



US005349471A

United States Patent [19][11] **Patent Number:** **5,349,471****Morris et al.**[45] **Date of Patent:** **Sep. 20, 1994****[54] HYBRID REFRACTIVE/DIFFRACTIVE
ACHROMATIC LENS FOR OPTICAL DATA
STORAGE SYSTEMS****[75] Inventors:** **G. Michael Morris**, Fairport; **David Kay**, Rochester, both of; **Dale Buralli**, both of Rochester, all of N.Y.; **David Kubalak**, Somerville, Mass.**[73] Assignee:** **The University of Rochester**, Rochester, N.Y.**[21] Appl. No.:** **17,712****[22] Filed:** **Feb. 16, 1993****[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****[56] References Cited****U.S. PATENT DOCUMENTS**

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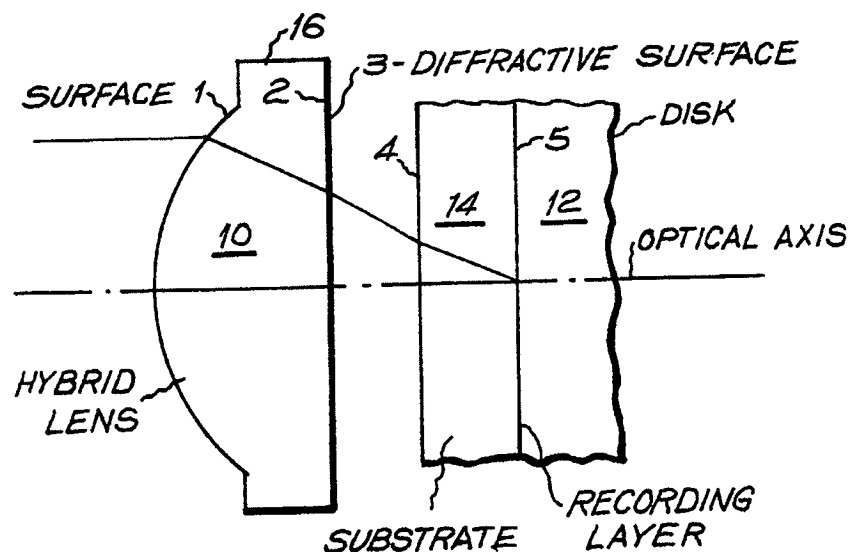
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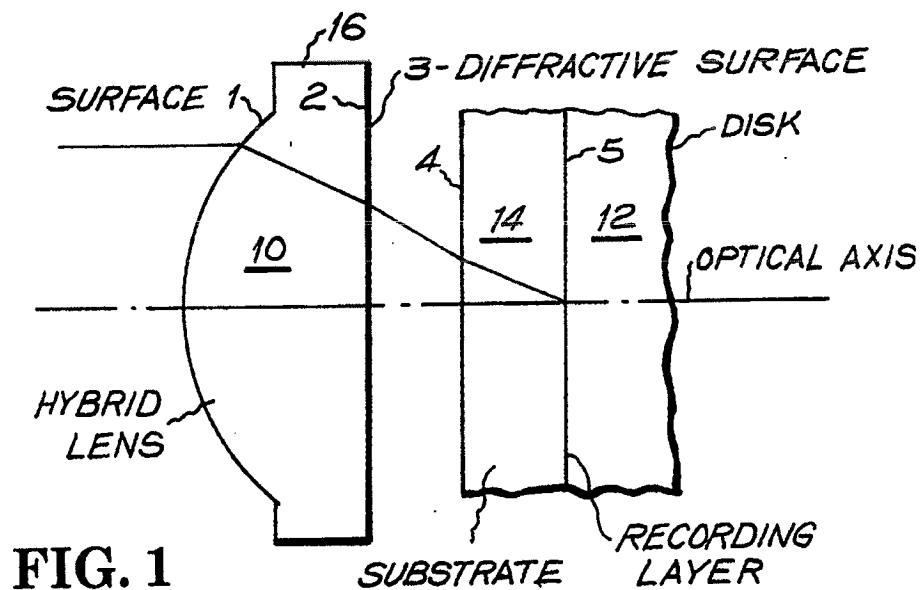
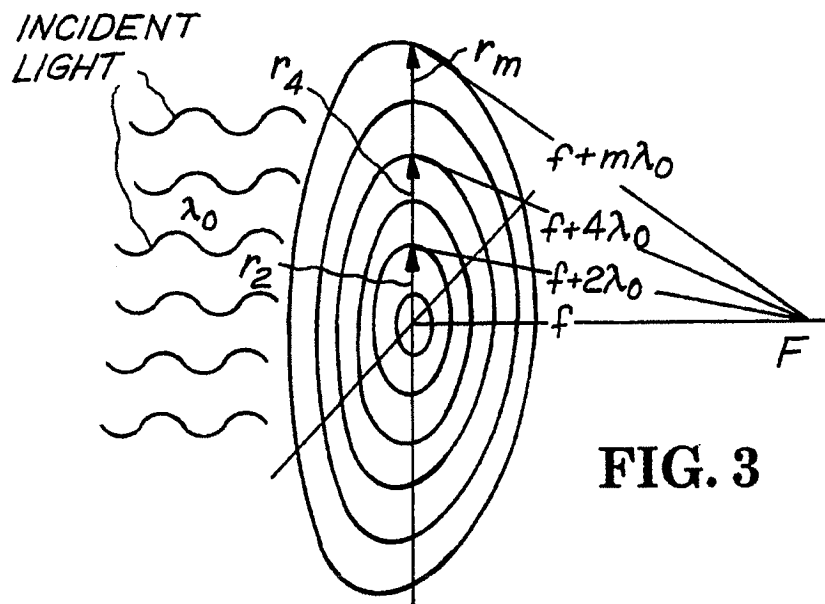
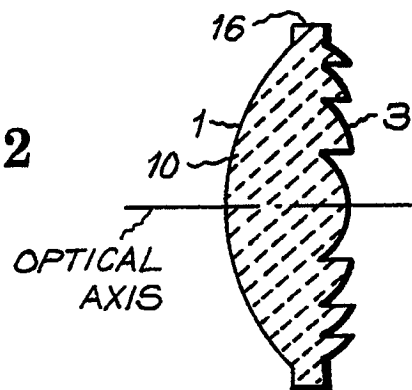
[57] ABSTRACT

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 bi-convex 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

LG Electronics, Inc. et al.

EXHIBIT 1011

**FIG. 2**

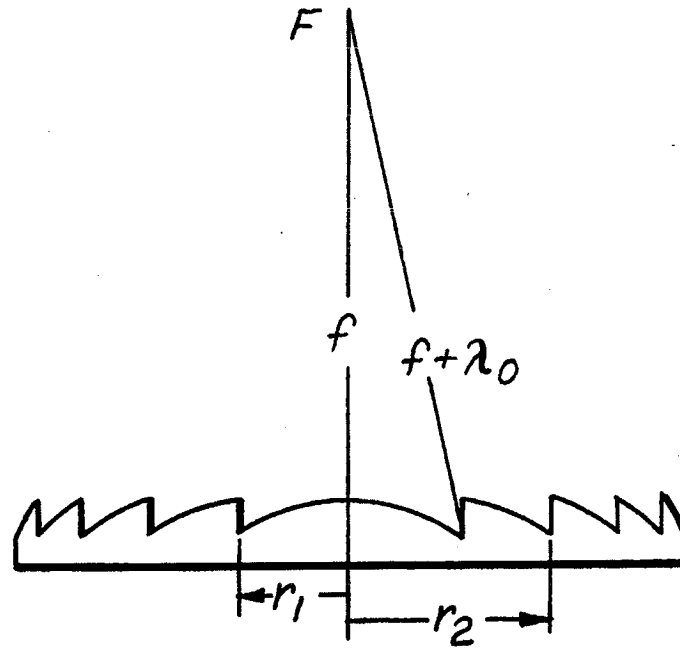


FIG. 4

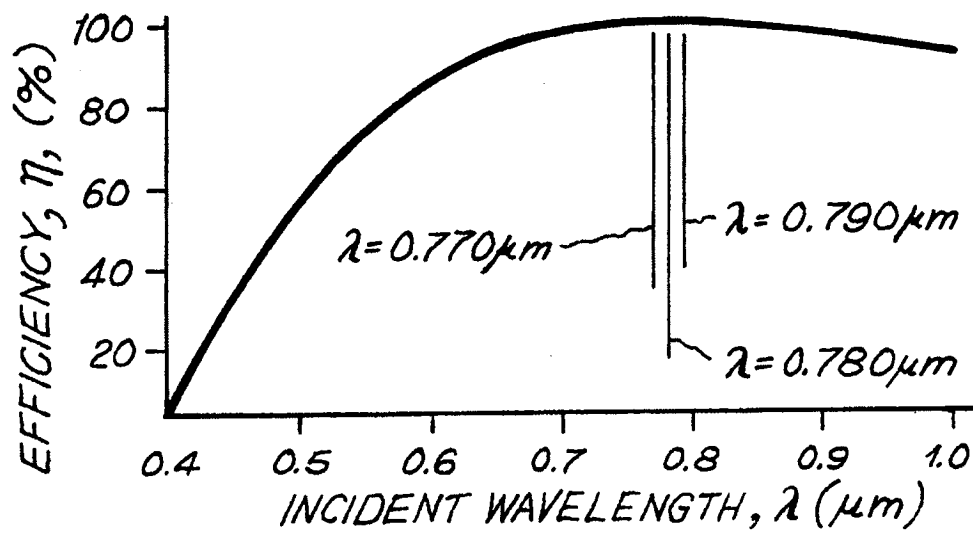


FIG. 5

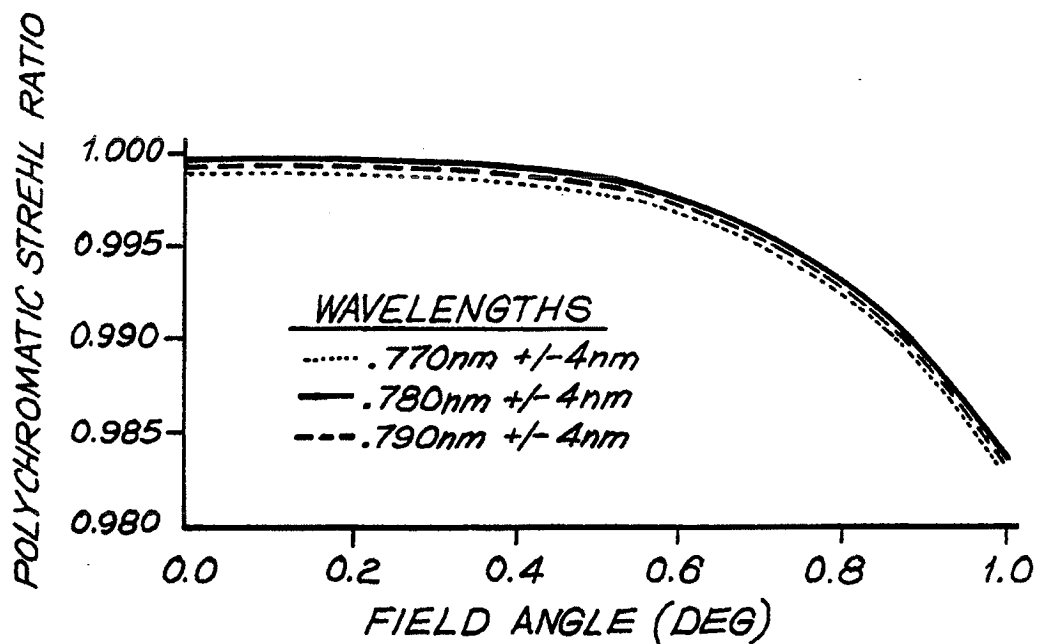


FIG. 6

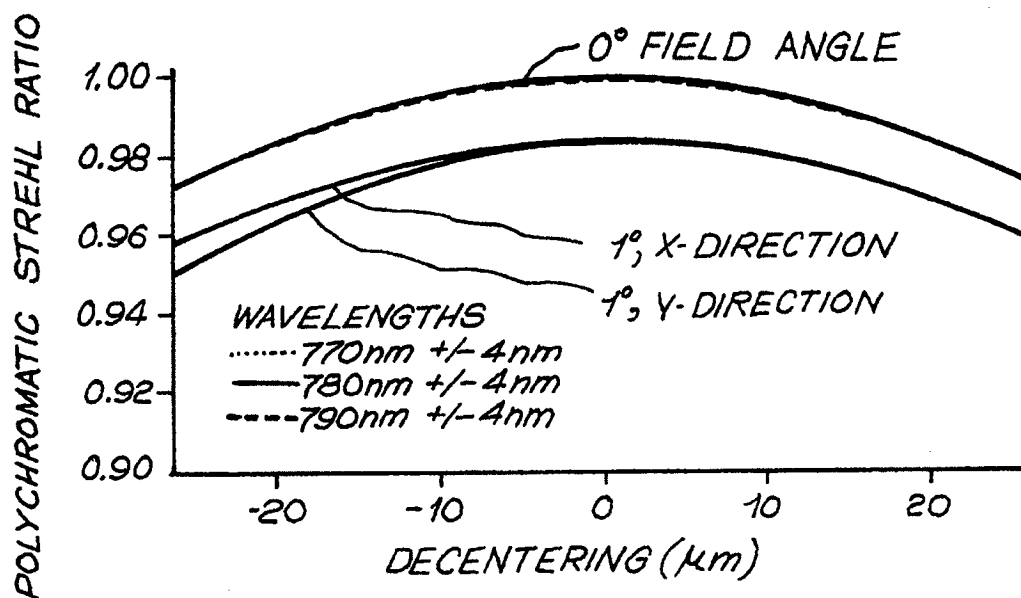


FIG. 7

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

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

FIG. 9

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