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(54) **TUNABLE ACOUSTIC GRADIENT INDEX OF REFRACTION LENS AND SYSTEM**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,150,242 A *	9/1992	Fellows	G02F 1/0128	252/582
6,798,929 B2 *	9/2004	Chen	G02B 6/29361	385/1
6,898,021 B1 *	5/2005	Tang	G02B 3/14	349/200

* cited by examiner

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(57) **ABSTRACT**

A tunable acoustic gradient index of refraction (TAG) lens and system are provided that permit, in one aspect, dynamic selection of the lens output, including dynamic focusing and imaging. The system may include a TAG lens and at least one of a source and a detector of electromagnetic radiation. A controller may be provided in electrical communication with the lens and at least one of the source and detector and may be configured to provide a driving signal to control the index of refraction and to provide a synchronizing signal to time at least one of the source and the detector relative to the driving signal. Thus, the controller is able to specify that the source irradiates the lens (or detector detects the lens output) when a desired refractive index distribution is present within the lens, e.g. when a desired lens output is present.

14 Claims, 27 Drawing Sheets

