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Morris et al.

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[54] HYBRID REFRACTIVE/DIFFRACTIVE ACHROMATIC LENS FOR OPTICAL DATA STORAGE SYSTEMS

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[51] **Int. Cl.**[5] **G02B 3/08**; G02B 5/18; G02B 27/44

[52] **U.S. Cl.** **359/565**; 359/566; 359/569; 359/571

[58] **Field of Search** 359/355, 356, 357, 565, 359/566, 569, 571; 369/109

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Primary Examiner—Martin Lerner

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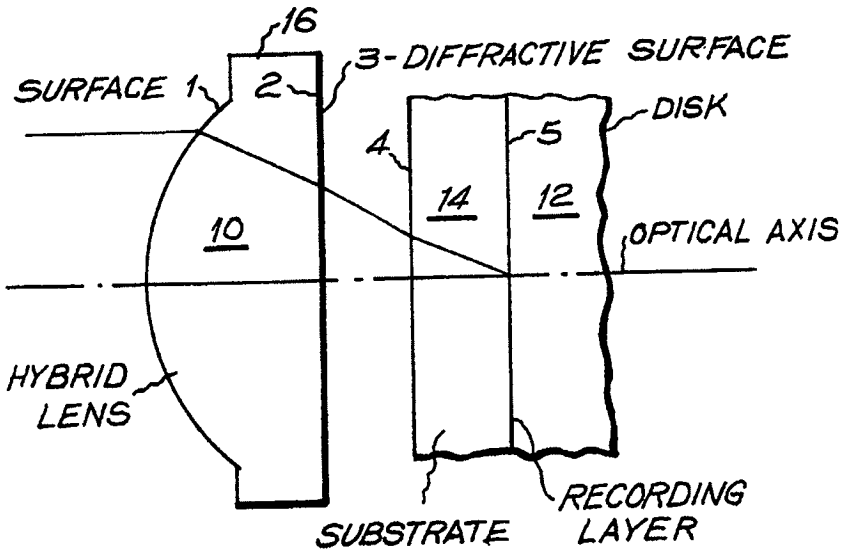
[57] **ABSTRACT**

A diffractive/refractive hybrid lens for use in an optical data storage system as an objective is provided by a convex-plano singlet having a refractive element defined by plano-convex surfaces and a diffractive element defined by a Fresnel zone-like pattern on the plano surface which together provide the total power of the lens. The refractive lens is made of a high index, high dispersion glass so that the curvature and thickness of the refractive lens is minimized while providing a large numerical aperture (at least 0.45) at the expense of increased longitudinal chromatic aberration, which are compensated by the diffractive element and without the need for one or more additional curved surfaces as in low index biaspheric glass objective lenses for chromatic and mono-chromatic aberration reduction, which increases the thickness and curvatures of the lens. The invention enables longitudinal chromatic aberration to be corrected for at least a 10 nm band width around a center wavelength over a 20 nm range, as results when different lasers are used and as laser power varies during optical data storage on an optical data storage device (an optical disk). The thin, light weight low curvature achromat has maximum tolerance for various possible manufacturing errors such as decentering, variations in thickness of the lens, tilt and focal length especially for on-axis field of view less than 2° while providing a very high quality spot (Strehl ratio of at least 0.9.).

6 Claims, 4 Drawing Sheets



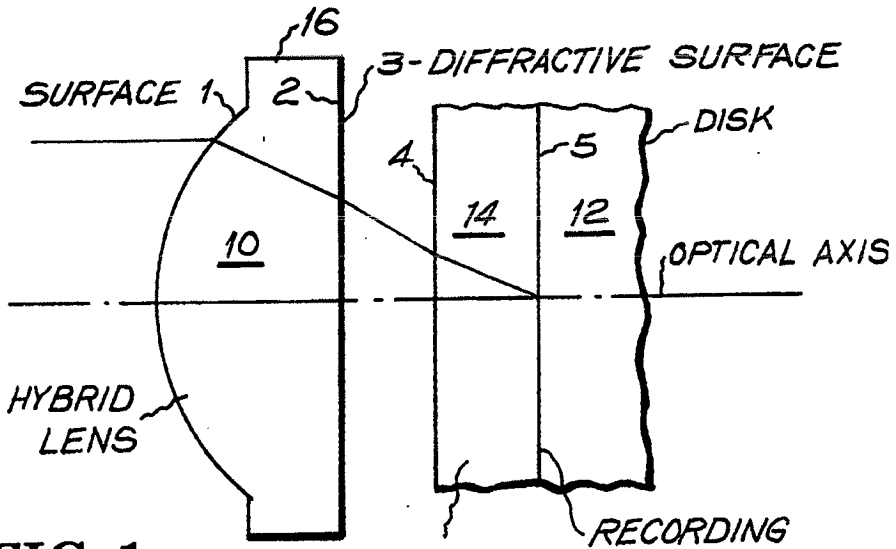


FIG. 1

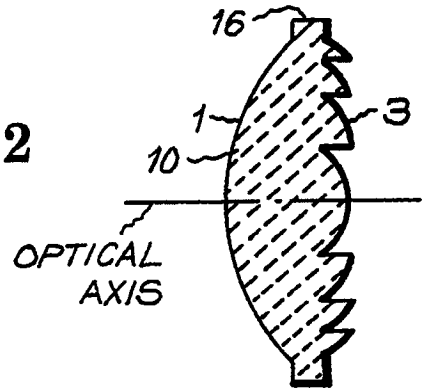


FIG. 2

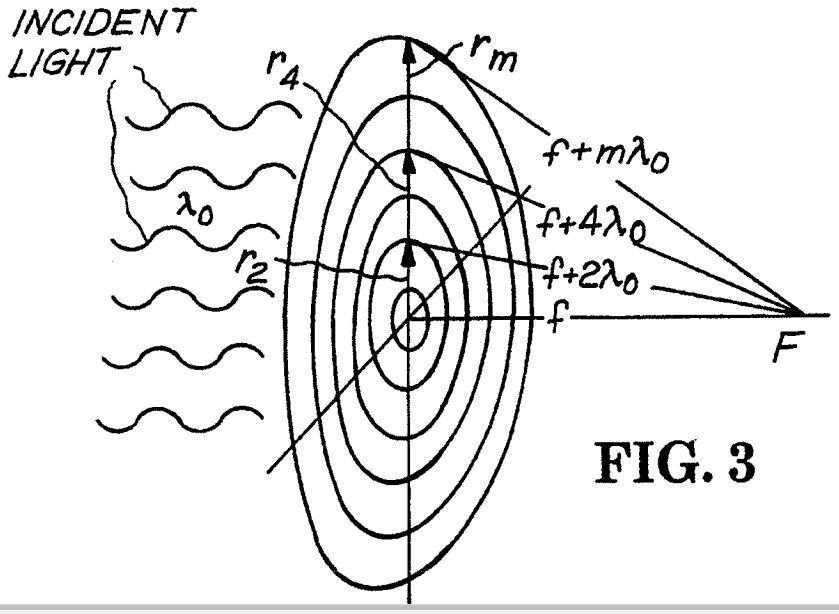


FIG. 3

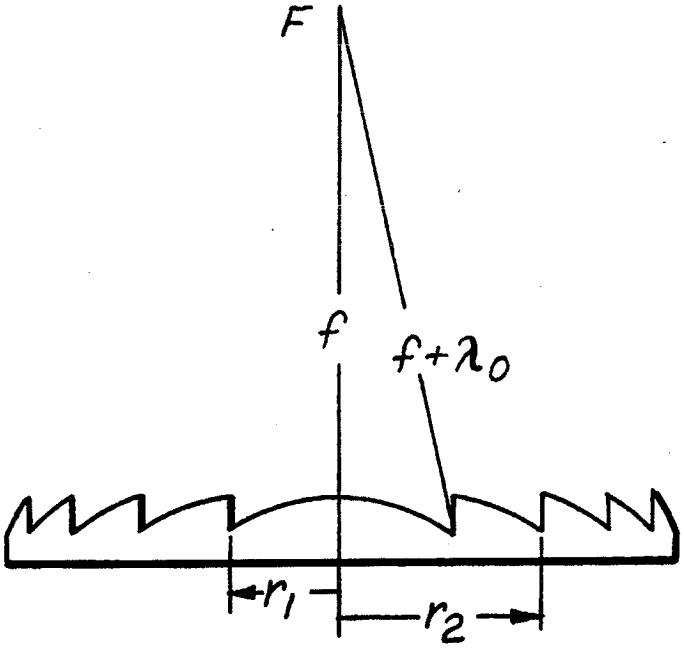


FIG. 4

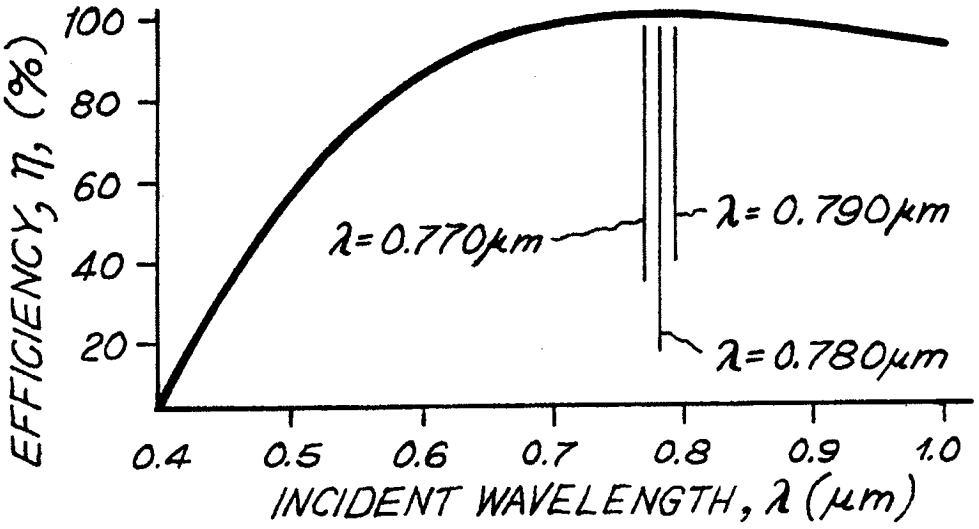


FIG. 5

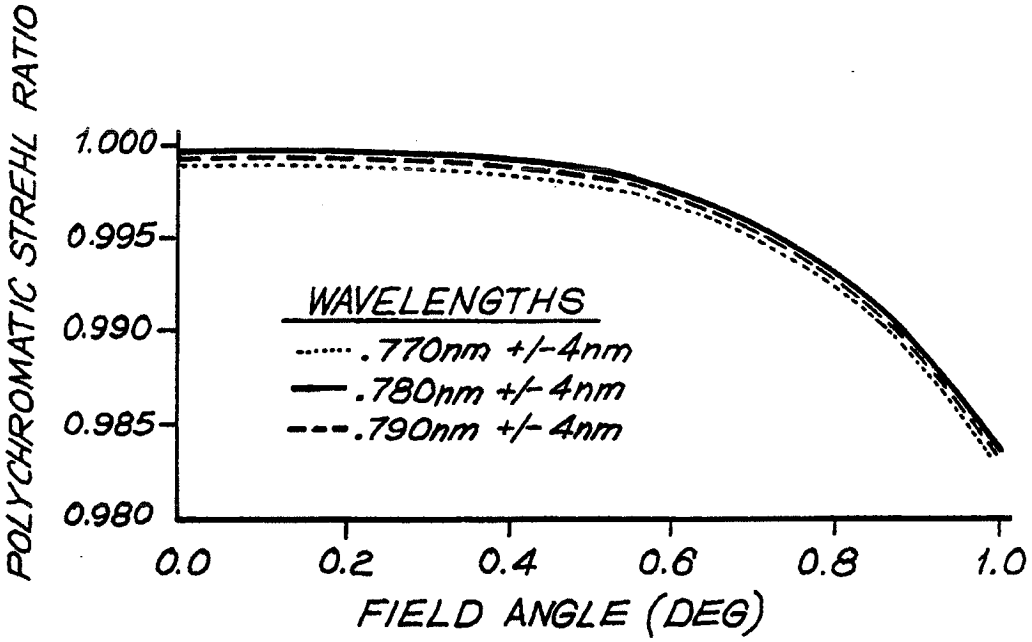


FIG. 6

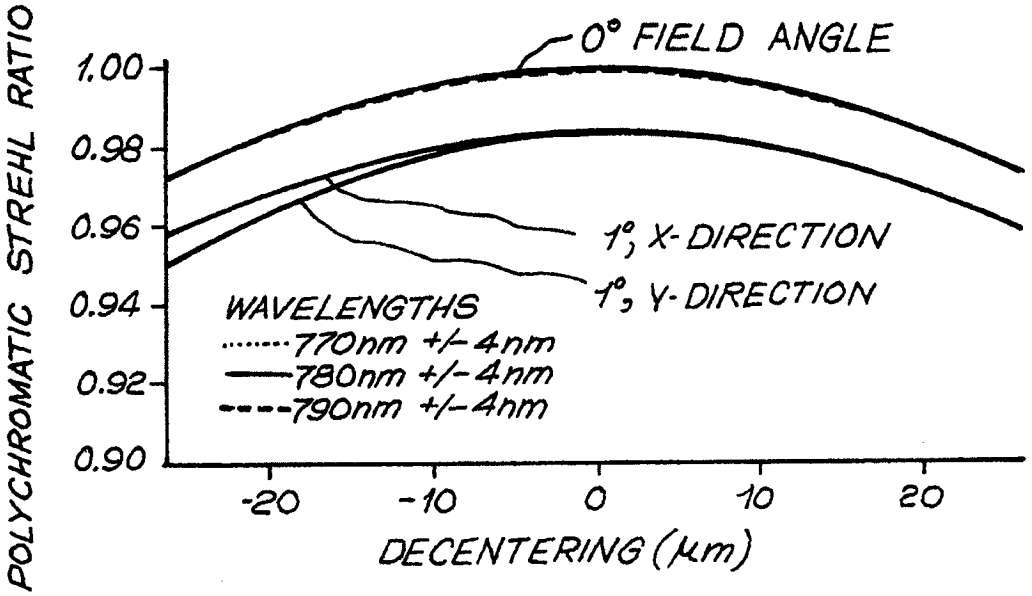


FIG. 7

SURFACE	RADIUS (mm)	THICKNESS (mm)	n_m
1	2.49707	2.12209	
			1.795
2	INF	0.0	
			DIFF. SURFACE
3	INF	1.10059	
			1.0
4	INF	1.20000	
			1.573
5	INF	0.0	

FIG. 8

	2nd ORDER	4th ORDER	6th ORDER	8th ORDER	10th ORDER
ASPHERIC COEFF. D	--	$-0.00380\ \frac{1}{mm^3}$	$-0.00054\ mm^{-5}$	$-5.149E\text{-}05\ mm^{-7}$	$-3.337E\text{-}05\ mm^{-9}$
PHASE COEFF. A	$-0.01319\ \frac{1}{mm}$	$0.003036\ \frac{1}{mm^3}$	$-7.3356E\text{-}04\ \frac{1}{mm^5}$	$-6.6266E\text{-}04\ \frac{1}{mm^7}$	$1.8276E\text{-}04\ \frac{1}{mm^9}$

FIG. 9

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