



[54] VEHICLE NAVIGATION SYSTEM AND METHOD

[75] Inventors: Steven R. Croyle, Franklin; Larry E. Spencer, II, Lake Orion; Ernie R. Sittaro, Romeo, all of Mich.

[73] Assignee: Magellan DIS, Inc., Rochester Hills, Mich.

[21] Appl. No.: 580,150

[22] Filed: Dec. 28, 1995

[51] Int. Cl.⁶ G06G 7/48

[52] U.S. Cl. 701/213; 701/214; 701/215; 701/208; 73/178 R

[58] Field of Search 364/460, 461, 364/444.1, 449.1, 450, 447, 449.7, 449.3, 454, 453, 448, 440, 443; 340/988, 990, 995; 73/178 R; 342/357, 457, 352, 451; 701/207, 208, 213, 214, 215, 221, 220, 216

[56] References Cited

U.S. PATENT DOCUMENTS

3,749,893	7/1973	Hileman	235/150.27
3,789,198	1/1974	Henson et al.	235/150.27
3,845,289	10/1974	French	235/151.2
3,984,806	10/1976	Tyler	340/23
4,032,758	6/1977	Lewis	235/150.2
4,086,632	4/1978	Lions	364/444
4,107,689	8/1978	Jellinek	343/112 TC

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

0 059 435	9/1982	European Pat. Off. .
0 061 564 1	10/1982	European Pat. Off. .
0 069 965	1/1983	European Pat. Off. .
0 103 847	3/1984	European Pat. Off. .
0110 171	6/1984	European Pat. Off. .
0 118 886	9/1984	European Pat. Off. .
0181012	5/1986	European Pat. Off. .
0 471 405	2/1992	European Pat. Off. .

(List continued on next page.)

OTHER PUBLICATIONS

Integration of GPS and Dead Reckoning Navigation Systems by Wei-Wen Kao published Jan. 10, 1991 in the Institute of Electrical and Electronics Engineers.
 Brochure: Fleet-Trak: Fleet Management System.
 McLellan, et al., Application of GPS Positioning to Management of Mobile Operations, pp. 1-16; 1991.
 Stanley K. Honey; A Novel Approach to Automotive Navigation and Map Display, pp. 40-43.
 Siemens, Ali-Scout System;
 G. C. Larson; Evaluation of an AVM System Implemented City-Wide in St. Louis, pp. 378-383.
 Brochure: NavTrax 1000 Fleet Management System.

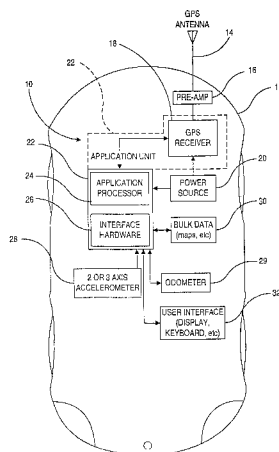
(List continued on next page.)

Primary Examiner—Jacques H. Louis-Jacques
Attorney, Agent, or Firm—Howard & Howard

[57] ABSTRACT

The improved vehicle navigation system and method uses information from a Global Positioning System (GPS) to obtain velocity vectors, which include speed and heading components, for "dead reckoning" the vehicle position from a previous position. If information from the GPS is not available, then the improved vehicle navigation system uses information from an orthogonal axes accelerometer, such as two or three orthogonally positioned accelerometers, to propagate vehicle position. Because the GPS information should almost always be available, the improved vehicle navigation system relies less on its accelerometers, thereby allowing the use of less expensive accelerometers. The improved vehicle navigation system retains the accuracy of the accelerometers by repeatedly calibrating them with the velocity data obtained from the GPS information. The improved vehicle navigation system calibrates the sensors whenever GPS data is available (for example, once a second at relatively high speeds). Furthermore, the improved vehicle navigation system does not need to rely on map matching to calibrate sensors. System flexibility is improved because map matching is oblivious to the hardware, and the system hardware can be updated without affecting map matching or a change in the map database.

17 Claims, 13 Drawing Sheets



U.S. PATENT DOCUMENTS

4,253,150	2/1981	Scovill	364/449
4,254,465	3/1981	Land	364/453
4,301,506	11/1981	Turco	364/436
4,312,577	1/1982	Fitzgerald	353/12
4,351,027	9/1982	Gay et al.	364/432
4,369,441	1/1983	Wohlmut	340/733
4,403,291	9/1983	Von Tomkewitsch	364/424
4,504,913	3/1985	Miura et al.	364/449
4,513,377	4/1985	Hasebe et al.	364/449
4,528,552	7/1985	Moriyama et al.	340/525
4,543,572	9/1985	Tanaka et al.	340/723
4,546,439	10/1985	Esparza	364/444
4,570,227	2/1986	Tachi et al.	364/444
4,571,684	2/1986	Takanabe et al.	364/449
4,608,656	8/1986	Tanaka et al.	364/449
4,639,773	1/1987	Hurst	358/105
4,646,089	2/1987	Takanabe et al.	340/995
4,660,037	4/1987	Nakamura	340/990
4,675,676	6/1987	Takanabe et al.	340/995
4,711,125	12/1987	Morrison	73/178 R
4,758,959	7/1988	Thoone et al.	364/454
4,796,191	1/1989	Honey et al.	364/450
4,814,989	3/1989	Dobereiner et al.	364/444
4,819,175	4/1989	Wuttke	364/449
4,847,769	7/1989	Reeve	364/424.02
4,890,104	12/1989	Takanabe et al.	340/995
4,899,285	2/1990	Nakayama et al.	364/453
4,903,212	2/1990	Yokouchi et al.	342/327
4,930,085	5/1990	Kleinschmidt	342/358
4,949,268	8/1990	Nishikawa et al.	364/449
4,954,833	9/1990	Evans et al.	342/357
4,989,151	1/1991	Nuimura	364/449
5,014,205	5/1991	Sindlinger et al.	364/449
5,023,798	6/1991	Neukirchner et al.	364/449
5,046,011	9/1991	Kakihara et al.	364/449
5,058,023	10/1991	Kozikaro	364/450
5,075,693	12/1991	McMillan et al.	342/457
5,109,344	4/1992	Kakihara et al.	364/449
5,111,209	5/1992	Toriyama	342/357
5,119,102	6/1992	Barnard	342/357
5,166,882	11/1992	Stambaugh	701/220
5,179,519	1/1993	Adachi et al.	701/216
5,185,610	2/1993	Ward et al.	342/357
5,220,509	6/1993	Takemura et al.	701/216
5,233,844	8/1993	Mansell et al.	342/357
5,257,195	10/1993	Hirata	701/216
5,276,451	1/1994	Odagawa	342/357
5,278,424	1/1994	Kagawa	250/561
5,311,195	5/1994	Mathis et al.	342/357
5,317,515	5/1994	Matsuzaki	364/454
5,331,563	7/1994	Masumoto et al.	342/457
5,334,986	8/1994	Fernhout	342/357
5,337,243	8/1994	Shibata et al.	364/449
5,361,212	11/1994	Class et al.	364/460
5,367,463	11/1994	Tsuji	701/216
5,383,127	1/1995	Shibata	364/449
5,416,712	5/1995	Geier et al.	701/216
5,422,814	6/1995	Sprage et al.	364/460
5,434,788	7/1995	Seymour et al.	701/207
5,469,158	11/1995	Morita	364/460
5,483,457	1/1996	Shibata et al.	364/449.7
5,485,161	1/1996	Vaughn	364/449.7
5,488,559	1/1996	Seymour	364/450
5,508,931	4/1996	Snider	364/450
5,512,903	4/1996	Schmidtke	701/221
5,523,765	6/1996	Ichikawa	364/449.7
5,525,998	6/1996	Geier	364/449.7
5,539,647	7/1996	Shibata et al.	701/221
5,563,607	10/1996	Loomis et al.	701/213
5,583,776	12/1996	Levi et al.	364/450

5,594,453	1/1997	Rodal et al.	342/357
5,596,500	1/1997	Sprague et al.	701/213
5,629,708	5/1997	Rodal et al.	342/357

FOREIGN PATENT DOCUMENTS

0488594	6/1992	European Pat. Off.	.
0 496 538	7/1992	European Pat. Off.	.
0 514 887	11/1992	European Pat. Off.	.
0527558	2/1993	European Pat. Off.	.
0 544 403	6/1993	European Pat. Off.	.
0 567 268	10/1993	European Pat. Off.	.
3242904 A1	11/1982	Germany	.
3912108	4/1989	Germany	.
57-158875	9/1982	Japan	.
58009017	1/1983	Japan	.
58-27008	2/1983	Japan	.
58-113711	7/1983	Japan	.
58-11969	7/1983	Japan	.
58-78213	10/1983	Japan	.
60-135817	7/1985	Japan	.
59-28244	3/1995	Japan	.
1 470 694	4/1977	United Kingdom	.
2 014 309	8/1979	United Kingdom	.
2144 007	2/1985	United Kingdom	.
2 115 946	9/1993	United Kingdom	.
WO 92/10824	6/1992	WIPO	.

OTHER PUBLICATIONS

Lezniak, et al.; A Dead Reckoning/Map Correlation System for Automatic Vehicle Tracking; pp. 47-60.

May, 1973; Vehicular Technology; Antarctic Navigation; pp. 36-41.

R. L. French; MAP Matching Origins Approaches and Applications; pp. 91-116.

Sep. 1974; R. L. Fey; Automatic Vehicle Location Techniques for Law Enforcement Use; pp. 1-22.

Tsumura, An Experimental System for Automatic Guidance of Ground Vehicle Following the Commanded Guidance Route on Map, pp. 2425-2430.

Totani et al.; Automotive Navigation System; pp. 469-477.

K. Mitamura et al.; SAE Technical Paper Series; The Driver Guide System; pp. 1-9.

Thoone; CARIN, a car information and navigation system; Philips Technical Review; vol. 43, No. 11/12, Dec. 1987; pp. 317-329.

T. Tsumura, et al.; A System for Measuring Current Position and/or Heading of Vehicles; pp. 3-8.

Edward N. Skomal; Automatic Vehicle Locating Systems; pp. 1-12, 65-98, 319-320.

AGARD; No. 176; Medium Accuracy Low Cost Navigation; pp. 28-1 to 28-31.

K. Tagami; et al.; New Navigation Technology to Advance Utilization of Passenger Cars; pp. 413-422.

Tagami et al.; SAE Technical Paper Series; "Electro Gyro-Cator" New Inertial Navigation System etc; pp. 1-15.

AGARD; W. M. Aspin Comed-A Combined Display Including a Full Electronic Facility etc.; pp. 30-1 to 30-11.

Evans; Chrysler Laser Atlas Satellite System (C.L.A.S.S.). pp. 1-31.

R. L. French; The Evolution of Automobile Navigation, 1992, Arlington, Virginia.

R. L. French, et al.; A Comparison of IVHS Progress in the United States, Japan and Europe.etc. Mar. 1994 pp. 17-22.

M. Shibita; et al; Current Status and Future Plans for Digital Map Databases in Japan; Oct. 1993 pp. 29-33.

Itoh, The Development of the Drive Guide System (japanese with English summary). 1989.

- Business Week Magazine; Space-Age Navigation for the Family Car; pp. 82-84, 1984.
- Journal: Nissan Technical Review; The Development of a New Multi-AV System, 1991.
- Buxton, et al., The Travepilot: A Second-Generation Automotive Navigation System, 1991.
- Pilsak, Eva-An Electronic Traffic Pilot for Motorists, 1986.
- French, The Evolving Roles of Vehicular Navigation, 1987, pp. 212, 216.
- Claussen, et al.; Status and Directions of Digital Map Databases in Europe; 1993, pp. 25-28.
- Jarvis, et al., Cathode-Ray Tube Information Center with Automotive Navigation, pp. 123-137.
- Dork, Satellite Navigation Systems for Land Vehicles; 1987, pp. 2-5.
- French, Automobile Navigation: Where is it Going? 1987, pp. 6-12.
- LaHaije, et al., Efficient Road-Map Management for a Car Navigation System, pp. 477-491.
- French, et al., Automatic Route Control System; 1973, pp. 36-41.
- Tsumura, et al., Automatic Vehicle Guidance—Commanded Map Routing, pp. 62-67.
- Sugie, et al., CARGuide—on board computer for automobile route guidance, pp. 695-706.
- McLellan, et al., Fleet Management Trials in Western Canada; pp. 797-806.
- Skomal, Comparative Analysis of Six Commercially Available Systems; pp. 34-45.
- Krause, et al. Veloc—A Vehicle Location and Fleet Management System.
- Dittloff, et al., Veloc—A New Kind of Information System; pp. 181-187; 1992.
- Article: Vehicle Positioning High Level Map Matching Design Document; pp. 1-25; 195.
- Brown, Low Cost Vehicle Location and Tracking using GPS; 1992.

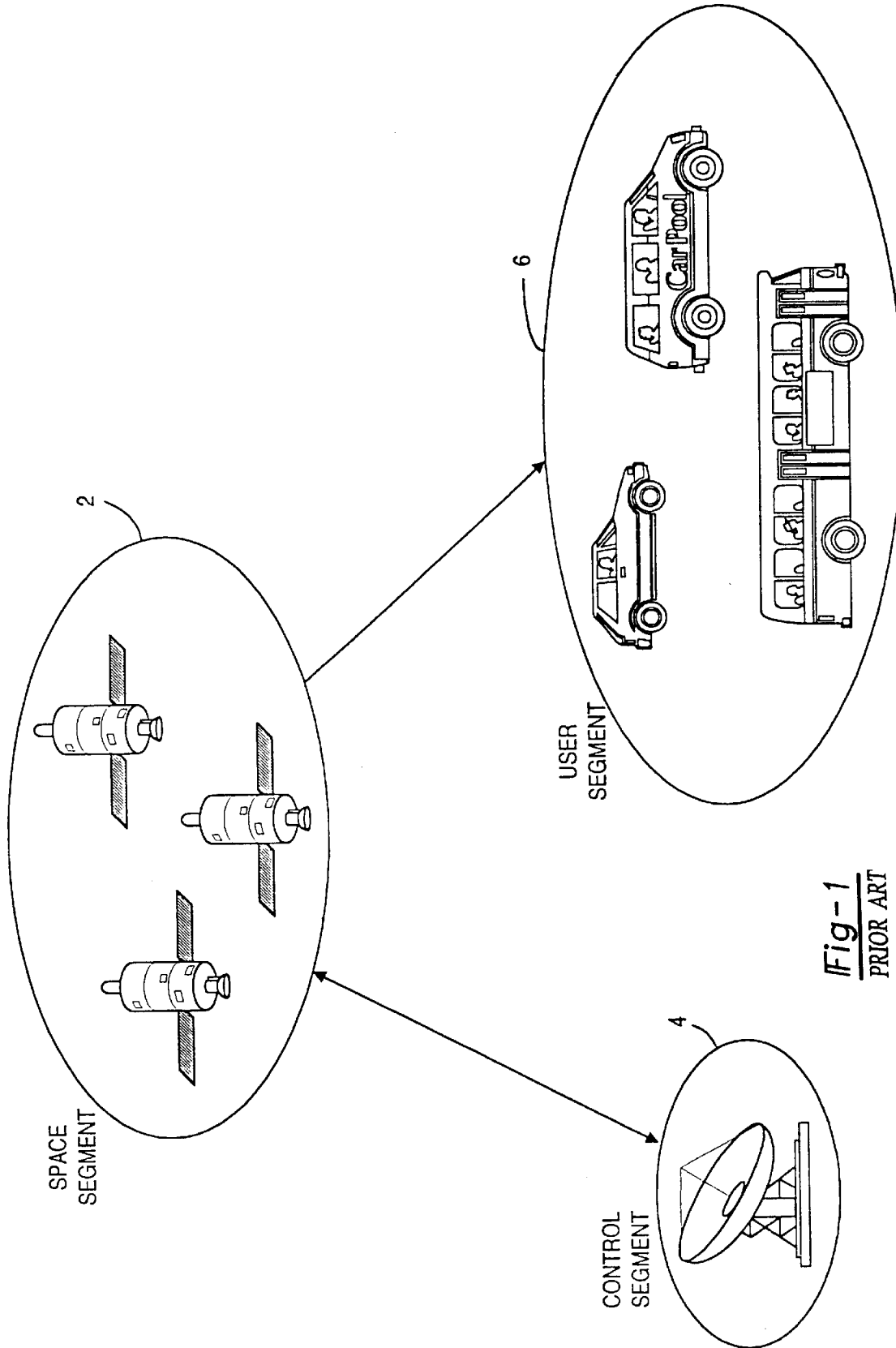


Fig-1
PRIOR ART

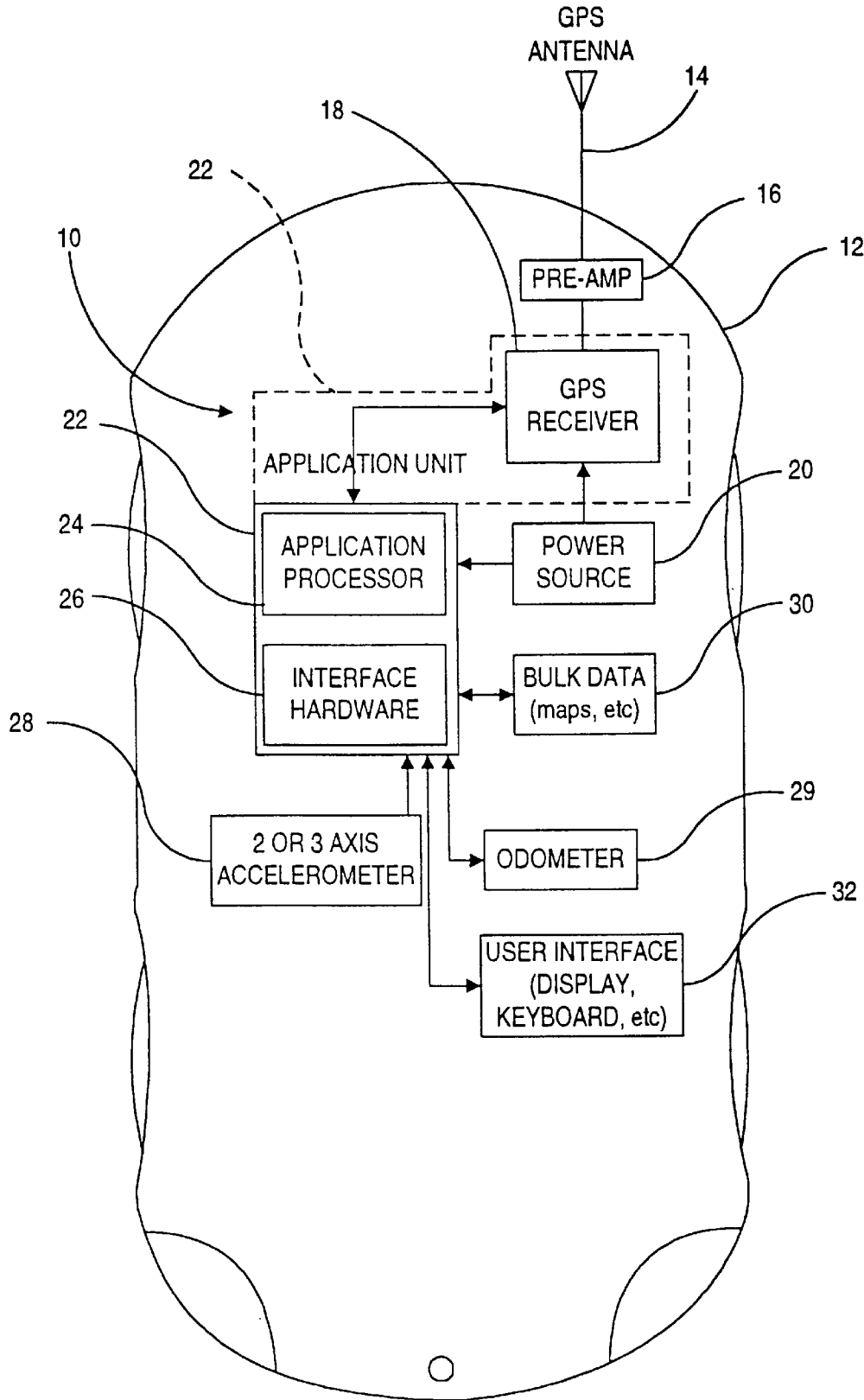


Fig-2a

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.