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

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This patent is subject to a terminal disclaimer.

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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.

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(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).

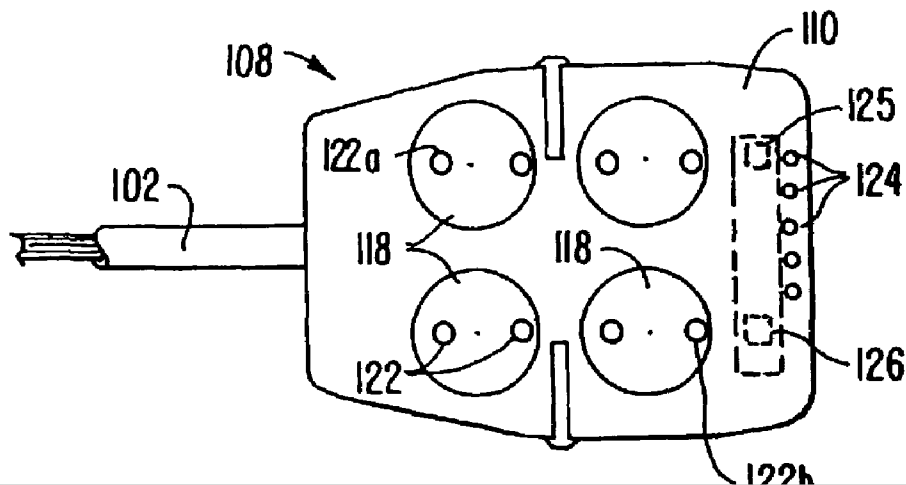
(Continued)

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(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 Heckeles 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

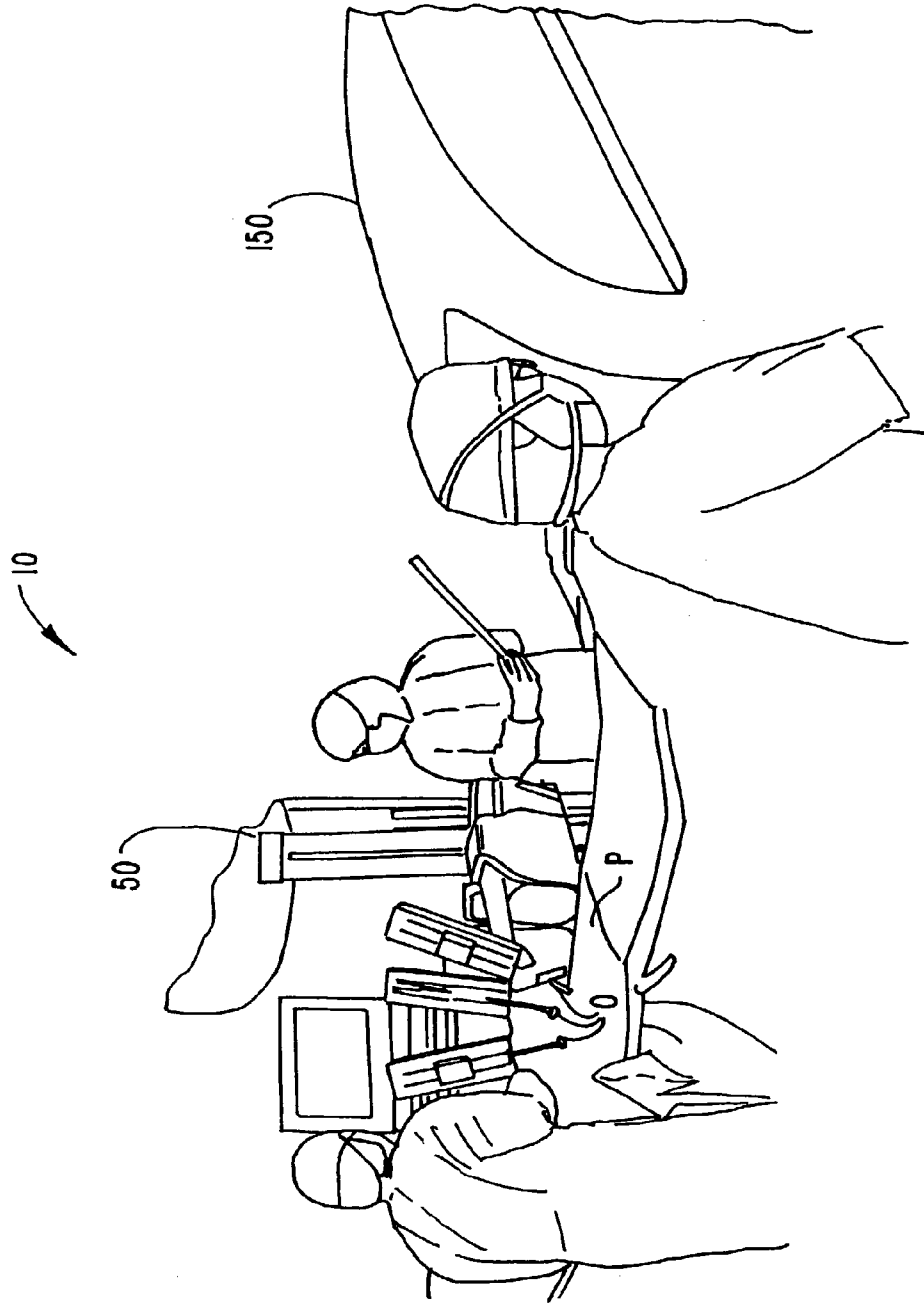


FIG. 1.

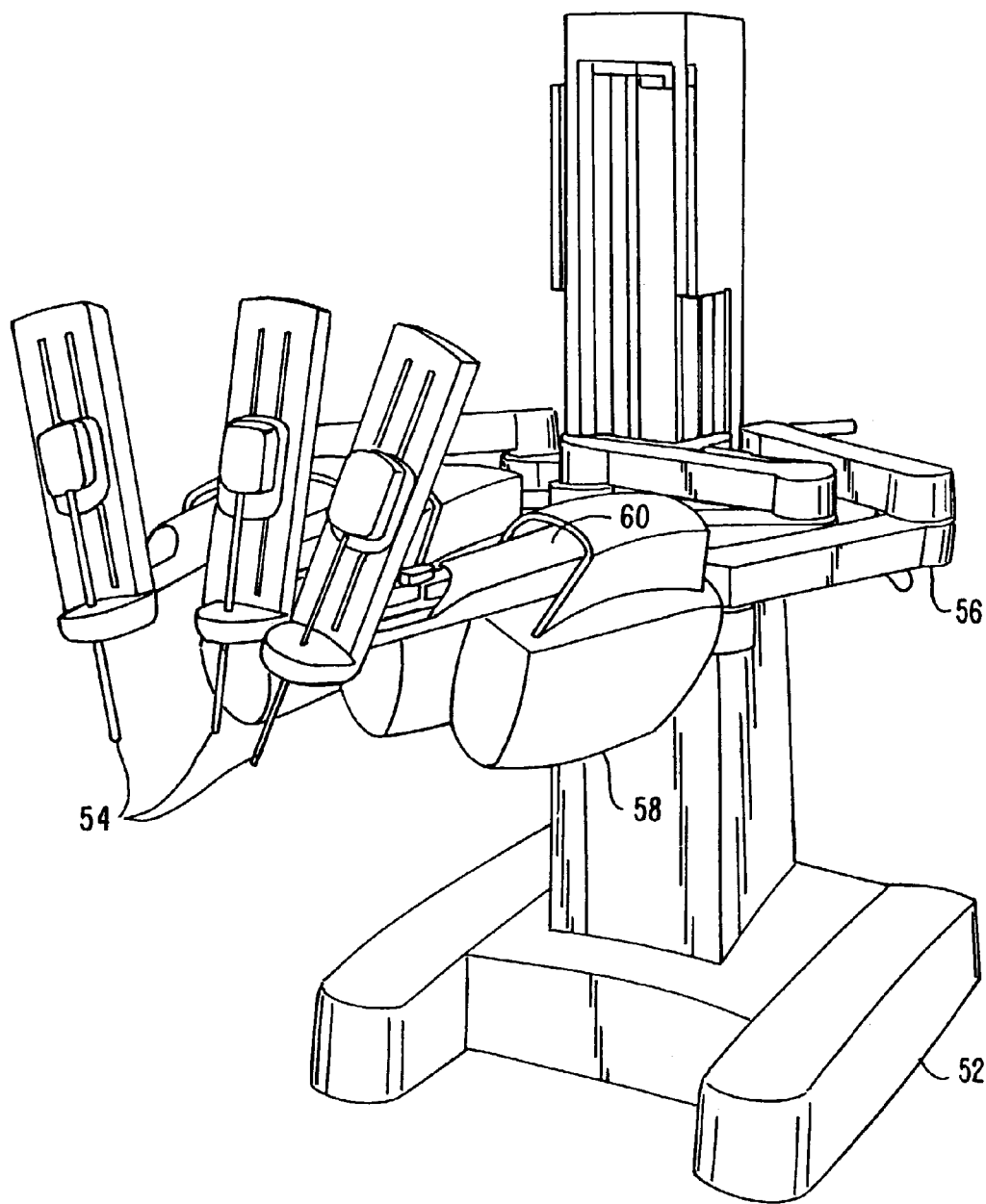


FIG. 2.

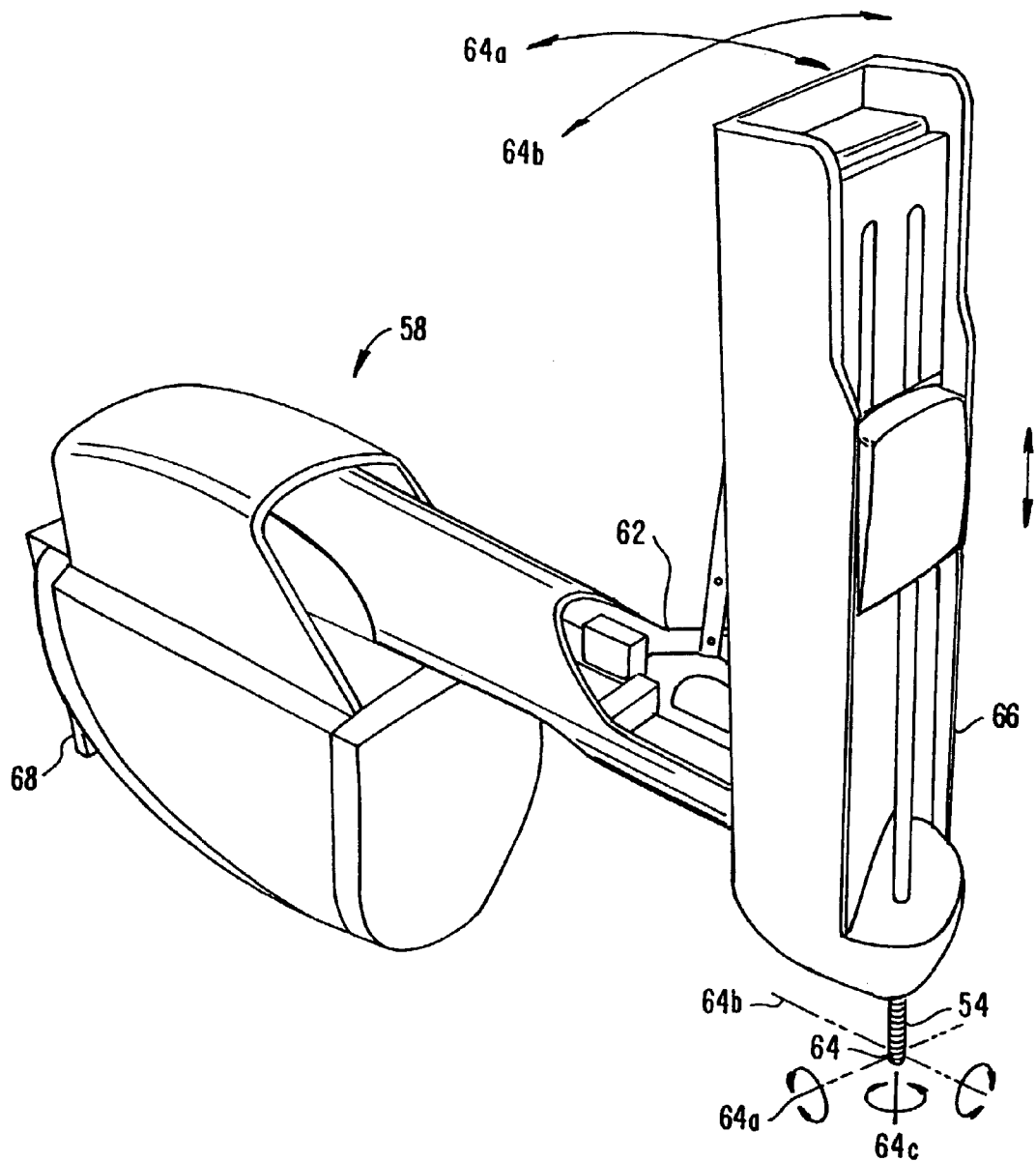


FIG. 2A.

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