

United States Patent [19]

[11] **Patent Number:** **5,691,802**

Takahashi

[45] **Date of Patent:** **Nov. 25, 1997**

[54] **CATADIOPTRIC OPTICAL SYSTEM AND EXPOSURE APPARATUS HAVING THE SAME**
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 5,402,205 3/1995 Markle et al. 355/53
 5,467,166 11/1995 Shiraishi 355/71

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[57] **ABSTRACT**

[21] **Appl. No.:** 552,453

It is an object of the invention to provide a catadioptric optical system with an arrangement for realizing a large numerical aperture and reducing the diameter of a concave mirror while ensuring a sufficient working distance on the image side, and also an exposure apparatus using this catadioptric optical system.

[22] **Filed:** Nov. 3, 1995

[30] **Foreign Application Priority Data**

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 Mar. 7, 1995 [JP] Japan 7-047142
 Jul. 14, 1995 [JP] Japan 7-177858

[51] **Int. Cl.⁶** **G03B 27/42**

[52] **U.S. Cl.** **355/53; 355/77; 355/60; 355/43; 359/727; 359/730; 359/366**

[58] **Field of Search** **355/53, 71, 43, 355/77, 57, 60; 359/366, 727, 730, 731**

[56] **References Cited**

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A catadioptric optical system according to the invention includes a first imaging optical system for forming an intermediate image of a pattern on a first plane, a second imaging optical system for forming a reduced image of the intermediate image on a second plane, and an optical path deflecting member for guiding a light beam from the first imaging optical system to the second imaging optical system. The first imaging optical system has at least a first optical element group having a positive refracting power, and a second optical element group having a concave mirror and a meniscus lens component with a concave surface facing the first imaging optical system. In particular, the first optical element group having a positive refracting power is arranged to guide a light beam from the first plane to the second optical element group.

35 Claims, 20 Drawing Sheets

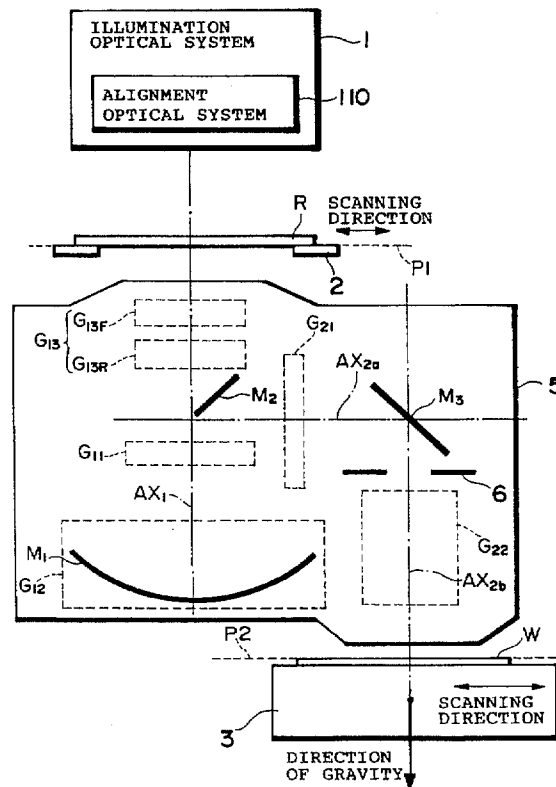


Fig. 1

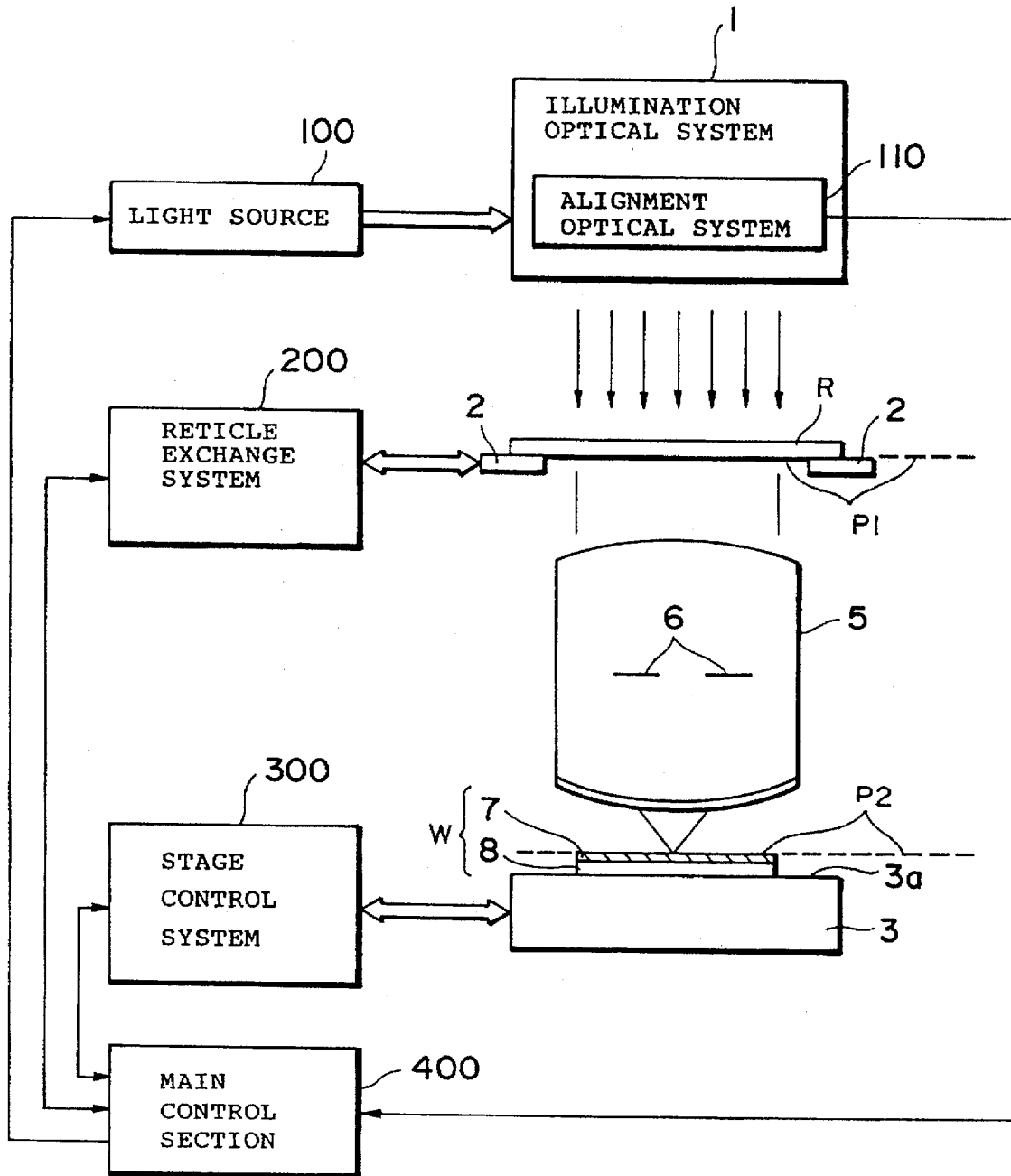


Fig. 2

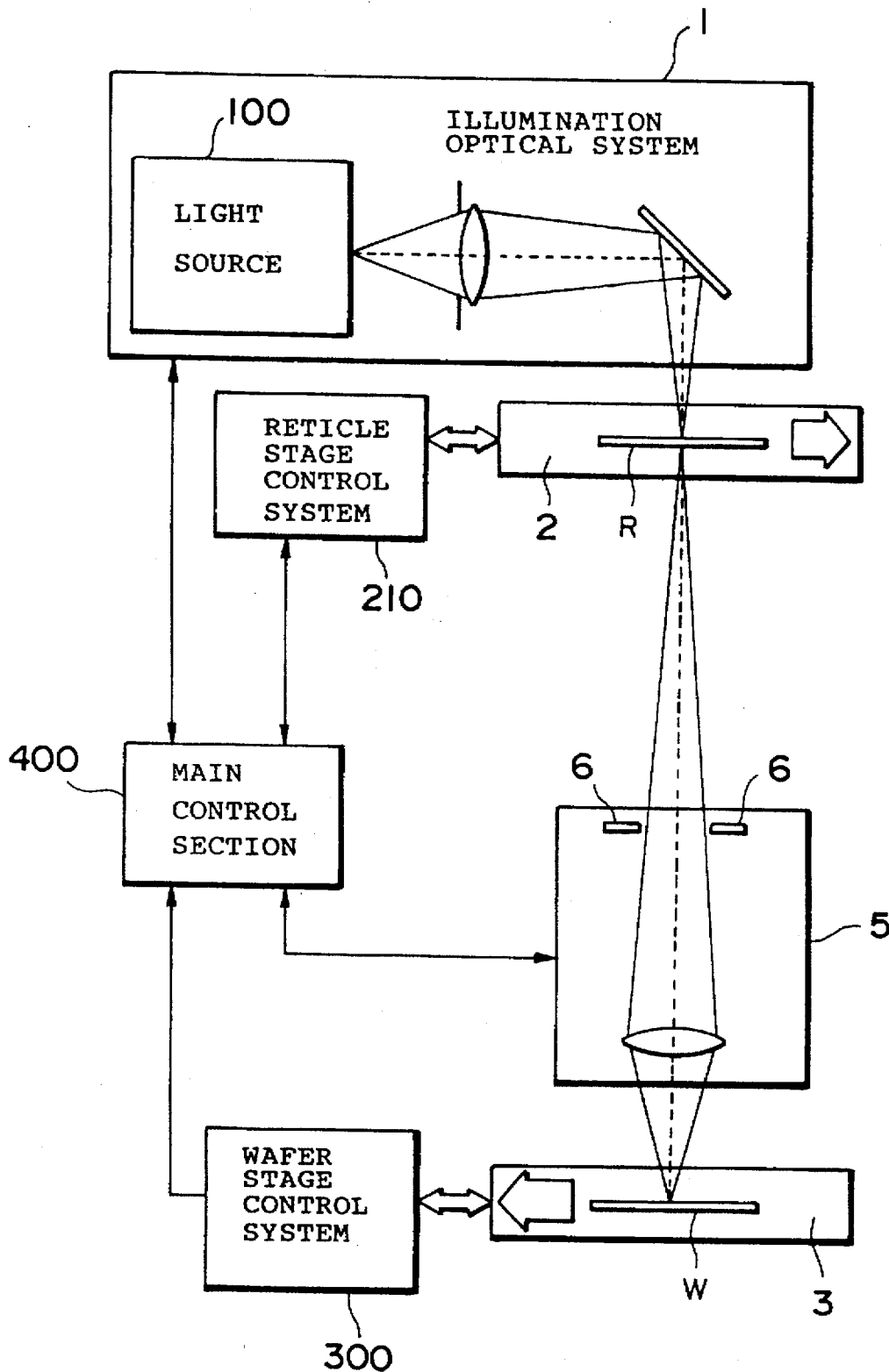


Fig. 3

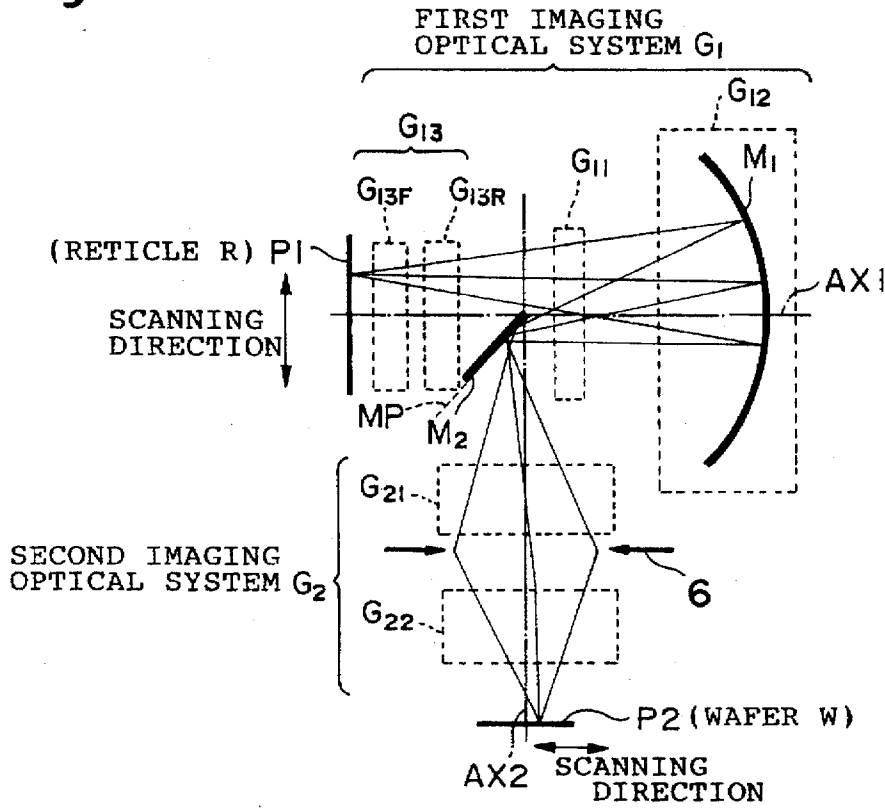


Fig. 4

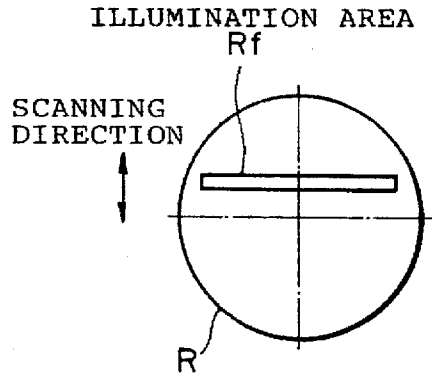


Fig. 5

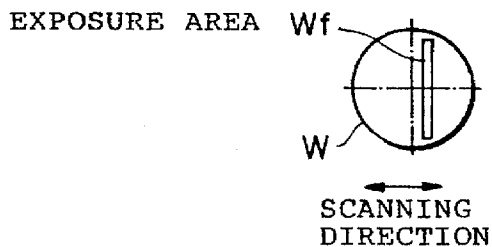


Fig. 6

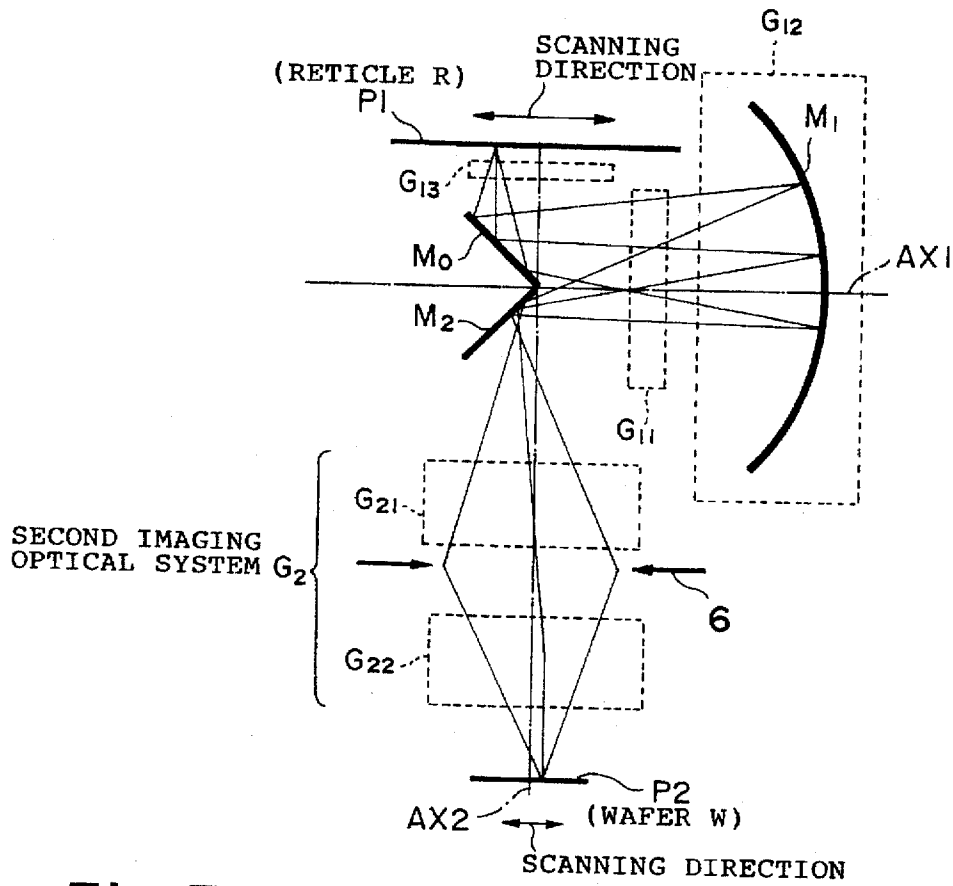


Fig. 7

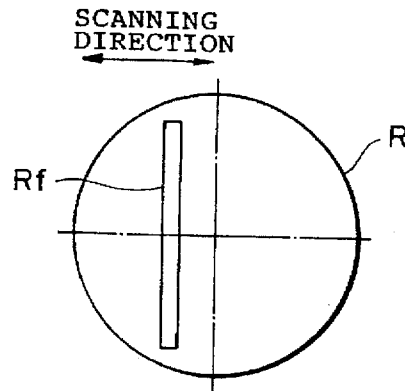
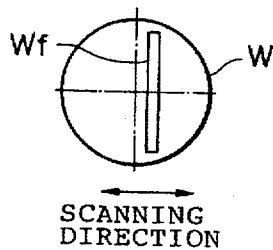


Fig. 8



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