



US006842502B2

(12) **United States Patent**  
**Jaffray et al.**

(10) **Patent No.:** **US 6,842,502 B2**  
(45) **Date of Patent:** **Jan. 11, 2005**

(54) **CONE BEAM COMPUTED TOMOGRAPHY WITH A FLAT PANEL IMAGER**

(75) Inventors: **David A. Jaffray**, Windsor (CA); **John W. Wong**, Bloomfield Hills, MI (US); **Jeffrey H. Siewerdesen**, Ann Arbor, MI (US)

(73) Assignee: **Dilliam Beaumont Hospital**, Royal Oak, MI (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/788,335**

(22) Filed: **Feb. 16, 2001**

(65) **Prior Publication Data**

US 2003/0007601 A1 Jan. 9, 2003

**Related U.S. Application Data**

(60) Provisional application No. 60/183,590, filed on Feb. 18, 2000.

(51) **Int. Cl.**<sup>7</sup> ..... **A61N 5/10; H05G 1/60**

(52) **U.S. Cl.** ..... **378/65; 378/9; 378/19; 378/196; 378/197; 378/198**

(58) **Field of Search** ..... **378/4, 8, 9, 11, 378/19, 20, 64, 65, 195, 196, 197, 198**

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

4,547,892 A	*	10/1985	Richey et al.	378/8
5,157,707 A		10/1992	Ohlson	378/181
5,394,452 A		2/1995	Swerdloff et al.	378/65
5,411,026 A		5/1995	Carol	600/439
5,661,773 A		8/1997	Swerdloff et al.	378/65
5,663,995 A	*	9/1997	Hu	378/15
5,675,625 A	*	10/1997	Röckseisen	378/206
5,719,914 A		2/1998	Rand et al.	378/4
5,748,700 A		5/1998	Shepherd et al.	378/65
5,751,781 A		5/1998	Brown et al.	378/65
5,848,126 A	*	12/1998	Fujita et al.	378/195
5,912,943 A		6/1999	Deucher et al.	378/98.8

5,929,449 A		7/1999	Huang	250/370.09
5,949,811 A		9/1999	Baba et al.	378/108
6,041,097 A	*	3/2000	Roos et al.	378/62
6,148,058 A	*	11/2000	Dobbs	378/19
6,152,598 A		11/2000	Tomisaki et al.	378/209
6,269,143 B1	*	7/2001	Tachibana	378/65
6,318,892 B1	*	11/2001	Suzuki et al.	378/197
6,385,286 B1	*	5/2002	Fitchard et al.	378/65
6,385,288 B1	*	5/2002	Kanematsu	378/65

**OTHER PUBLICATIONS**

B. D. Cullity. Elements of X-Ray Diffraction, Second Edition (Reading, MA: Addison-Wesley, 1978), p. 6-12.\*  
Jaffray et al., "Exploring 'Target of the Day' Strategies for a Medical Linear Accelerator with Conebeam-CT Scanning Capability," XIIth ICCR held in Salt Lake City, Utah, May 27-30, 1997, pp. 172-174.

Jaffray et al., "Conebeam Tomographic Guidance of Radiation Field Placement for Radiotherapy of the Prostate," Manuscript accepted for publication in the International Journal of Radiation Oncology, Biology, date unknown, 32 pages.

(List continued on next page.)

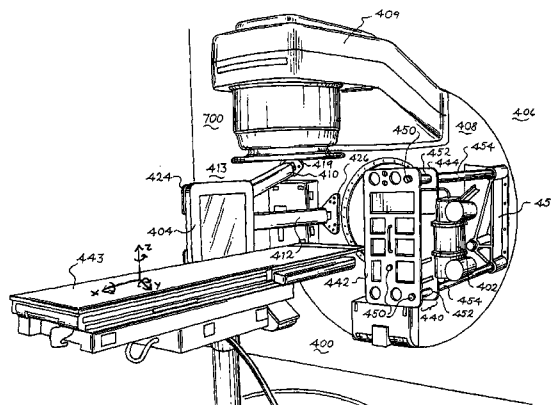
*Primary Examiner*—Allen C. Ho

(74) *Attorney, Agent, or Firm*—Brinks, Hofer, Gilson & Lione

(57) **ABSTRACT**

A radiation therapy system that includes a radiation source that moves about a path and directs a beam of radiation towards an object and a cone-beam computer tomography system. The cone-beam computer tomography system includes an x-ray source that emits an x-ray beam in a cone-beam form towards an object to be imaged and an amorphous silicon flat-panel imager receiving x-rays after they pass through the object, the imager providing an image of the object. A computer is connected to the radiation source and the cone beam computerized tomography system, wherein the computer receives the image of the object and based on the image sends a signal to the radiation source that controls the path of the radiation source.

**76 Claims, 26 Drawing Sheets**



## OTHER PUBLICATIONS

Jaffray et al., "Managing Geometric Uncertainty in Conformal Intensity-Modulated Radiation Therapy," *Seminars in Radiation Oncology*, vol. 9, No. 1, Jan., 1999 pp. 4-19.

Jaffray et al., "Performance of a Volumetric CT Scanner Based Upon a Flat-Panel Imager," *SPIE Physics of Medical Imaging*, vol. 3659, Feb., 1999, pp. 204-214.

Jaffray et al., "A Ghost Story: Spatio-temporal Response Characteristics of an Indirect-Detection Flat-Panel Imager." *Med. Phys.*, vol. 26, No. 8, Aug., 1999, pp. 1624-1641.

Jaffray et al., "Cone-Beam Computed Tomography with a Flat-Panel Imager: Initial Performance Characterization," Submission to the *Medical Physics Journal* for publication on Aug., 1999, 36 pages.

Siewerdsen et al., "Cone-Beam Computed Tomography with a Flat-Panel Imager: Effects of Image Lag," *Med. Phys.*, vol. 26, No. 12, Dec., 1999, pp. 2635-2647.

Jaffray et al., "Cone-Beam CT: Applications in Image-Guided External Beam Radiotherapy and Brachytherapy," publication source unknown, date unknown, one page.

Siewerdsen et al., "Cone-Beam CT with a Flat-Panel Imager: Noise Consideration for Fully 3-D Computed Tomography," *SPIE Physics of Medical Imaging*, vol. 3336, Feb., 2000, pp. 546-554.

Jaffray et al., "Cone-Beam Computed Tomography with a Flat-Panel Imager: Initial Performance Characterization," *Med. Phys.*, vol. 27, No. 6, Jun. 2000, pp. 1311-1323.

Siewerdsen et al., "Optimization of X-Ray Imaging Geometry (with Specific Application to Flat-Panel Cone-Beam Computed Tomography)," Non-Final Version of Manuscript to be published in *Med. Phys.*, vol. 27, No. 8, Aug., 2000, pp. 1-12.

Dieu et al., "Ion Beam Sputter-Deposited SiN/TiN Attenuating Phase-Shift Photoblanks," publication source and date unknown, 8 pages.

Jaffray et al., "Flat-Panel Cone-Beam CT for Image-Guided External Beam Radiotherapy," publication source unknown, Oct., 1999, 36 pages.

\* cited by examiner

Fig. 1(c)

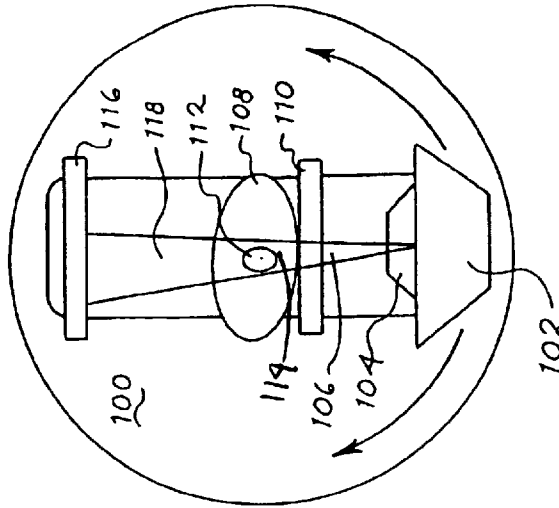


Fig. 1(b)

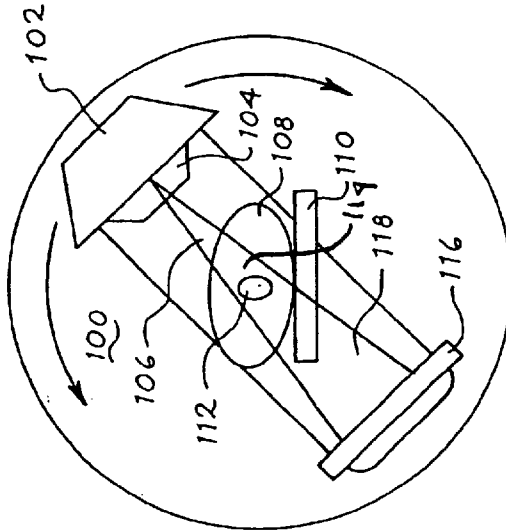
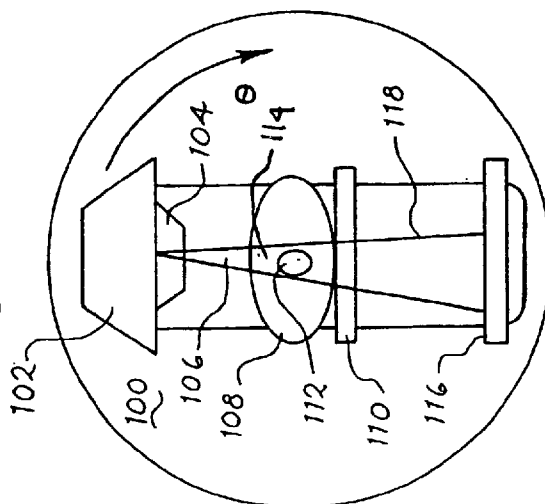


Fig. 1(a)



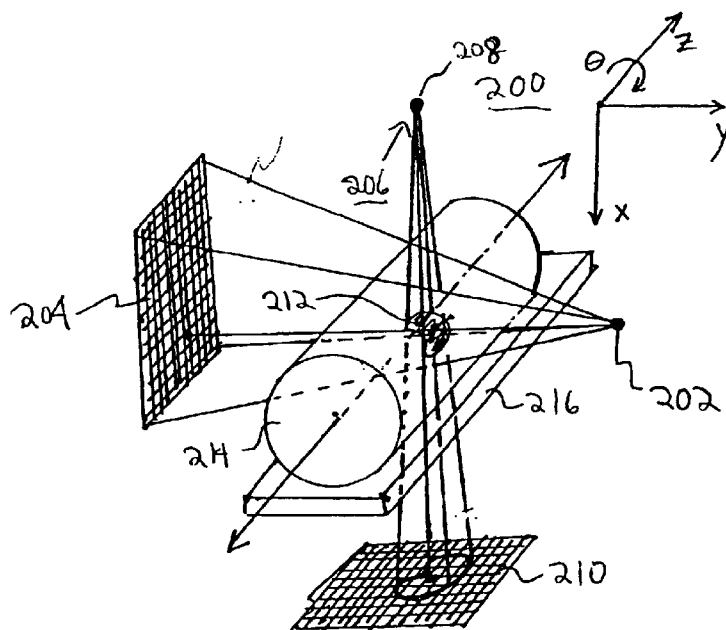
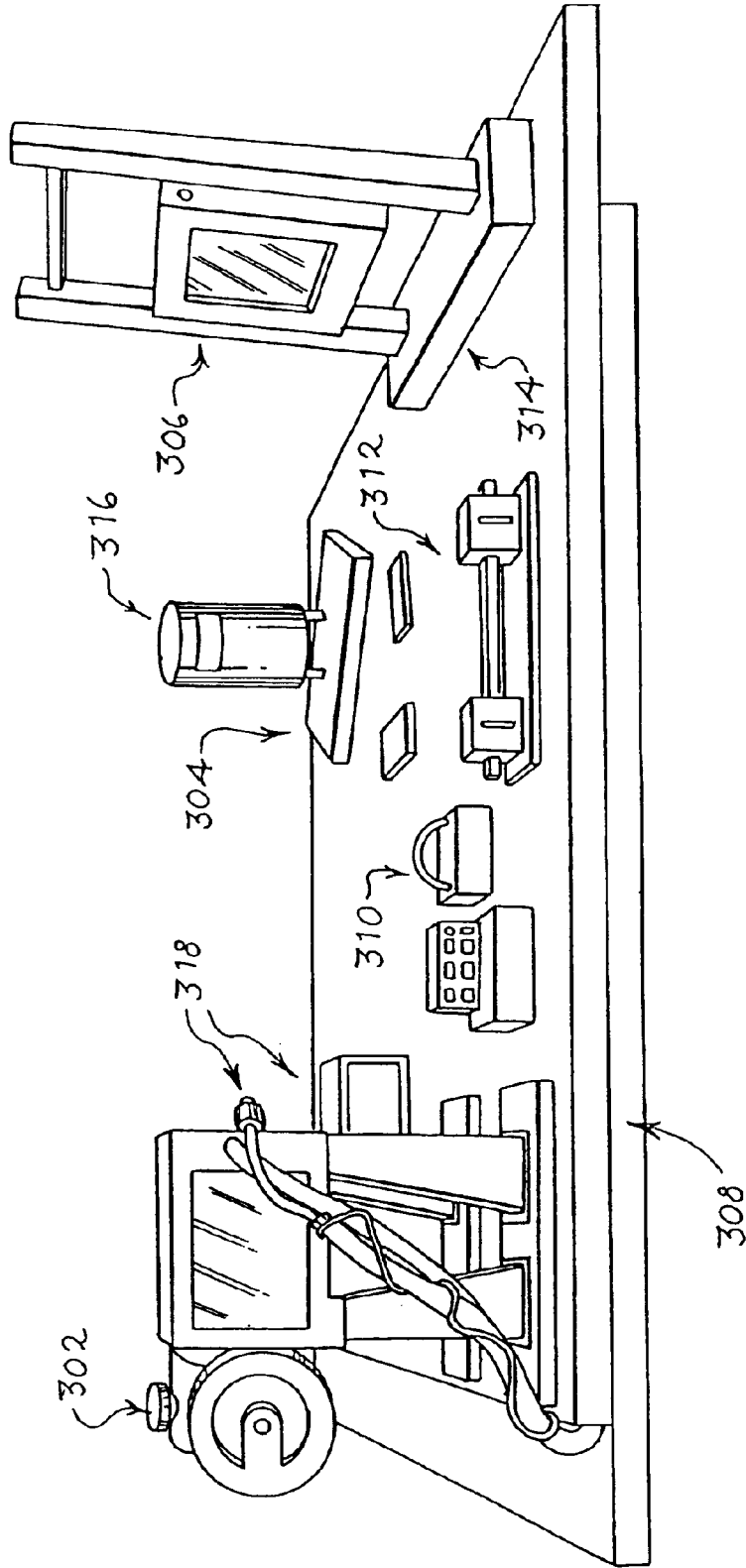


FIG. 2

*Fig. 3*



# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.