



US006783524B2

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

(10) **Patent No.:** **US 6,783,524 B2**
(45) **Date of Patent:** **Aug. 31, 2004**

(54) **ROBOTIC SURGICAL TOOL WITH
ULTRASOUND CAUTERIZING AND
CUTTING INSTRUMENT**

(75) Inventors: **Stephen C. Anderson**, Northampton,
MA (US); **Christopher A. Julian**, Los
Gatos, 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 0 days.

(21) Appl. No.: **10/126,499**

(22) Filed: **Apr. 18, 2002**

(65) **Prior Publication Data**

US 2002/0177843 A1 Nov. 28, 2002

Related U.S. Application Data

(60) Provisional application No. 60/285,485, filed on Apr. 19,
2001.

(51) **Int. Cl.**⁷ **A61B 18/04**

(52) **U.S. Cl.** **606/28; 606/1**

(58) **Field of Search** 606/1-19, 49-52

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,038,987 A	8/1977	Komiya
4,149,278 A	4/1979	Frosch 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
4,486,928 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

(List continued on next page.)

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 99/50721	10/1999

OTHER PUBLICATIONS

Madhani et al., "The black falcon: A teleoperated surgical
instrument for minimally invasive surgery" (submitted to
IROS 1998) 9 pages total.

(List continued on next page.)

Primary Examiner—Roy D. Gibson

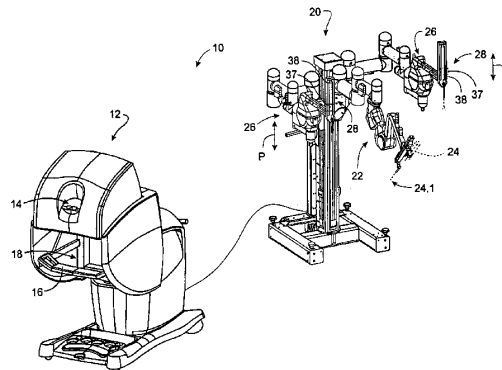
Assistant Examiner—Pete Vrettakos

(74) *Attorney, Agent, or Firm*—Townsend&Townsend&CrewLLP; Nathan S.
Cassell, Esq.

(57) **ABSTRACT**

A surgical instrument for enhancing robotic surgery generally includes an elongate shaft with an ultrasound probe, an end effector at the distal end of the shaft, and a base at the proximal end of the shaft. The end effector includes an ultrasound probe tip and the surgical instrument is generally configured for convenient positioning of the probe tip within a surgical site by a robotic surgical system. Ultrasound energy delivered by the probe tip may be used to cut, cauterize, or achieve various other desired effects on tissue at a surgical site. In various embodiments, the end effector also includes a gripper, for gripping tissue in cooperation with the ultrasound probe tip. The base is generally configured to removably couple the surgical instrument to a robotic surgical system and to transmit forces from the surgical system to the end effector, through the elongate shaft. A method for enhancing robotic surgery generally includes coupling the surgical instrument to a robotic surgical system, positioning the probe tip in contact with tissue at a surgical site, and delivering ultrasound energy to the tissue.

19 Claims, 28 Drawing Sheets



U.S. PATENT DOCUMENTS

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	
5,143,453 A	9/1992	Weynait	
5,154,717 A	10/1992	Matsen, III et al.	
5,174,300 A	12/1992	Bales et al.	
5,217,003 A	6/1993	Wilk	
5,221,283 A	6/1993	Chang	
5,236,432 A	8/1993	Matsen, III et al.	
5,255,429 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.	
5,322,055 A	6/1994	Davison et al.	
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.	
5,624,398 A	* 4/1997	Smith et al.	604/95.01
5,631,973 A	5/1997	Green	
5,649,956 A	* 7/1997	Jensen et al.	606/205
5,695,500 A	12/1997	Taylor et al.	
5,697,939 A	12/1997	Kubota et al.	
5,762,458 A	6/1998	Wang et al.	
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	
5,808,665 A	9/1998	Green	
5,845,646 A	* 12/1998	Lemelson	128/899
5,876,325 A	3/1999	Mizuno et al.	
6,056,735 A	* 5/2000	Okada et al.	606/1
6,058,323 A	* 5/2000	Lemelson	600/408
6,066,151 A	5/2000	Miyawaki et al.	
6,096,033 A	* 8/2000	Tu et al.	606/31
6,129,735 A	* 10/2000	Okada et al.	606/169
6,132,368 A	10/2000	Cooper	
6,139,561 A	10/2000	Shibata et al.	
6,165,191 A	12/2000	Shibata et al.	
6,193,709 B1	2/2001	Miyawaki et al.	
6,280,407 B1	8/2001	Manna et al.	
6,319,227 B1	* 11/2001	Mansouri-Ruiz	604/95.01
6,331,181 B1	12/2001	Tierney et al.	
6,394,998 B1	5/2002	Wallace et al.	
6,454,717 B1	* 9/2002	Pantages et al.	600/466
6,491,701 B2	* 12/2002	Tierney et al.	606/130

OTHER PUBLICATIONS

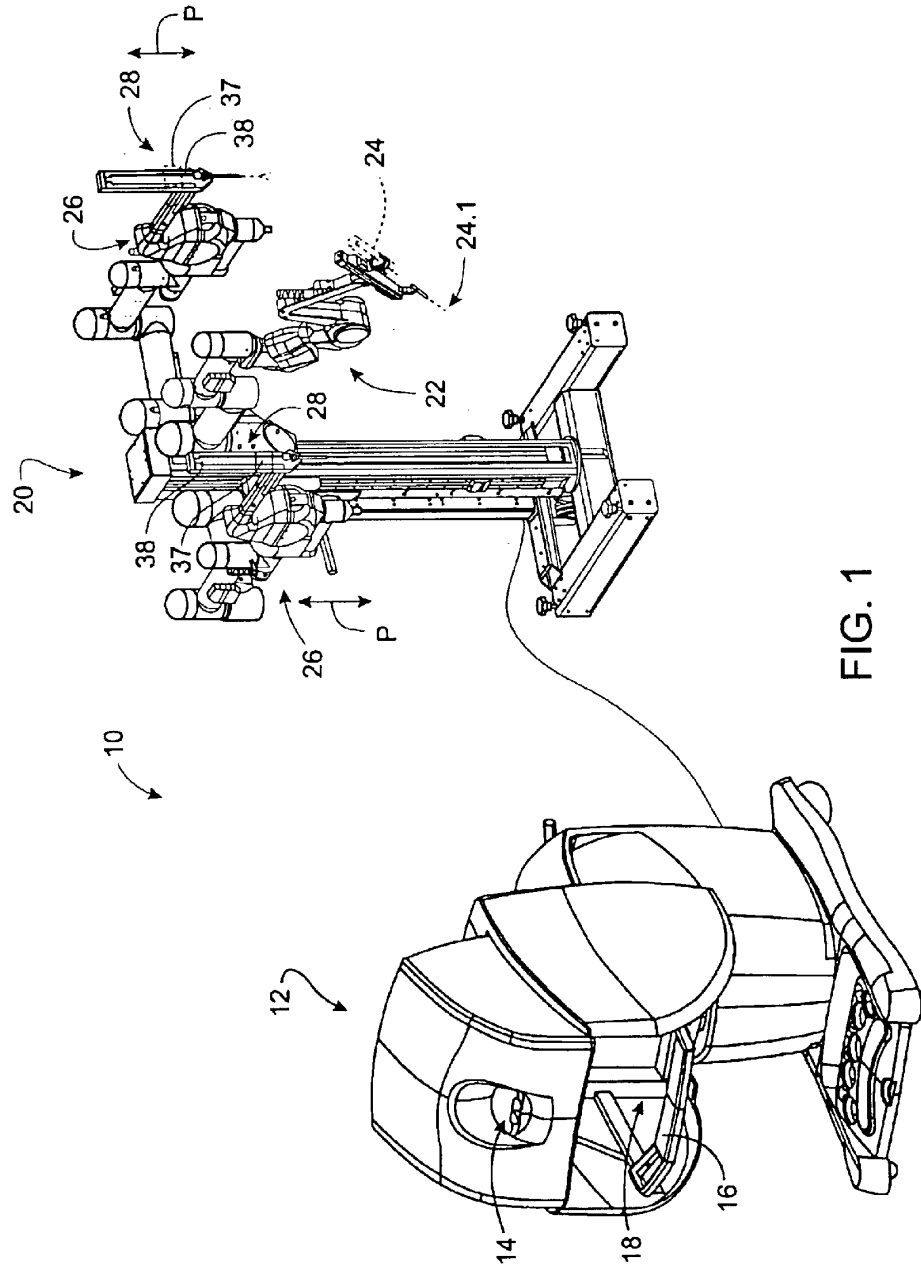
Moyer, T.H., Thesis entitled "The design of an integrated hand and wrist mechanism" for Master of Science in Mechanical Engineering at the Massachusetts Institute of Technology (1992) pp. 1-106.

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-89-921 (1982) Chapter 9, pp. 67-77.

Thring, "Robots and telechairs: 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.

* cited by examiner



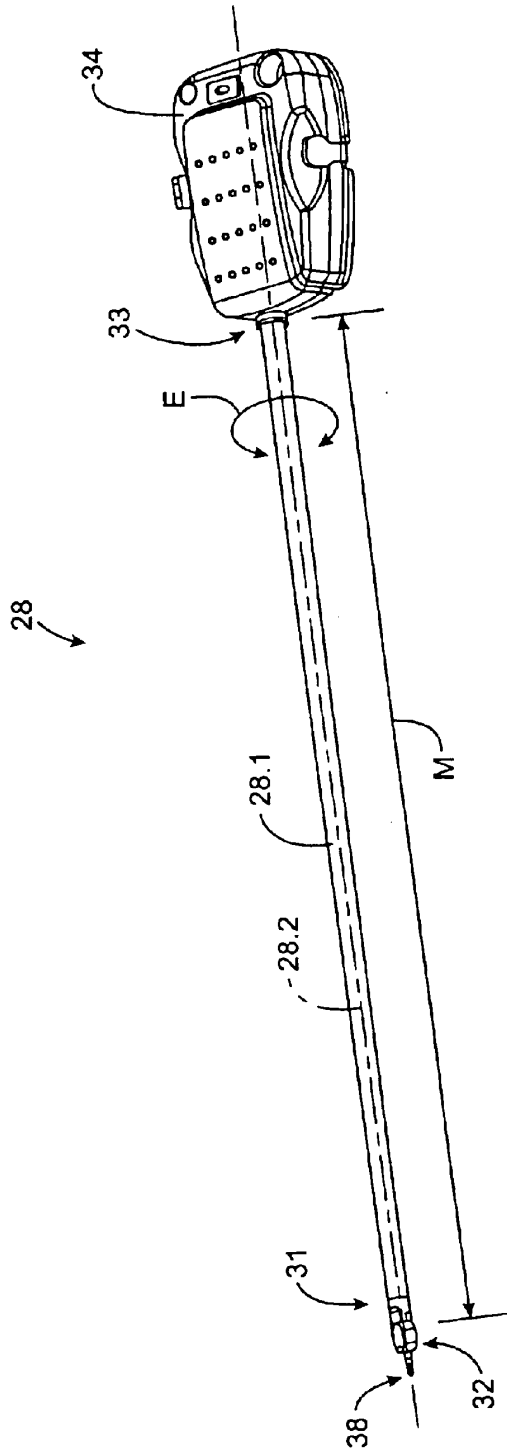


FIG. 2

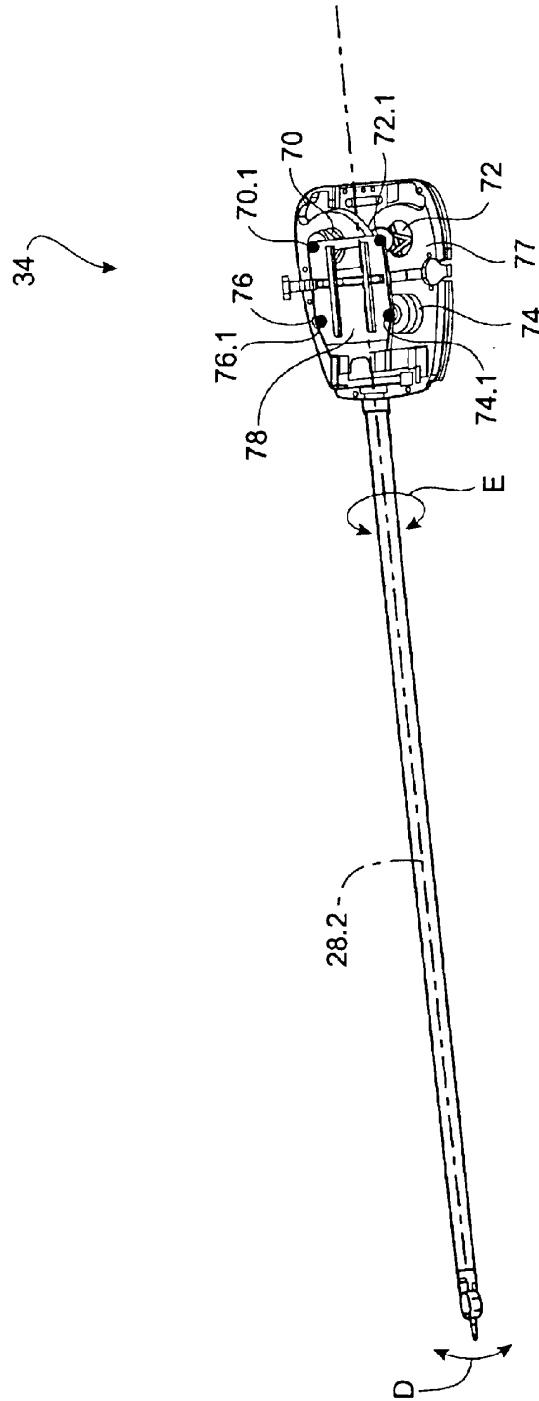


FIG. 3

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.