



US007524320B2

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

(10) **Patent No.:** **US 7,524,320 B2**  
(45) **Date of Patent:** **\*Apr. 28, 2009**

(54) **MECHANICAL ACTUATOR INTERFACE SYSTEM FOR ROBOTIC SURGICAL TOOLS**

(75) Inventors: **Michael J. Tierney**, Pleasanton, CA (US); **Thomas G. Cooper**, Menlo Park, CA (US); **Chris A. Julian**, Los Gatos, CA (US); **Stephen J. Blumenkranz**, Redwood City, CA (US); **Gary S. Guthart**, Foster City, CA (US); **Robert G. Younge**, Portola Valley, CA (US)

(73) Assignee: **Intuitive Surgical, Inc.**, Sunnyvale, CA (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1036 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/316,666**

(22) Filed: **Dec. 10, 2002**

(65) **Prior Publication Data**

US 2003/0083673 A1 May 1, 2003

**Related U.S. Application Data**

(60) Continuation of application No. 09/929,453, filed on Aug. 13, 2001, now Pat. No. 7,048,745, which is a division of application No. 09/418,726, filed on Oct. 15, 1999, now Pat. No. 6,331,181.

(60) Provisional application No. 60/111,713, filed on Dec. 8, 1998.

(51) **Int. Cl.**  
**A61B 19/00** (2006.01)

(52) **U.S. Cl.** ..... **606/130; 606/1**

(58) **Field of Classification Search** ..... **606/1, 606/130; 700/259, 260, 263**

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,038,987 A 8/1977 Komiya

(Continued)

FOREIGN PATENT DOCUMENTS

JP 7-194610 8/1995

(Continued)

OTHER PUBLICATIONS

Alexander, Arthur D., III., "Impacts of Telem Manipulation on Modern Society," *International Centre for Mechanical Sciences, Courses and Lectures* No. 201, vol. II, pp. 122-136 (Sep. 5-8, 1973).

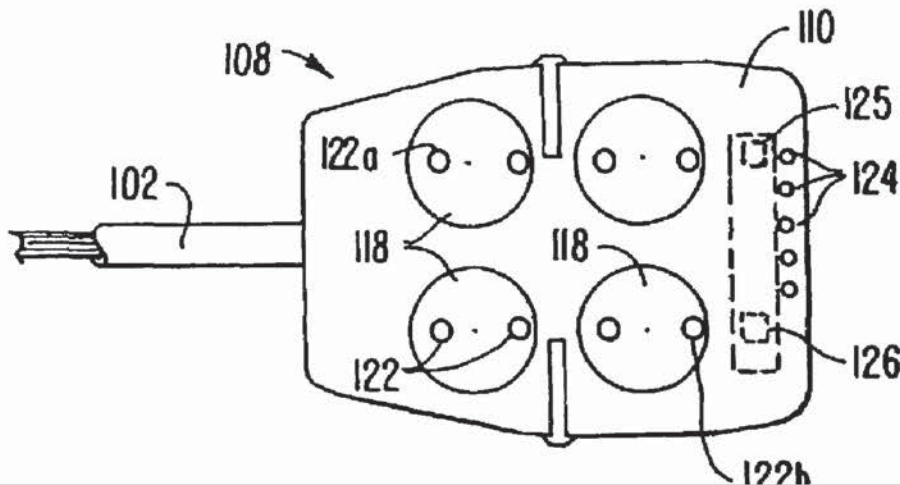
(Continued)

*Primary Examiner*—Eduardo C Robert  
*Assistant Examiner*—James L Swiger, III

(57) **ABSTRACT**

Robotic surgical tools, systems, and methods for preparing for and performing robotic surgery include a memory mounted on the tool. The memory can perform a number of functions when the tool is loaded on the tool manipulator: first, the memory can provide a signal verifying that the tool is compatible with that particular robotic system. Secondly, the tool memory may identify the tool-type to the robotic system so that the robotic system can reconfigure its programming. Thirdly, the memory of the tool may indicate tool-specific information, including measured calibration offsets indicating misalignment of the tool drive system, tool life data, or the like. This information may be stored in a read only memory (ROM), or in a nonvolatile memory which can be written to only a single time. The invention further provides improved engagement structures for coupling robotic surgical tools with manipulator structures.

**31 Claims, 22 Drawing Sheets**



U.S. PATENT DOCUMENTS

4,149,278 A 4/1979 Wiker et al.  
 4,281,447 A 8/1981 Miller et al.  
 4,332,066 A 6/1982 Hailey et al.  
 4,367,998 A 1/1983 Causer  
 4,386,933 A 6/1983 Sanchez  
 4,456,960 A 6/1984 Wakai  
 4,486,928 A 12/1984 Tucker et al.  
 4,500,065 A 2/1985 Hennekes et al.  
 4,511,305 A 4/1985 Kawai et al.  
 4,512,709 A 4/1985 Hennekes et al.  
 4,706,372 A 11/1987 Ferrero et al.  
 4,710,093 A 12/1987 Zimmer et al.  
 4,744,363 A 5/1988 Hasson  
 4,751,925 A 6/1988 Tontarra  
 4,766,775 A 8/1988 Hodge  
 4,793,053 A 12/1988 Zuccaro et al.  
 4,809,747 A 3/1989 Choly et al.  
 4,830,569 A 5/1989 Jannborg  
 4,832,198 A 5/1989 Alikhan  
 4,837,703 A 6/1989 Kakazu et al.  
 4,928,546 A 5/1990 Walters  
 4,943,939 A 7/1990 Hoover  
 4,979,949 A 12/1990 Matsen, III et al.  
 4,996,975 A 3/1991 Nakamura  
 5,018,266 A 5/1991 Hutchinson et al.  
 5,078,140 A 1/1992 Kwoh  
 5,086,401 A \* 2/1992 Glassman et al. .... 700/259  
 5,143,453 A 9/1992 Weynant née Girones  
 5,154,717 A 10/1992 Matsen, III et al.  
 5,155,693 A 10/1992 Altmayer et al.  
 5,174,300 A 12/1992 Bales et al.  
 5,184,601 A 2/1993 Putman  
 5,217,003 A 6/1993 Wilk  
 5,221,283 A 6/1993 Chang  
 5,236,432 A 8/1993 Matsen, III et al.  
 5,243,266 A \* 9/1993 Kasagami et al. .... 318/568.1  
 5,255,429 A 10/1993 Nishi et al.  
 5,257,998 A 11/1993 Ota et al.  
 5,271,384 A 12/1993 McEwen et al.  
 5,294,209 A 3/1994 Naka et al.  
 5,305,203 A 4/1994 Raab  
 5,312,212 A 5/1994 Naumec  
 5,313,935 A 5/1994 Kortenbach et al.  
 5,337,732 A 8/1994 Grundfest et al.  
 5,339,799 A \* 8/1994 Kami et al. .... 600/117  
 5,343,385 A 8/1994 Joskowicz et al.  
 5,354,314 A 10/1994 Hardy et al.  
 5,355,743 A 10/1994 Tesar  
 5,359,993 A 11/1994 Slater et al.  
 5,372,147 A 12/1994 Lathrop, Jr. et al.  
 5,397,323 A 3/1995 Taylor  
 5,399,951 A 3/1995 Lavallee et al.  
 5,400,267 A 3/1995 Denen et al.  
 5,402,801 A 4/1995 Taylor  
 5,403,319 A 4/1995 Matsen, III et al.  
 5,417,210 A 5/1995 Funda et al.  
 5,427,097 A 6/1995 Depp  
 5,451,368 A 9/1995 Jacob  
 5,520,678 A 5/1996 Heckele et al.  
 5,617,857 A 4/1997 Chader et al.  
 5,624,398 A 4/1997 Smith et al.  
 5,630,431 A \* 5/1997 Taylor ..... 128/897  
 5,631,973 A 5/1997 Green  
 5,649,956 A 7/1997 Jensen et al.  
 5,690,635 A 11/1997 Baumgarten et al.  
 5,695,500 A 12/1997 Taylor et al.  
 5,695,501 A 12/1997 Carol et al.

5,697,939 A 12/1997 Kubota et al.  
 5,710,870 A \* 1/1998 Ohm et al. .... 700/263  
 5,762,458 A 6/1998 Wang et al.  
 5,784,542 A \* 7/1998 Ohm et al. .... 700/260  
 5,792,135 A 8/1998 Madhani et al.  
 5,797,900 A 8/1998 Madhani et al.  
 5,800,423 A 9/1998 Jensen  
 5,807,377 A 9/1998 Madhani et al.  
 5,808,665 A 9/1998 Green  
 5,814,038 A 9/1998 Jensen et al.  
 5,817,084 A 10/1998 Jensen  
 5,855,583 A 1/1999 Wang et al.  
 5,876,325 A 3/1999 Mizuno et al.  
 5,878,193 A 3/1999 Wang et al.  
 5,976,122 A 11/1999 Madhani et al.  
 6,132,368 A 10/2000 Cooper  
 6,151,981 A 11/2000 Costa  
 6,246,200 B1 6/2001 Blumenkranz et al.  
 6,259,806 B1 \* 7/2001 Green ..... 382/128  
 6,331,181 B1 12/2001 Tierney et al.  
 6,346,072 B1 2/2002 Cooper  
 6,370,411 B1 4/2002 Osadchy et al.  
 6,398,726 B1 \* 6/2002 Ramans et al. .... 600/229  
 6,424,885 B1 7/2002 Niemeyer et al.  
 6,434,507 B1 8/2002 Clayton et al.  
 6,468,265 B1 \* 10/2002 Evans et al. .... 606/1  
 6,491,701 B2 12/2002 Tierney et al.  
 6,554,844 B2 \* 4/2003 Lee et al. .... 606/130  
 6,699,177 B1 3/2004 Wang et al.  
 6,738,656 B1 5/2004 Ferre et al.  
 6,866,671 B2 3/2005 Tierney et al.  
 2002/0032452 A1 3/2002 Tierney et al.

FOREIGN PATENT DOCUMENTS

WO WO 93/13916 7/1993  
 WO WO 94/26167 11/1994  
 WO WO 95/16396 6/1995  
 WO WO 95/30964 11/1995  
 WO WO 96/39944 12/1996  
 WO WO 97/29710 8/1997  
 WO WO 98/25666 6/1998  
 WO WO 99/50721 10/1999  
 WO WO 00/33755 6/2000

OTHER PUBLICATIONS

Madhani et al., "The black falcon: A teleoperated surgical instrument for minimally invasive surgery" (submitted to IROS 1998) 9 pages total.  
 Moyer, T.H., Thesis entitled "The design of an integrated hand and wrist mechanism" for Master of Science in Mechanical Engineering at the Massachusetts Institute of Technology (1992) pp. 1-106.  
 Neisius et al., "Robotic manipulator for endoscopic handling of surgical effectors and cameras" Proceedings of the First International Symposium on Medical Robotics and Computer Assisted Surgery, vol. 2, Workshop (Part I & II)- Session VI, pp. 169-175.  
 Salisbury, J.K., "Kinematic and force analysis of articulated hands" Department of Computer Science, Stanford University, Report No. STAN-CS-82-921 (1982) Chapter 9, pp. 67-77.  
 Thring, "Robots and telechirs: Manipulators with memory; remote manipulators; machine limbs for the handicapped" (1993) M.W. Thring/Ellis Horwood Ltd. pp. 9-11, 122-131, 194-195, 235-257, 274-279.  
 "Task 2: Miniature end effector—A preliminary design" pp. 32-47.  
 Vertut, Jean and Coeffet, Philippe Coiffet; "Robot Technology; vol. 3A Teleoperation and Robotics Evolution and Development"; 1986; Prentice-Hall, Inc; Englewood Cliffs, N.J.

\* cited by examiner



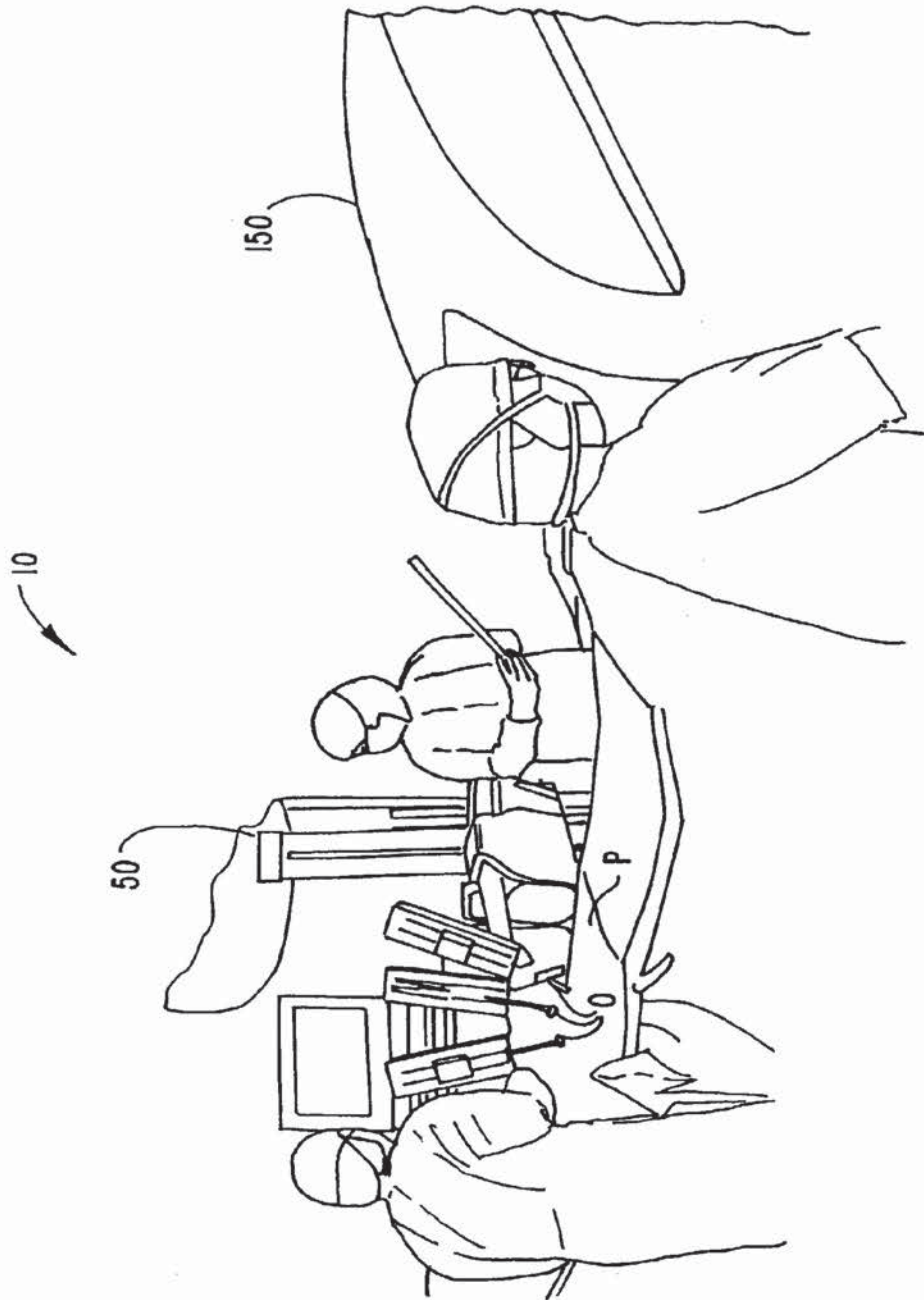


FIG. 1.

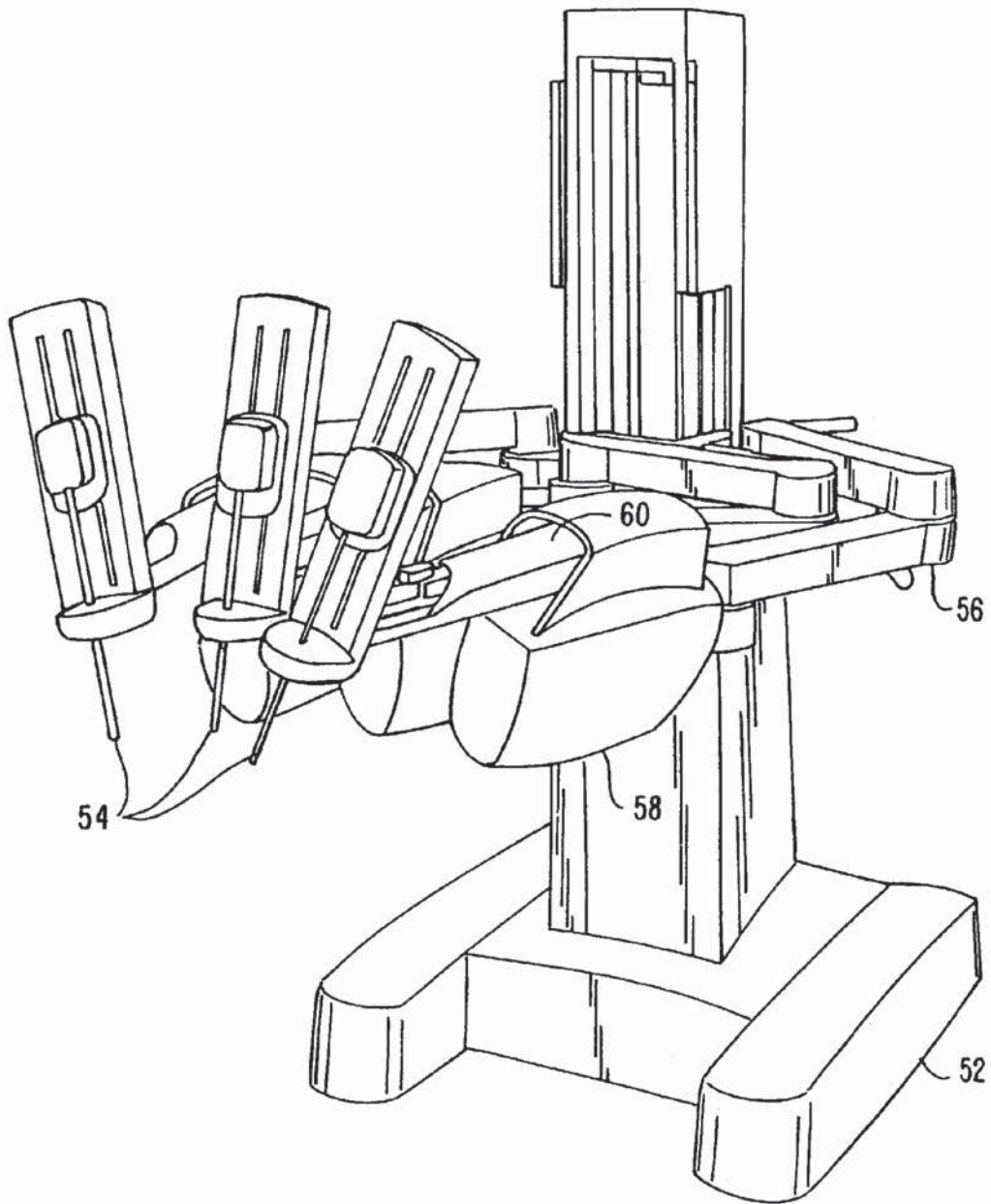


FIG. 2.

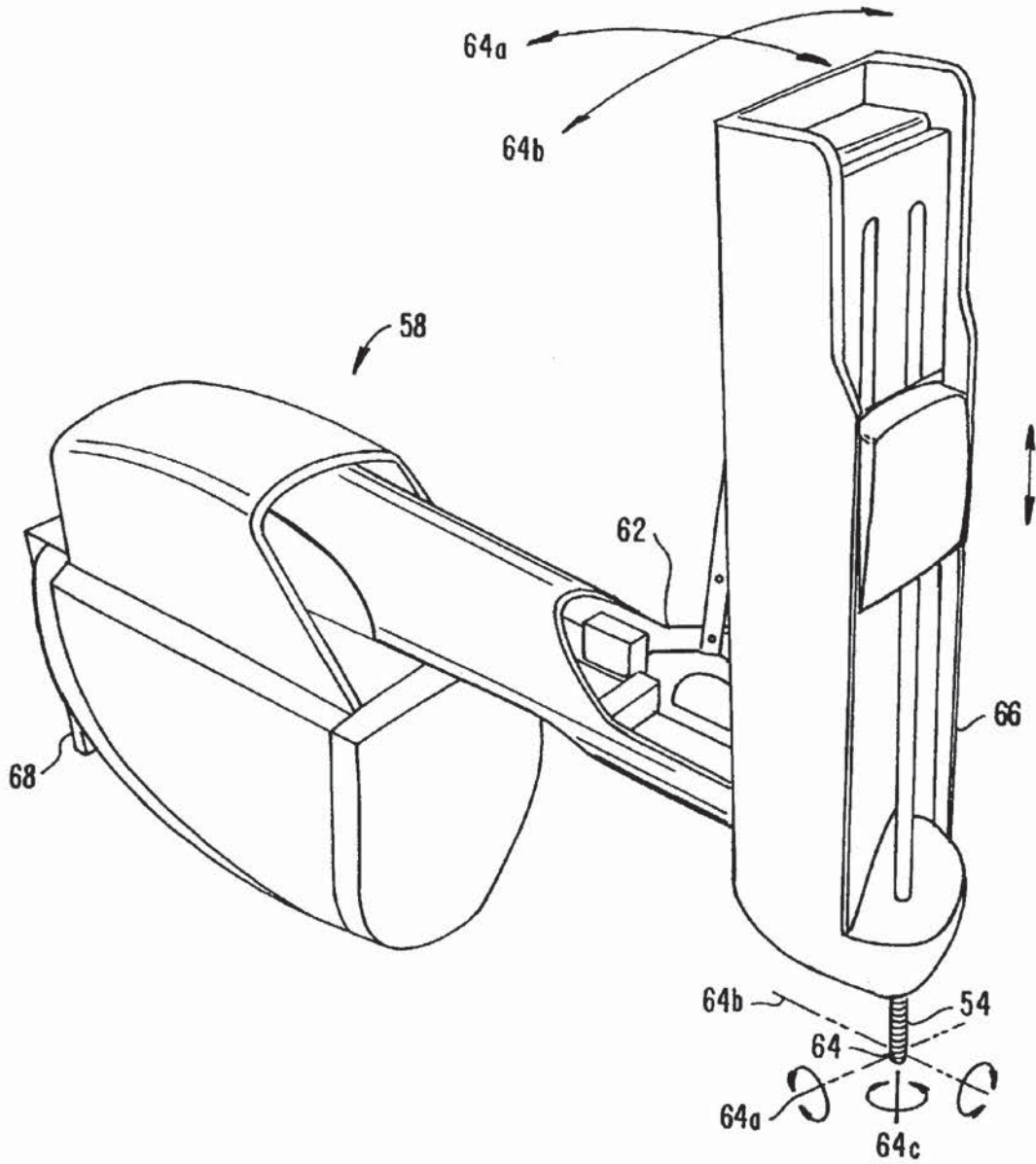


FIG. 2A.

# 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.