



US006772057B2

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

(10) **Patent No.:** **US 6,772,057 B2**
(45) **Date of Patent:** **Aug. 3, 2004**

(54) **VEHICULAR MONITORING SYSTEMS USING IMAGE PROCESSING**

(75) Inventors: **David S. Breed**, Boonton Township, Morris County, NJ (US); **Wilbur E. DuVall**, Kimberling City, MO (US); **Wendell C. Johnson**, Signal Hill, CA (US)

(73) Assignee: **Automotive Technologies International, Inc.**, Denville, NJ (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.: **10/302,105**

(22) Filed: **Nov. 22, 2002**

(65) **Prior Publication Data**

US 2003/0125855 A1 Jul. 3, 2003

Related U.S. Application Data

(63) Continuation-in-part of application No. 10/116,808, filed on Apr. 5, 2002, which is a continuation-in-part of application No. 09/925,043, filed on Aug. 8, 2001, now Pat. No. 6,507,779, which is a continuation-in-part of application No. 09/765,559, filed on Jan. 19, 2001, now Pat. No. 6,553,296, and a continuation-in-part of application No. 09/389,947, filed on Sep. 3, 1999, now Pat. No. 6,393,133, and a continuation-in-part of application No. 09/838,919, filed on Apr. 20, 2001, now Pat. No. 6,442,465, which is a continuation-in-part of application No. 09/765,559, which is a continuation-in-part of application No. 09/476,255, filed on Dec. 30, 1999, now Pat. No. 6,324,453, and a continuation-in-part of application No. 09/389,947, which is a continuation-in-part of application No. 09/200,614, filed on Nov. 30, 1998, now Pat. No. 6,141,432, which is a continuation of application No. 08/474,786, filed on Jun. 7, 1995, now Pat. No. 5,845,000.

(60) Provisional application No. 60/114,507, filed on Dec. 31, 1998.

(51) **Int. Cl.⁷** **B60R 21/32**

(52) **U.S. Cl.** **701/45; 340/573.1; 348/77; 180/271; 280/735; 382/181**

(58) **Field of Search** **701/45, 36, 301; 340/461, 435, 436, 438, 815.4, 573.1; 348/148, 77, 154; 180/271; 280/735, 728.1; 382/181, 115, 190, 224, 100, 104**

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,496,222 A 1/1985 Shah 3592/300

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

EP 0885782 12/1998

(List continued on next page.)

OTHER PUBLICATIONS

"Analysis of Hidden Units in a Layered Network Trained to Classify Sonar Targets", R. Paul Gorman, et al., Neural Networks, vol. 1, pp. 75-89, 1988.

(List continued on next page.)

Primary Examiner—Thomas G. Black

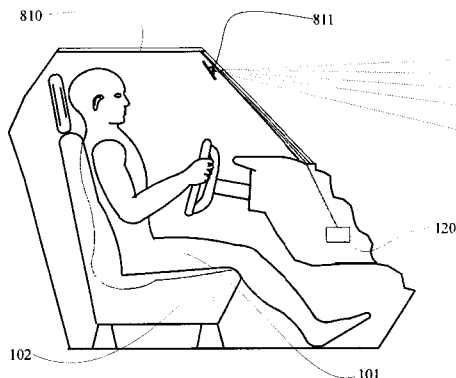
Assistant Examiner—Tuan C To

(74) *Attorney, Agent, or Firm*—Brian Roffe

(57) **ABSTRACT**

Vehicular monitoring arrangement for monitoring an environment of the vehicle including at least one active pixel camera for obtaining images of the environment of the vehicle and a processor coupled to the active pixel camera(s) for determining at least one characteristic of an object in the environment based on the images obtained by the active pixel camera(s). The active pixel camera can be arranged in a headliner, roof or ceiling of the vehicle to obtain images of an interior environment of the vehicle, in an A-pillar or B-pillar of the vehicle to obtain images of an interior environment of the vehicle, or in a roof, ceiling, B-pillar or C-pillar of the vehicle to obtain images of an interior environment of the vehicle behind a front seat of the vehicle. The determined characteristic can be used to enable optimal control of a reactive component, system or subsystem coupled to the processor. When the reactive component is an airbag assembly including at least one airbag, the processor can be designed to control at least one deployment parameter of the airbag(s).

86 Claims, 19 Drawing Sheets



U.S. PATENT DOCUMENTS

4,625,329	A	11/1986	Ishikawa et al.	382/104
4,648,052	A	3/1987	Friedman et al.	364/550
4,720,189	A	1/1988	Heynen et al.	351/210
4,768,088	A	8/1988	Ando	358/93
4,836,670	A	6/1989	Hutchinson	351/210
4,881,270	A	11/1989	Knecht et al.	382/17
4,906,940	A	3/1990	Greene et al.	382/16
4,950,069	A	8/1990	Hutchinson	351/210
4,966,388	A	10/1990	Warner et al.	280/730
5,003,166	A	3/1991	Girod	250/201.4
5,008,946	A	4/1991	Ando	382/2
5,026,153	A	6/1991	Suzuki et al.	356/1
5,060,278	A	10/1991	Fukumizu	382/157
5,062,696	A	11/1991	Oshima et al.	359/554
5,064,274	A	11/1991	Alten	359/604
5,071,160	A	12/1991	White et al.	280/735
5,074,583	A	12/1991	Fujita et al.	280/735
5,103,305	A	4/1992	Watanabe	358/105
5,118,134	A	6/1992	Mattes et al.	280/735
5,162,861	A	11/1992	Tamburino et al.	356/5.05
5,181,254	A	1/1993	Schweizer et al.	382/1
5,185,667	A	2/1993	Zimmermann	348/143
5,193,124	A	3/1993	Subbarao	382/41
5,214,744	A	5/1993	Schweizer et al.	395/21
5,227,784	A	7/1993	Masamori et al.	340/903
5,235,339	A	8/1993	Morrison et al.	342/159
5,249,027	A	9/1993	Mathur et al.	356/3.14
5,249,157	A	9/1993	Taylor	340/903
5,298,732	A	3/1994	Chen	250/203.4
5,305,012	A	4/1994	Faris	345/7
5,309,137	A	* 5/1994	Kajiwara	340/436
5,329,206	A	7/1994	Slotkowski et al.	315/159
5,330,226	A	7/1994	Gentry et al.	280/735
5,339,075	A	8/1994	Abst et al.	340/903
5,355,118	A	10/1994	Fukuhara	340/435
5,390,136	A	2/1995	Wang	364/754
5,441,052	A	8/1995	Miyajima	128/661.09
5,446,661	A	8/1995	Gioutsos et al.	364/424.05
5,454,591	A	10/1995	Mazur et al.	280/735
5,463,384	A	* 10/1995	Juds	340/903
5,473,515	A	* 12/1995	Liu	362/80.1
5,482,314	A	1/1996	Corrado et al.	280/735
5,497,305	A	* 3/1996	Pastrick et al.	362/83.1
5,528,698	A	6/1996	Kamei et al.	382/100
5,531,472	A	7/1996	Semchena et al.	280/735
5,537,003	A	7/1996	Bechtel et al.	315/82
5,550,677	A	8/1996	Schofield et al.	359/604
5,563,650	A	10/1996	Poelstra	348/36
5,653,462	A	8/1997	Breed et al.	280/735
5,706,144	A	* 1/1998	Brandin	359/843
5,785,347	A	7/1998	Adolph et al.	280/735
5,821,633	A	10/1998	Burke et al.	307/10.1
5,829,782	A	11/1998	Breed et al.	280/735
5,835,613	A	11/1998	Breed et al.	382/100
5,845,000	A	12/1998	Breed et al.	382/100
5,848,802	A	12/1998	Breed et al.	280/735
5,877,897	A	* 3/1999	Schofield et al.	359/604
5,943,295	A	8/1999	Varga et al.	367/99
5,949,331	A	* 9/1999	Schofield et al.	340/461
5,954,360	A	9/1999	Griggs, III et al.	280/735
5,959,367	A	* 9/1999	O'Farrell et al.	307/10.1
5,983,147	A	11/1999	Krumm	701/45
6,005,958	A	12/1999	Farmer et al.	382/103
6,007,095	A	12/1999	Stanley	280/735
6,020,812	A	2/2000	Thompson et al.	340/438
6,027,138	A	2/2000	Tanaka et al.	280/735

6,029,105	A	2/2000	Schweizer	701/45
6,087,953	A	* 7/2000	Deline et al.	340/815.4
6,111,517	A	8/2000	Atick et al.	340/825.34
6,113,137	A	9/2000	Mizutani et al.	280/735
6,115,552	A	9/2000	Kaneda	396/82
2002/0154379	A1	* 10/2002	Tonar et al.	359/267

FOREIGN PATENT DOCUMENTS

GB	2289332	11/1995	
JP	360166806	8/1985	
JP	3-42337	2/1991	180/273
JP	407055573 A	3/1995	
JP	2001-325700	11/2001	
WO	94/22693	10/1994	
WO	0196147	12/2001	

OTHER PUBLICATIONS

Learned Classification of Sonar Targets Using a Massively Parallel Network, R. Paul Gorman et al., IEEE Transactions on Acoustics, Speech and Signal Processing, vol. 36, No. 7, Jul., 1988, pp 1135-1140.

"How Airbags Work", David S. Breed, Presented at the Canadian Association of Road Safety Professionals, Oct. 19, 1992-Oct. 20, 1992.

Intelligent System for Video Monitoring of Vehicle Cockpit, S. Boverie et al., SAE Paper No. 980613, Feb., 1998.

Omnidirectional Vision Sensor for Intelligent Vehicles, T. Ito et al., 1998 IEEE International Conference on Intelligent Vehicles, pp. 365-370, 1998.

A 256x256 CMOS Brightness Adaptive Imaging Array with Column-Parallel Digital Output, C. Sodini et al., 1998 IEEE International Conference on Intelligent Vehicles, 1998, pp. 347-352.

Derwent Abstract of German Patent Publication No. DE 42 11 556, Oct. 7, 1993.

Derwent Abstract of Japanese patent application No. 02-051332, Nov. 13, 1991.

3D Perception for Vehicle Inner Space Monitoring, S. Boverie et al., Advanced Microsystems for Automotive Applications 2000, Apr., 2000, pp. 157-172.

Low-Cost High Speed CMOS Camera for Automotive Applications, N. Stevanovic et al., Advanced Microsystems for Automotive Applications 2000, Apr., 2000, pp. 173-180.

New Powerful Sensory Tool in Automotive Safety Systems Based on PMD-Technology, R. Schwarte et al., Advanced Microsystems for Automotive Applications 2000, Apr., 2000, pp. 181-203.

An Interior Compartment Protection System Based on Motion Detection Using CMOS Imagers, S. B. Park et al., 1998 IEEE International Conference on Intelligent Vehicles. Sensing Automobile Occupant Position with Optical Triangulation, W. Chapelle et al., Sensors, Dec. 1995.

Intelligent System for Video Monitoring of Vehicle Cockpit, S. Boverie et al., SAE Paper No. 980613, Feb. 23-26, 1998. A 256x256 CMOS Brightness Adaptive Imaging Array with Column-Parallel Digital Output, CG. Sodini et al., 1998 IEEE International Conference on Intelligent Vehicles.

The FERET Evaluation Methodology for Face-Recognition Algorithms, P.J. Phillips et al., NISTIR 6264, Jan. 7, 1999. The Technology Review Ten: Biometrics, J. Atick, Jan./Feb. 2001.

* cited by examiner

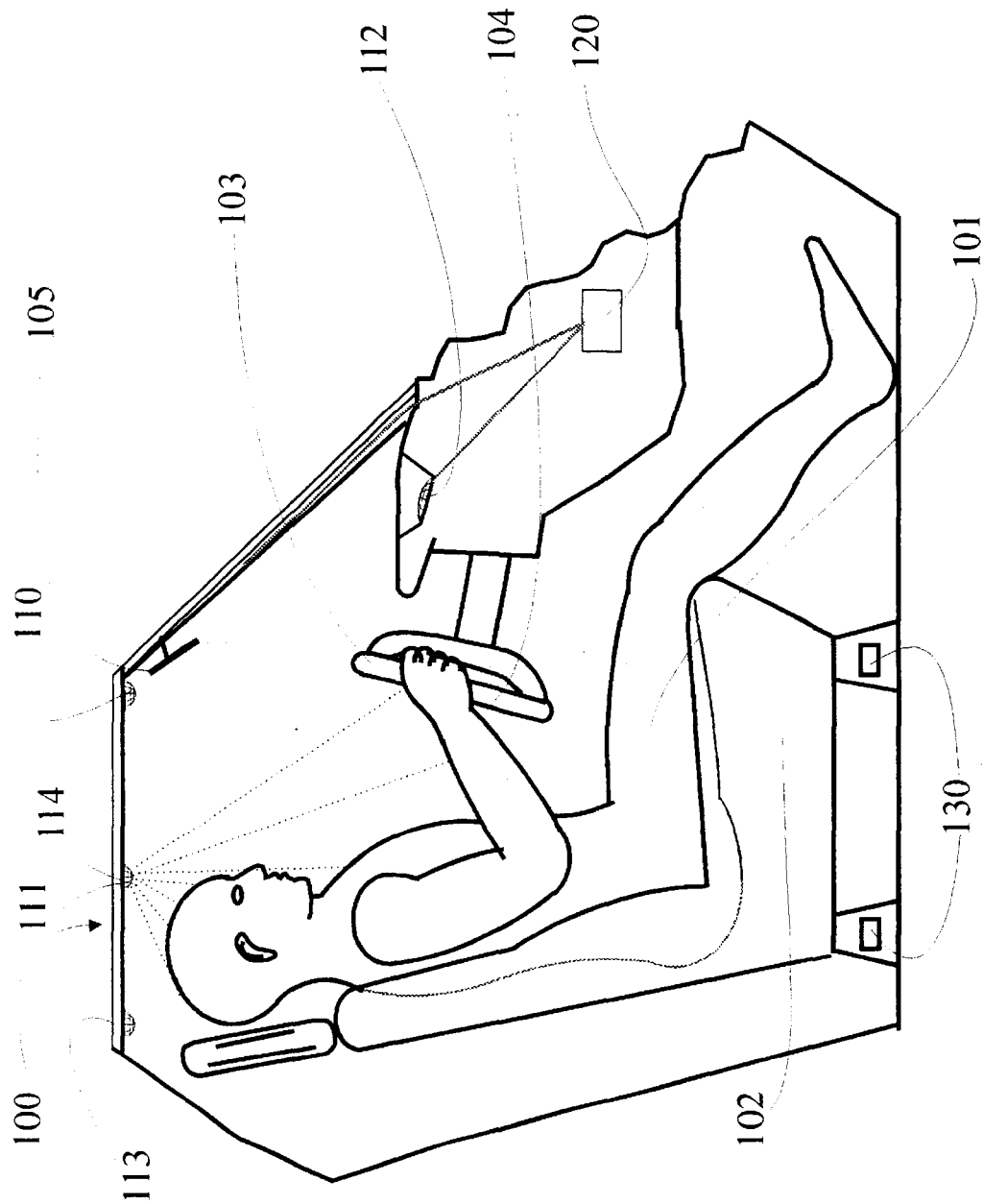


FIG. 1A

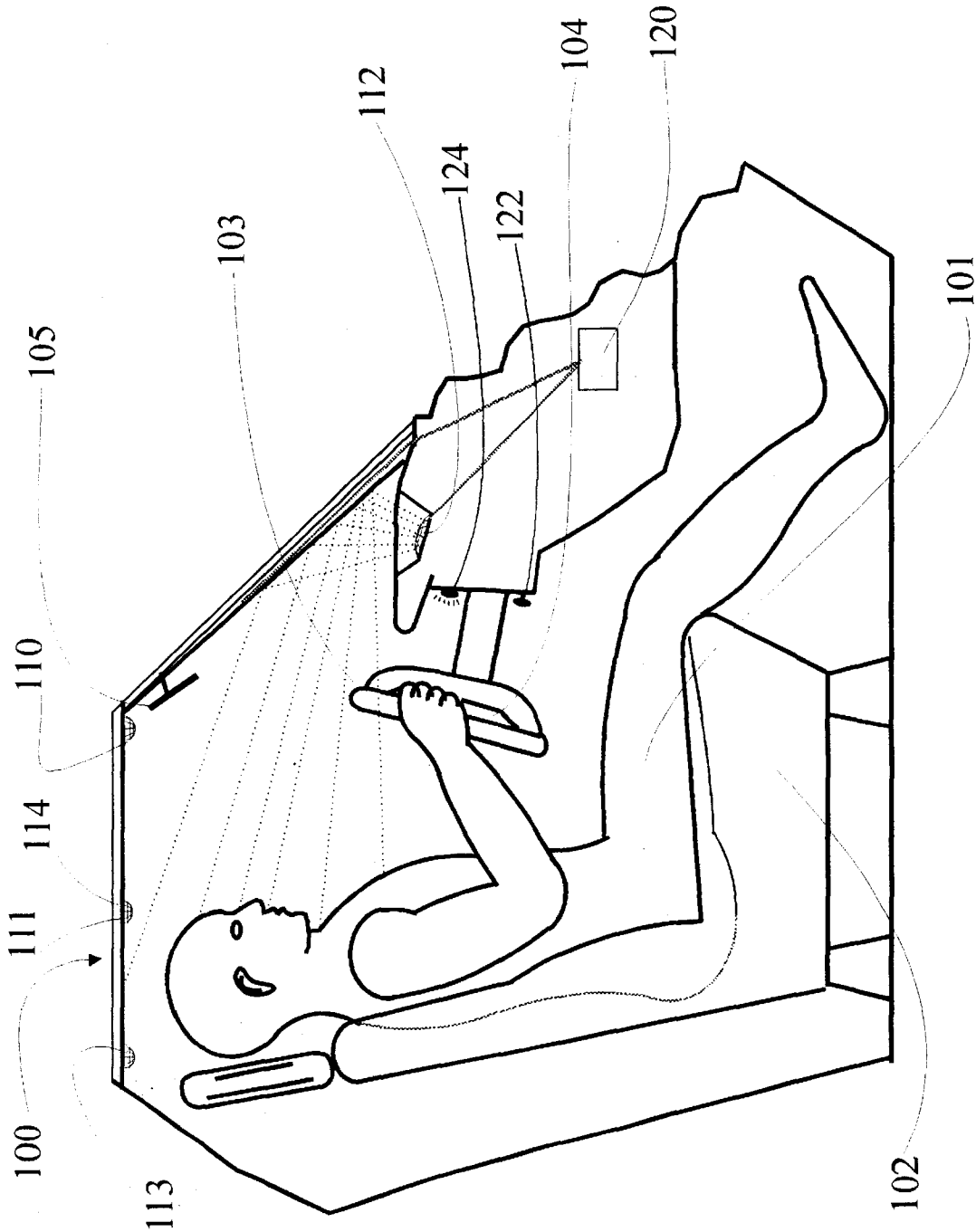


FIG. 1B

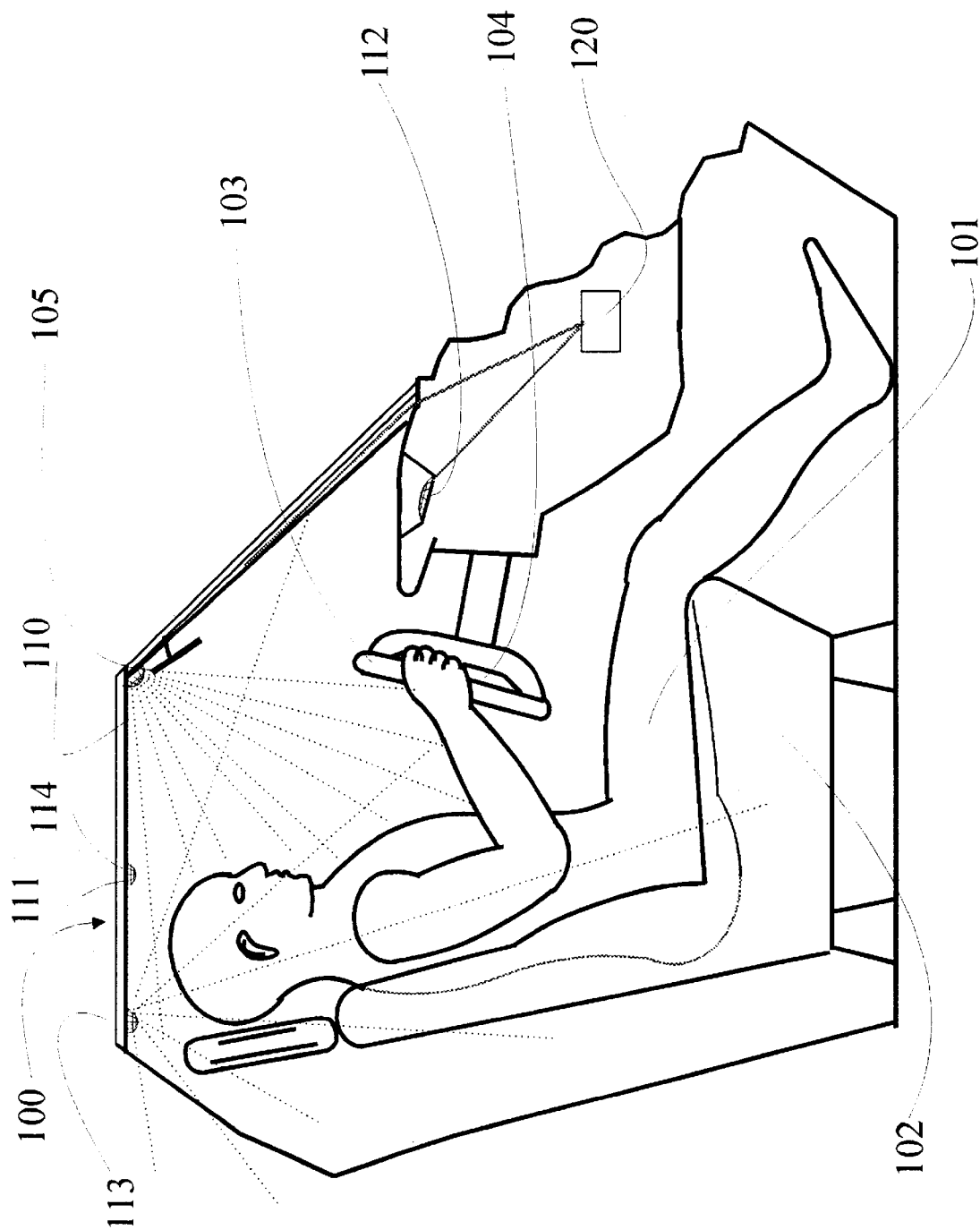


FIG. 1C

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.