homogenizer, and an imaging lens positioned to receive the light from the output end of the homogenizer and image the light onto a target plane.

18 Claims, 5 Drawing Sheets