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(12) **United States Patent**
Smith

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(54) **LIGHT SOURCE FOR GENERATING LIGHT FROM A LASER SUSTAINED PLASMA IN A ABOVE-ATMOSPHERIC PRESSURE CHAMBER**

USPC 250/504 R
See application file for complete search history.

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Related U.S. Application Data

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(Continued)

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G01J 3/10 (2006.01)
G21K 5/04 (2006.01)

(52) **U.S. Cl.**
CPC **G21K 5/04** (2013.01)
USPC **250/504 R**

(58) **Field of Classification Search**
CPC H01J 5/00; H01J 61/62; H01J 15/00;
H01J 15/02; H05G 2/00

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,826,996	A	7/1974	Jaegle et al.
4,088,966	A	5/1978	Samis
4,152,625	A	5/1979	Conrad
4,179,566	A	12/1979	Nadelson
4,498,029	A	2/1985	Yoshizawa et al.
4,646,215	A	2/1987	Levin et al.
RE32,626	E	3/1988	Yoshizawa et al.

(Continued)

FOREIGN PATENT DOCUMENTS

JP	61 193358	8/1986
JP	1-296560	11/1989

(Continued)

OTHER PUBLICATIONS

Beck, "Simple Pulse Generator for Pulsing Xenon Arcs with High Repetition Rate," *Rev. Sci. Instrum.*, vol. 45, No. 2, Feb. 1974, pp. 318-319.

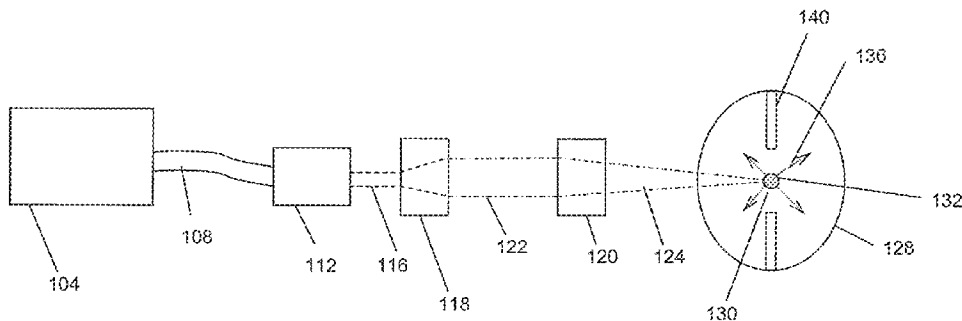
(Continued)

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(57) **ABSTRACT**

An apparatus for producing light includes a chamber and an ignition source that ionizes a gas within the chamber. The apparatus also includes at least one laser that provides energy to the ionized gas within the chamber to produce a high brightness light. The laser can provide a substantially continuous amount of energy to the ionized gas to generate a substantially continuous high brightness light.

30 Claims, 39 Drawing Sheets



Related U.S. Application Data

application No. 12/166,918, filed on Jul. 2, 2008, now Pat. No. 7,989,786, which is a continuation-in-part of application No. 11/695,348, filed on Apr. 2, 2007, now Pat. No. 7,786,455, which is a continuation-in-part of application No. 11/395,523, filed on Mar. 31, 2006, now Pat. No. 7,435,982.

(60) Provisional application No. 61/302,797, filed on Feb. 9, 2010.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,780,608	A *	10/1988	Cross et al.	250/281
4,789,788	A	12/1988	Cox	
4,868,458	A	9/1989	Davenport et al.	
5,801,495	A	9/1998	Smolka et al.	
6,184,517	B1	2/2001	Sawada	
6,288,780	B1	9/2001	Fairley et al.	
6,417,625	B1	7/2002	Brooks et al.	
6,541,924	B1 *	4/2003	Kane et al.	315/246
6,788,404	B2	9/2004	Lange	
6,956,329	B2	10/2005	Brooks et al.	
7,050,149	B2	5/2006	Owa et al.	
7,427,167	B2	9/2008	Holder et al.	
7,429,818	B2	9/2008	Chang et al.	
7,652,430	B1	1/2010	Delgado	
2002/0021508	A1	2/2002	Ishihara	
2002/0044629	A1	4/2002	Hertz et al.	
2002/0080834	A1	6/2002	Kusunose	
2002/0172235	A1	11/2002	Chang et al.	
2003/0052609	A1 *	3/2003	Eastlund et al.	313/634
2003/0068012	A1	4/2003	Ahmad et al.	
2003/0147499	A1 *	8/2003	Kondo	378/119
2003/0168982	A1	9/2003	Kim	
2003/0231496	A1	12/2003	Sato et al.	
2004/0016894	A1	1/2004	Wester	
2004/0026512	A1	2/2004	Otsubo	
2004/0129896	A1	7/2004	Schmidt et al.	
2004/0183038	A1	9/2004	Hiramoto et al.	
2004/0238762	A1	12/2004	Mizoguchi et al.	
2004/0264512	A1	12/2004	Hartlove et al.	
2005/0167618	A1	8/2005	Hoshino et al.	
2005/0199829	A1	9/2005	Partlo et al.	
2005/0205811	A1	9/2005	Partlo et al.	
2005/0243390	A1	11/2005	Tejnil	
2006/0039435	A1	2/2006	Cheyamol et al.	
2006/0131515	A1	6/2006	Partlo et al.	
2006/0152128	A1 *	7/2006	Manning	313/113
2006/0186356	A1	8/2006	Iami et al.	
2006/0192152	A1 *	8/2006	Ershov et al.	250/503.1
2006/0219957	A1 *	10/2006	Ershov et al.	250/504 R
2007/0228288	A1	10/2007	Smith	
2007/0228300	A1	10/2007	Smith	
2007/0285921	A1	12/2007	Zulim et al.	
2009/0032740	A1	2/2009	Smith et al.	

FOREIGN PATENT DOCUMENTS

JP	04-144053	5/1992
JP	05-82087	4/1993
JP	08-299951	11/1996
JP	09-288995	11/1997
JP	2006-10675	1/2006
JP	2006-080255	3/2006
WO	2010/093903	8/2010

OTHER PUBLICATIONS

Bussiahn, R., et. al., "Experimental and theoretical investigations of a low-pressure He-Xe discharge for lighting purpose," *Journal of Applied Physics*, vol. 95, No. 9, May 1, 2004, pp. 4627-4634.

Carlhoff et al., "Continuous Optical Discharges at Very High Pressure," *Physica* 103C, 1981, pp. 439-447.

Cremers et al., "Evaluation of the Continuous Optical Discharge for Spectrochemical Analysis," *Spectrochimica Acta*, vol. 40B, No. 4, 1985, pp. 665-679.

Fiedorowicz et al., "X-Ray Emission from Laser-Irradiated Gas Puff Targets," *Appl. Phys. Lett.* 62 (22), May 31, 1993, pp. 2778-2780.

Franzen, "CW Gas Breakdown in Argon Using 10.6- μ m Laser Radiation," *Appl. Phys. Lett.*, vol. 21, No. 2, Jul. 15, 1972, pp. 62-64.

Generalov et al., "Continuous Optical Discharge," *ZhETF Pis. Red.* 11, No. 9, May 5, 1970, pp. 302-304.

Generalov et al., "Experimental Investigation of a Continuous Optical Discharge," *Soviet Physics JETP*, vol. 34, No. 4, Apr. 1972, pp. 763-769.

Hamamatsu Product Information, "Super-Quiet Xenon Lamp Super-Quiet Mercury-Xenon Lamp," Nov. 2005, pp. 1-16.

Hecht, "Refraction," *Optics (Third Edition)*, 1998, Chapter 4, pp. 100-101.

Jeng et al., "Theoretical Investigation of Laser-Sustained Argon Plasmas," *J. Appl. Phys.* 60 (7), Oct. 1, 1986, pp. 2272-2279.

Keefer et al., "Experimental Study of a Laser-Sustained Air Plasma," *Journal of Applied Physics*, vol. 46, No. 3, Mar. 1975, pp. 1080-1083.

Keefer, "Laser-Sustained Plasmas," *Laser-Induced Plasmas and Applications*, published by Marcel Dekker, edited by Radziemski et al., 1989, pp. 169-206.

Kozlov et al., "Radiative Losses by Argon Plasma and the Emissive Model of a Continuous Optical Discharge," *Sov. Phys. JETP*, vol. 39, No. 3, Sep. 1974, pp. 463-468.

Kozlov et al., "Sustained Optical Discharges in Molecular Gases," *Sov. Phys. Tech. Phys.* 49(11), Nov. 1979, pp. 1283-1287.

Moody, "Maintenance of a Gas Breakdown in Argon Using 10.6- μ cw Radiation," *Journal of Applied Physics*, vol. 46, No. 6, Jun. 1975, pp. 2475-2482.

Nakr, "Radiometric Characterization of Ultrahigh Radiance Xenon Short-arc Discharge Lamps," *Applied Optics*, vol. 47, No. 2, Jan. 9, 2008, pp. 224-229.

Raizer, "Optical Discharges," *Sov. Phys. Usp.* 23(11), Nov. 1980, pp. 789-806.

Wilbers et al., "The Continuum Emission of an Arc Plasma," *J. Quant. Spectrosc. Radiat. Transfer*, vol. 45, No. 1, 1991, pp. 1-10.

Wilbers et al., "The VUV Emissivity of a High-Pressure Cascade Argon Arc from 125 to 200 nm," *J. Quant. Spectrosc. Radiat. Transfer*, vol. 46, 1991, pp. 299-308.

* cited by examiner

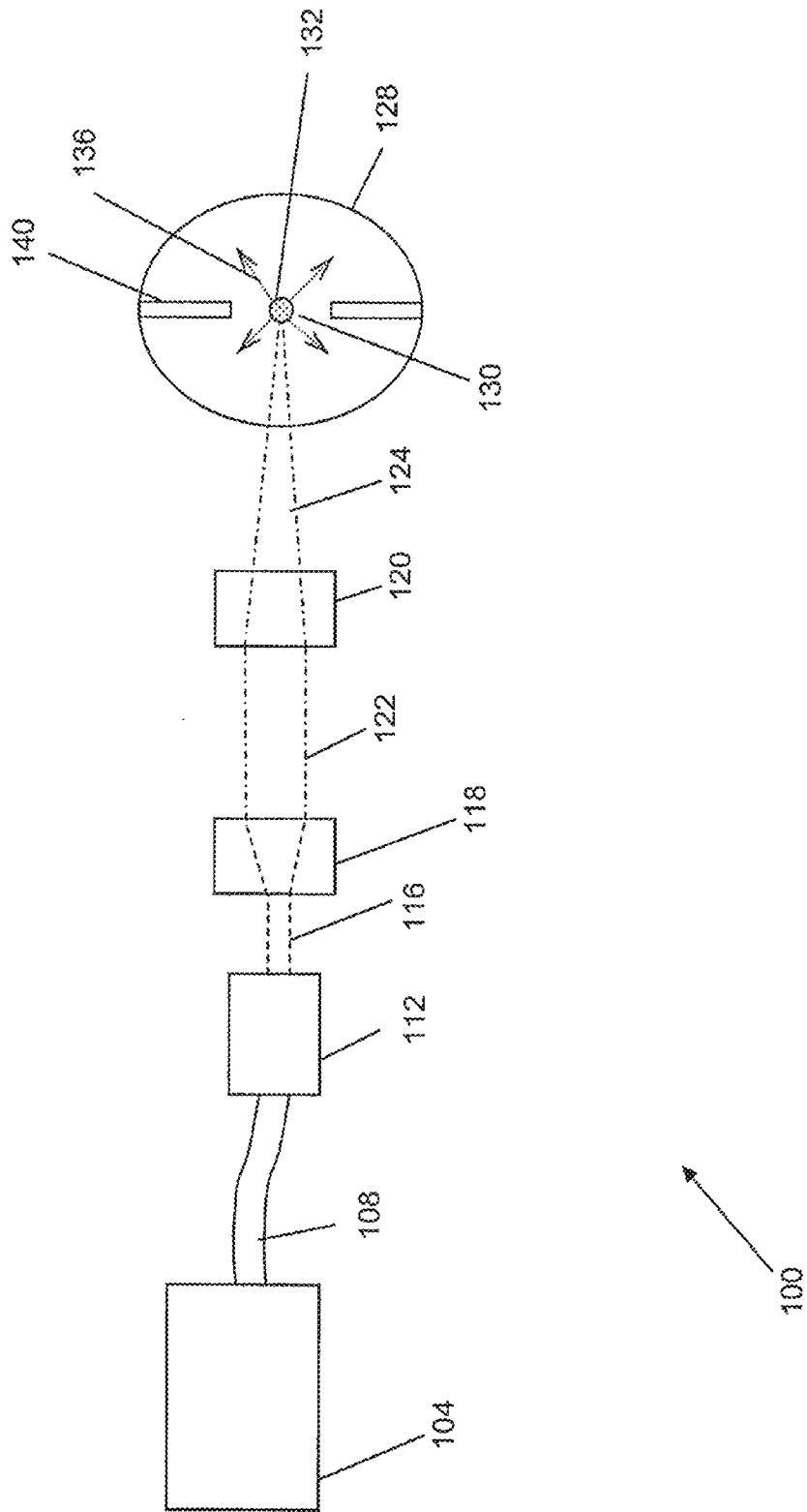


FIG. 1

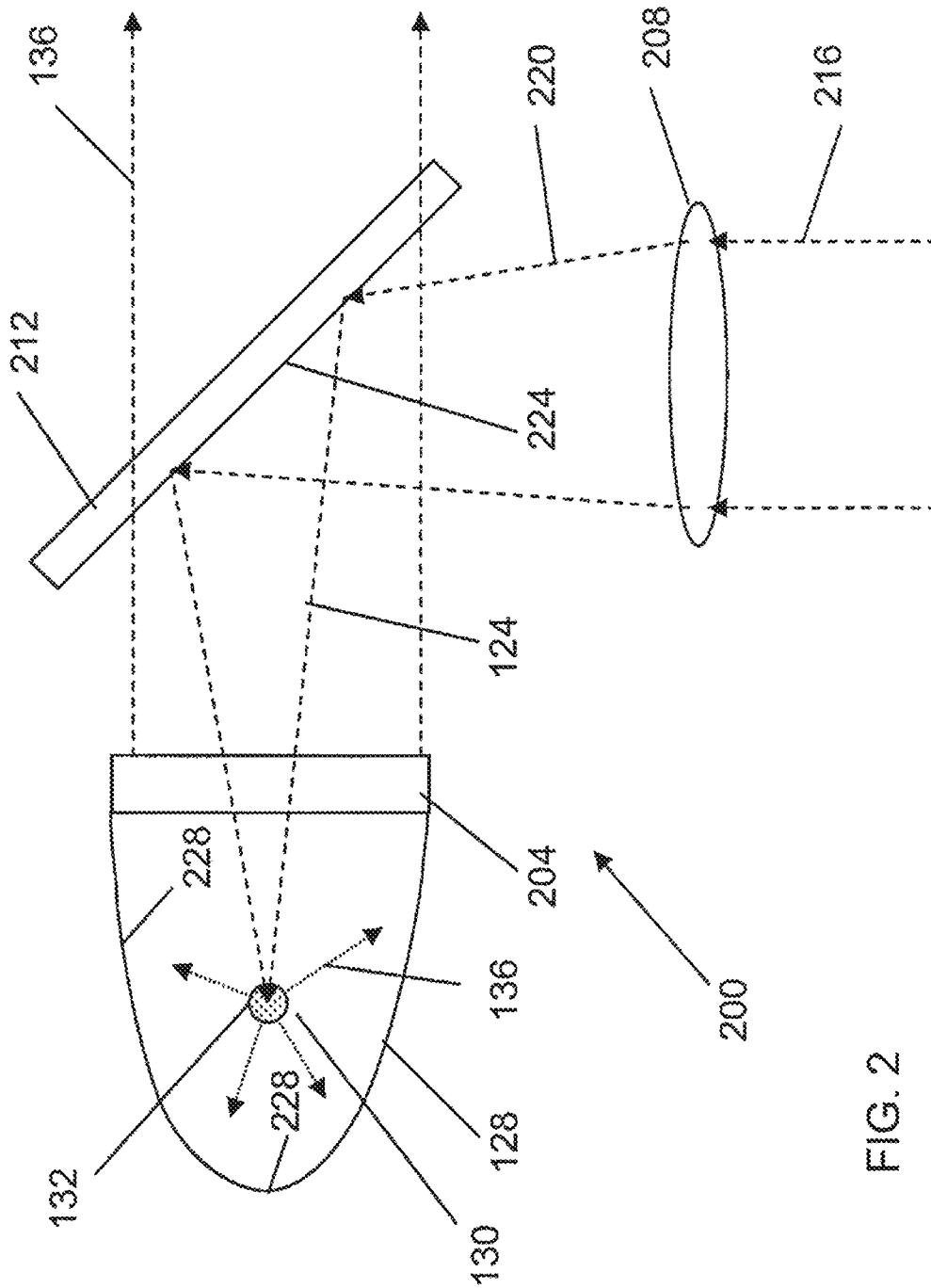


FIG. 2

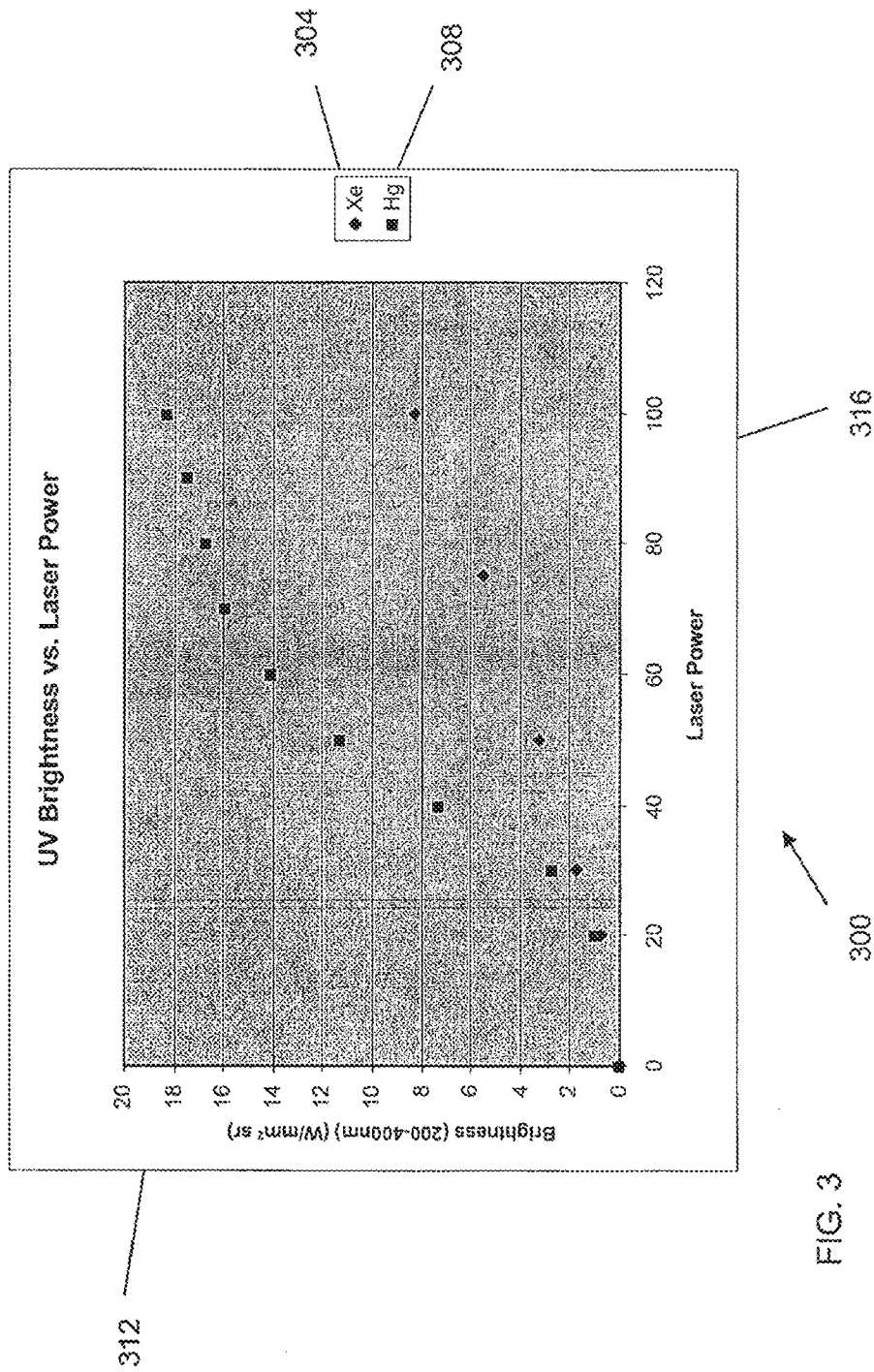


FIG. 3

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