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(54) **DIFFRACTION ENHANCED X-RAY IMAGING OF ARTICULAR CARTILAGE**

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(52) **U.S. Cl.** ..... **378/82; 378/84**

(58) **Field of Search** ..... **378/82, 84, 85**

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

4,599,741 A	7/1986	Wittry
5,245,648 A	9/1993	Kinney et al.
5,259,013 A	11/1993	Kuriyama et al.
5,319,694 A	6/1994	Ingal et al.
5,428,657 A	6/1995	Papanicolopoulos et al.
5,579,363 A	11/1996	Ingal et al.
5,805,662 A	9/1998	Kurbatov et al.
5,987,095 A	11/1999	Chapman et al.
6,035,227 A	3/2000	Shmueli
6,038,285 A	3/2000	Zhong et al.

**FOREIGN PATENT DOCUMENTS**

WO 95/05725 2/1995

**OTHER PUBLICATIONS**

D. Chapman, W. Thomlinson, R.E. Johnson, D. Washburn, E. Pisano, N. Gmür, Z. Zhong, R. Menk, F. Arfelli and D. Sayers, *X-Ray Refraction Imaging (XRI) Applied to Mammography*, published Oct. 31, 1997.

V.N. Ingal and E.A. Beliaevskaya, *Phase Dispersion Intros-copy*, (published prior to Oct. 16, 1996).

(List continued on next page.)

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(57) **ABSTRACT**

A method and system for detecting an image of an object, particularly a soft tissue material. A generated x-ray beam is transmitted through the soft tissue material. A transmitted beam is directed at an angle of incidence upon a crystal analyzer. An image of the object is detected from a beam diffracted from the crystal analyzer either at or near a peak of a rocking curve of the crystal analyzer. The method and system of this invention is particularly useful for analyzing images of cartilage.

**15 Claims, 15 Drawing Sheets**

