光学 精密工程
OPTICS AND PRECISION ENGINEERING
核心期刊
主管：中国科学院
主办：中国科学院长春光学精密机械与物理研究所
中国仪器仪表学会
主编：曹健林

光学精密工程 2012, 20(9) 1883-1889 ISSN: 1004-924X CN: 22-1198/TH

现代应用光学

大画幅等待式转镜分幅相机系统设计

李剑, 汪伟, 肖正飞, 尚长水

中国工程物理研究院 流体物理研究所,四川 绵阳 621900

摘要： 采用共轴设计理论和控制离焦的方法,设计了画幅尺寸达30 mm×18 mm的大画幅等待式转镜分幅相机。该相机同时具备相对孔径大和分辨率高的特点,对底片的相对孔径为空间方向1/15,扫描方向1/35;静态目视分辨率为46 lp/mm,动态目视分辨率为35 lp/mm;总画幅数为80 ,摄影频率为1×10^4 ~5×10^5 frame/s。相机的高速转镜部件采用光纤传感器系统来产生和传输转速信号,避免了高速直流电机对转速信号的干扰,确保了测速准确度。研制的相机已应用于爆轰物理和冲击波物理实验中,并采用2×10^5 frame/s的拍摄频率对爆轰过程进行了试验记录,得到了高分辨率的图像。试验结果表明:设计的相机画幅尺寸大、空间分辨率高,适用于冲击、爆轰和弹体姿态等试验过程和目标的拍摄。

关键词： 高速摄影 高速相机 共轴设计 爆轰试验

Design of large frame and framing camera with continuous rotating mirror

LI Jian, WANG Wei, XIAO Zheng-fei, SHANG Chang-shui

Institute of Fluid Physics, China Academy of Engineering Physics, Mianyang 621900,China

Abstract: A large frame and framing camera with a continuous rotating mirror is developed under the coaxial imaging theory and a controlling defocusing range. With the frame size of 30 mm×18 mm, it shows a large relative aperture and higher resolution. Moreover, its big stops are 1/15 for the spatial direction and 1/35 for the scanning direction. The static visual resolution and dynamic visual resolution of the camera are 46 lp/mm and 35 lp/mm, respectively, and it can offer the number of frames of 80 and framing rate from 1×10^4 frame/s to 5×10^5 frame/s. Furthermore, the high speed rotation mirror in the camera uses a fiber sensor system to produce and transfer the rotation signals, which eliminates the influence of the electromagnetic disturbance from a high speed rotating electromotor on the rotation signals and ensures the measurement accuracy. The camera has been applied to the detonation and shock wave physics experiments and the experimental processing has been recorded at a framing rate of 2×10^5 frame/s. Obtained results demonstrate that the camera has larger frames and higher resolution and is suitable for the various experiments of shocking, detonation, projectile attitude and target photography.

Keywords: high speed photography high speed camera coaxial imaging design detonation experiment

收稿日期 2012-04-17 修回日期 2012-06-13 网络版发布日期

基金项目:

国家空间碎片专题研究资助项目(No.09203)

通讯作者: 李剑

作者简介: 李 剑 (1976-),男,河南新乡人,硕士,工程师,1999年于长春光学精密机械学院获得学士学位,2005年于四川大学获得硕士学位,主要从事高速摄影及光电测试技术方面的研究。E-mail:lijsana@sohu.com
作者Email: lijsana@sohu.com

参考文献：

[1] EUGENE A L, MANGE K. *Rotating Mirror Streak and Framing Cameras*[M]. Bellingham:SPIE Optical Engineering Press, 1997. [2] 李景镇. 超高速摄影的评价研究[J]. 光子学报,1999, 28 (Z1):82-88. LI J ZH. Assessing study of ultra high speed photography[J]. *Acta Photonica Sinica*, 1999, 28 (Z1): 82-88.(in Chinese) [3] 李景镇,龚向东,李善祥,等. Miller型超高速摄影系统经典设计理论的研究[J]. 光子学报,2004,33(6):739-742. LI J ZH, GONG X D, LI SH X, *et al*.. Study on classical designing theory of miller type ultra high speed photographic system [J]. *Acta Photonica Sinica*,2004,33(6):739-742.(in Chinese) [4] 李剑, 畅里华, 谭显详. FJZ-1000型超高速转镜分幅相机及应用[J]. 爆炸与冲击,2005,25(6):574-576. LI J, CHANG L H, TAN X X. Model 1000 ultra-high speed rotating mirror framing camera and applications[J]. *Explosion and Shock Waves*,2005,25(6):574-576.(in Chinese) [5] 谭显祥. 高速扫描相机时间测量不确定度分析[J]. 光子学报, 2002,31 (11):1387-1390. TAN X X. The uncertainty analysis of the measurement results of high speed rotating mirror streak camera [J]. *Acta Phtonica Sinca*, 2002,31 (11):1387-1390.(in Chinese) [6] 汪伟,谭显详. 转镜式高速相机扫描速度检测装置及不确定度评定[J]. 光学与光电技术, 2008, 6(5):76-79. WANG W, TAN X X. Test device and its uncertainty for writing rate of ultra-high speed rotating mirror streak camera[J]. *Optics & Optoel Ectronic Technology*, 2008, 6(5):76-79.(in Chinese) [7] 赵剑衡,谭显祥,孙承纬,等. 用高速阴影技术研究K9玻璃中的失效波[J]. 爆炸与冲击, 2001, 21(2):150-156. ZHAO J H, TAN X X, SUN CH W, *et al*.. Investigations of failure waves in K9 glass using shadowgraph [J]. *Explosion and Shockwaves*, 2001, 21(2):150-156.(in Chinese) [8] 畅里华,谭显祥,汪伟,等. 纹影技术用于爆轰与冲击波物理实验研究[J]. 激光与光电子学进展, 2006, 43(12):58-61. CHANG L H, TAN X X, WANG W, *et al*.. Schlieren techniques in experiments of shock wave and detonation physics[J]. *Laser & Optoelectronics Progress*, 2006, 43(12):58-61.(in Chinese) [9] MILLER C D. Half-million stationary images per second with refocused resolving beam[J]. *SMPE*,1949,43:479. [10] 李德熊. 高速摄影译文集I (转镜扫描原理) [M]. 北京:科学出版社,1965:126-156. Li D X. *Collection of Translated Papers on High Speed Photography (Principle of Rotating Mirror Scanning)*[M]. Beijing: Science Press,1965: 126-156.(in Chinese) [11] 李景镇,孙凤山. 超高速摄影用高强度铝合金转镜动态特性的研究[J]. 光子学报,2000, 29 (5):636-639. LI J ZH, SUN F SH. Dynamic property of rotating mirrors of high intensity aluminium alloy for ultra high speed photography[J]. *Acta Phtonica Sinca*, 2000,29 (5): 636-639.(in Chinese) [12] 黄虹宾,李景镇,孙凤山,等. 超高速摄影中三

面体铝合金转镜的空间结构强度数值分析[J]. 强激光与粒子束, 2006,18(8):1277-1281. HUANG H B, LI J ZH, SUN F SH, *et al*.. Numeric analysis of structural strength of aluminous alloy rotating mirror for ultra-high speed photography [J]. *High Power Laser and Particle Beams*, 2006,18(8):1277-1281.(in Chinese) [13] LI J ZH. Possibility of simultaneously attaining the curve without out of focus and with constant writing speed[J]. *SPIE*,1982,348: 471-474. [14] LI J ZH, HUANG J H, TIAN J, *et al*.. Advanced designing theory of recording surface of rotating mirror streak cameras[J]. *Acta Photonica Sinica*,2001,30(8):1033-1035. [15] 许家隆. 转镜式高速摄影 [M]. 北京: 科学出版社, 1985:139-142. XU J L. *High Speed Rotating Mirror Camera[M]*. Beijing: Science Press, 1985:139-142.(in Chinese) [16] 朗见林. 转镜分幅相机代替圆参数的综合设计. 第四届全国高速摄影和光子学学术会议论文汇编:天津,1985. LANG J L. Comprehensive design of substitution circular for rotating mirror framing camera. *Proc. of the 4th NCHSPP*: Tianjin,1985.(in Chinese)

本刊中的类似文章

1．姚峰林, 高世桥.基于高速摄影动态测试微陀螺振动[J]. 光学精密工程, 2012,20(1): 165-170

2．薛旭成[1,2];李云飞[1,2];郭永飞[1].CCD成像系统中模拟前端设计[J]. 光学精密工程, 2007,15(8): 1191-1195

3．罗 均;邢兰兴;周 焱;谢少荣.C8051F020的微型旋翼飞行器实验平台的控制系统[J]. 光学精密工程, 2007,15(5): 713-718

4．蒋 明[1,2];杨福俊[2];董萼良[2];郑 翔[2];何小元[2].基于高速摄像的双线性振动陀螺力学特性分析[J]. 光学精密工程, 2006,14(1): 121-126

5．达争尚, 何俊华, 陈良益.信噪比对高速视频系统作用距离制约的分析[J]. 光学精密工程, 2004,12(2): 165-168

6．达争尚, 陈良益, 何俊华, 罗长洲.对高速摄影供片阻尼实现方法的改进[J]. 光学精密工程, 2002,10(4): 397-401

7．李剑 汪伟 尚长水.大画幅等待式转镜分幅相机系统设计[J]. 光学精密工程, ,(): 0-0