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(54) **FREQUENCY MODULATION PATTERN FOR DISK DRIVE ASSEMBLIES**

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(58) **Field of Search** **360/48, 46, 77.08**

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,365,586 A	11/1994	Indeck et al.	
5,408,505 A	4/1995	Indeck et al.	
5,428,683 A	6/1995	Indeck et al.	
5,546,462 A	8/1996	Indeck et al.	
5,587,654 A	12/1996	Indeck et al.	
5,625,689 A	4/1997	Indeck et al.	
5,626,941 A *	5/1997	Ouano	428/141
5,740,244 A	4/1998	Indeck et al.	
5,786,958 A	7/1998	Negishi et al.	
5,815,333 A *	9/1998	Yamamoto et al.	360/60
5,920,628 A	7/1999	Indeck et al.	
5,959,794 A	9/1999	Indeck et al.	
5,966,264 A	10/1999	Belser et al.	
6,025,970 A	2/2000	Cheung	

6,028,731 A	2/2000	Bond	
6,034,835 A	3/2000	Serrano	
6,072,669 A	6/2000	Indeck	
6,078,445 A	6/2000	Serrano et al.	
6,347,016 B1 *	2/2002	Ishida et al.	360/17
6,452,990 B1 *	9/2002	Leis et al.	375/361

OTHER PUBLICATIONS

Alexei H. Sacks (Ph.D. thesis), "Position Signal Generation in Magnetic Disk Drives," 1995, pp. 24-49.

Xiangdong Lin et al., "Investigation of Advanced Position Error Signal Patterns In Patterned Media," *Journal of Applied Physics*, vol. 87, No. 9, pp. 5117-5119, May 1, 2000.

Jian-Gang Zhu et al., "Recording, Noise, and Servo Characteristics of Patterned Thin Film Media," *IEEE Transactions on Magnetics*, vol. 36, No. 1, Jan., 2000.

* cited by examiner

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(57) **ABSTRACT**

The invention relates to control systems for data storage media. More particularly, the invention relates to a system, method and apparatus for forming various frequency modulation patterns on storage media for providing position error signals. The invention also relates to forming various frequency modulation patterns on storage media for providing position error signals having a continuously varying frequency that is proportional to the position of a read/write transducer head within a track defined on a storage medium. The invention also relates to providing a demodulated signal that is proportional to a continuously varying position error signal frequency and thus to the position of the read/write head within a track defined on a storage medium.

30 Claims, 22 Drawing Sheets

