



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 Telemanipulation on Modern Society," *International Centre for Mechanical Sciences*, Courses and Lectures No. 201, vol. II, pp. 122-136 (Sep. 5-8, 1973).

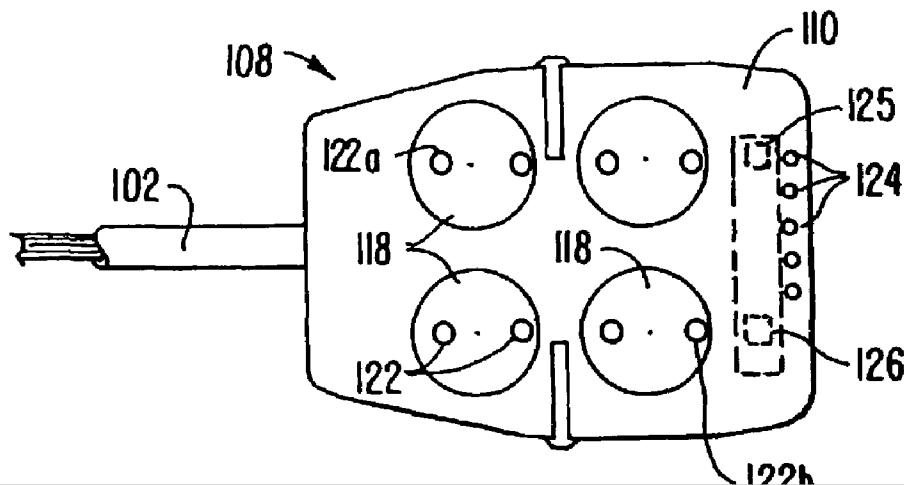
(Continued)

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

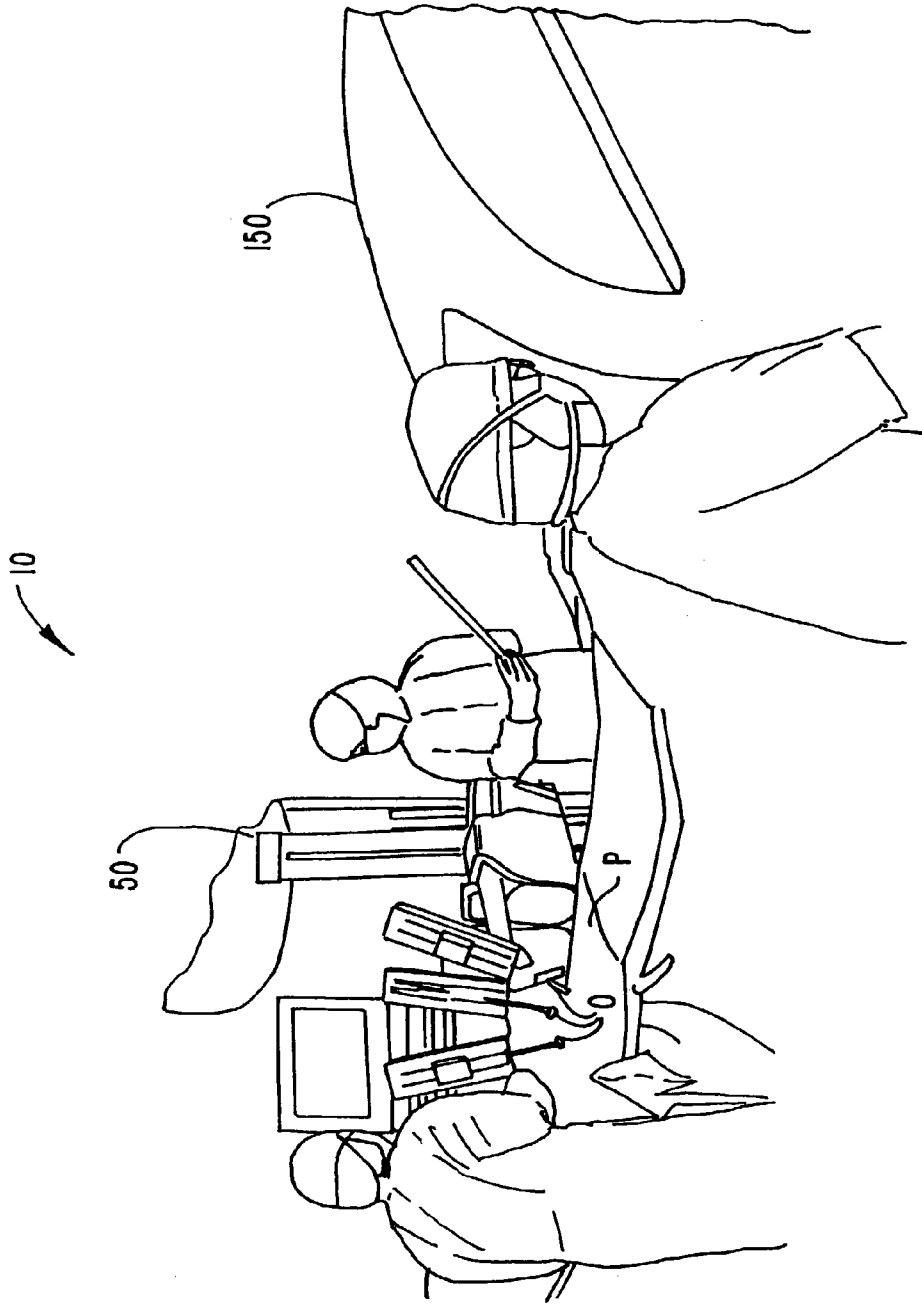


FIG. 1.

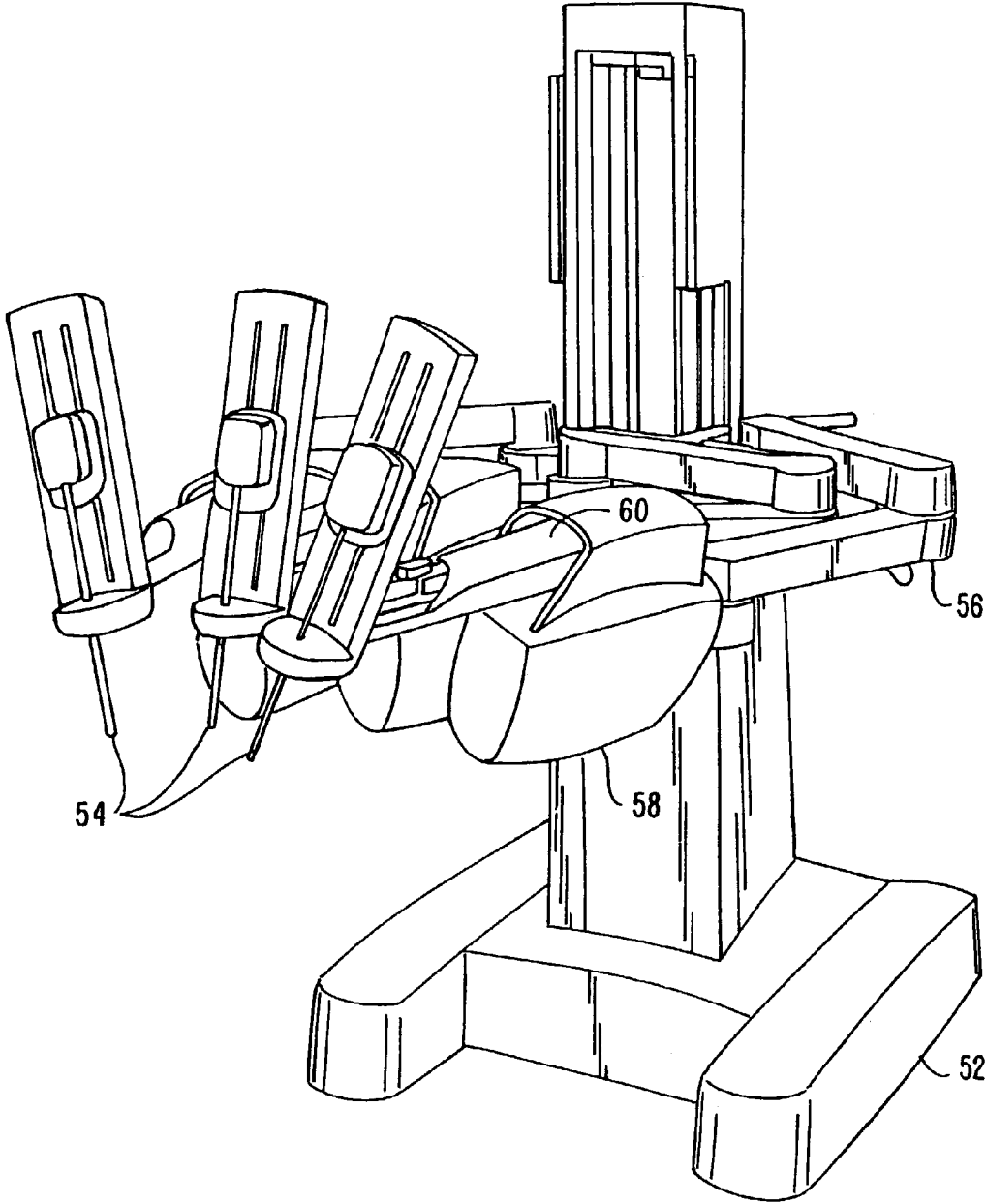


FIG. 2.

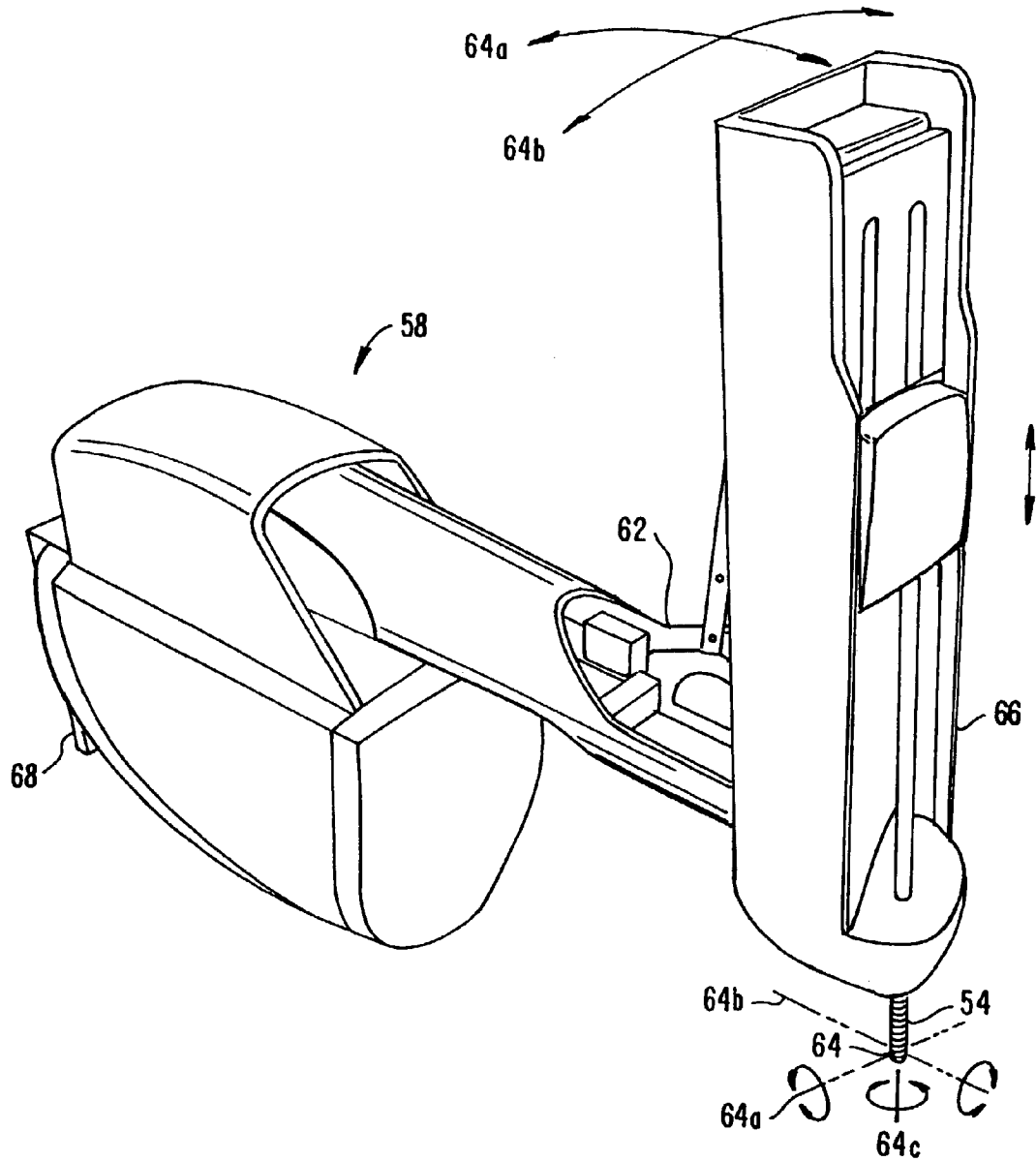


FIG. 2A.

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.