



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	Causser
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

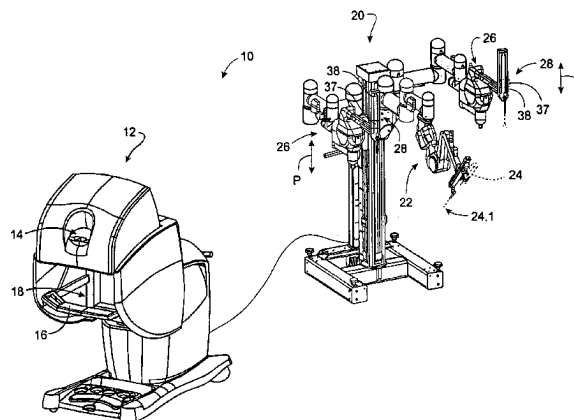
Assistant Examiner—Pete Vrettakos

(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

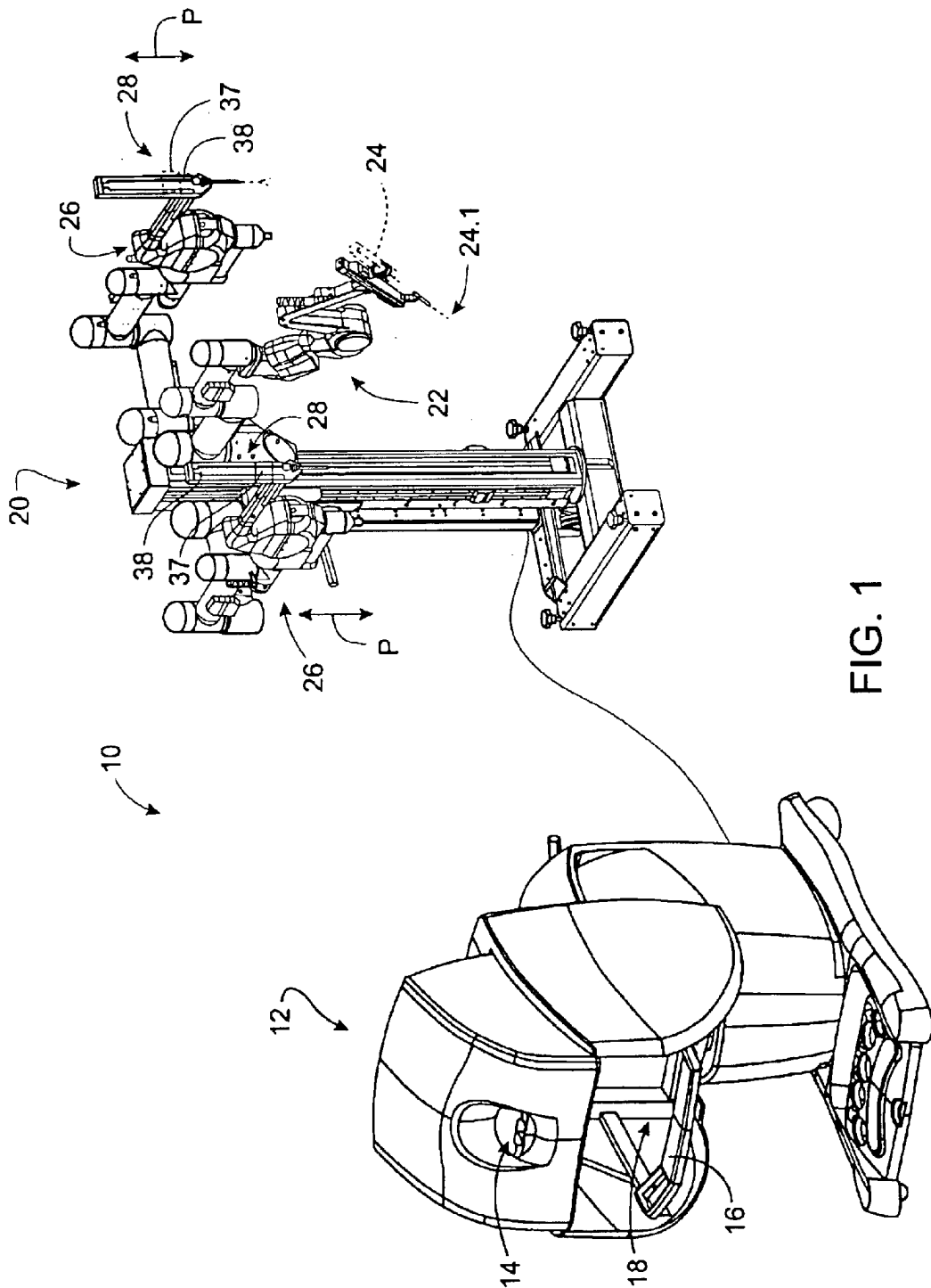
4,766,775 A 8/1988 Hodge
 4,793,053 A 12/1988 Zuccaro et al.
 4,809,747 A 3/1989 Choly et al.
 4,830,569 A 5/1989 Jannborg
 4,832,198 A 5/1989 Alikhan
 4,837,703 A 6/1989 Kakazu et al.
 4,928,546 A 5/1990 Walters
 4,943,939 A 7/1990 Hoover
 4,979,949 A 12/1990 Matsen, III et al.
 4,996,975 A 3/1991 Nakamura
 5,018,266 A 5/1991 Hutchinson et al.
 5,078,140 A 1/1992 Kwoh
 5,143,453 A 9/1992 Weynant
 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 Hecke 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.

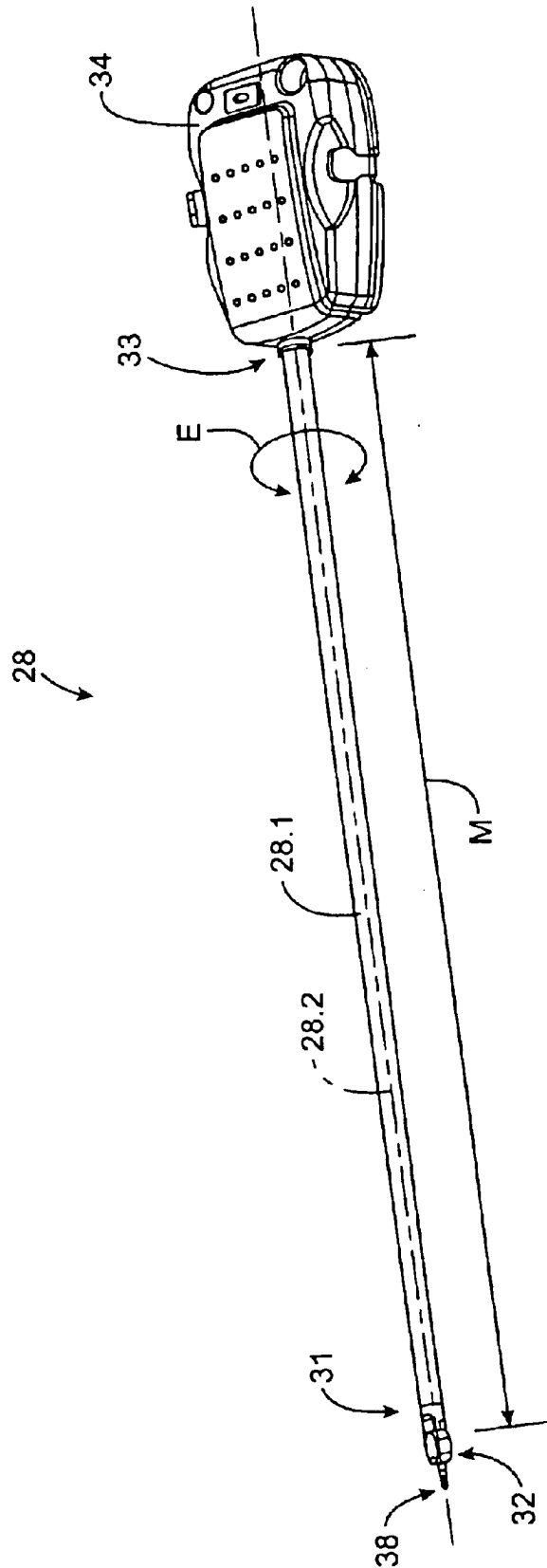
5,697,939 A 12/1997 Kubota et al.
 5,762,458 A 6/1998 Wang et al.
 5,792,135 A 8/1998 Madhani et al.
 5,797,900 A 8/1998 Madhani et al.
 5,800,423 A 9/1998 Jensen
 5,808,665 A 9/1998 Green
 5,845,646 A * 12/1998 Lemelson 128/899
 5,876,325 A 3/1999 Mizuno et al.
 6,056,735 A * 5/2000 Okada et al. 606/1
 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





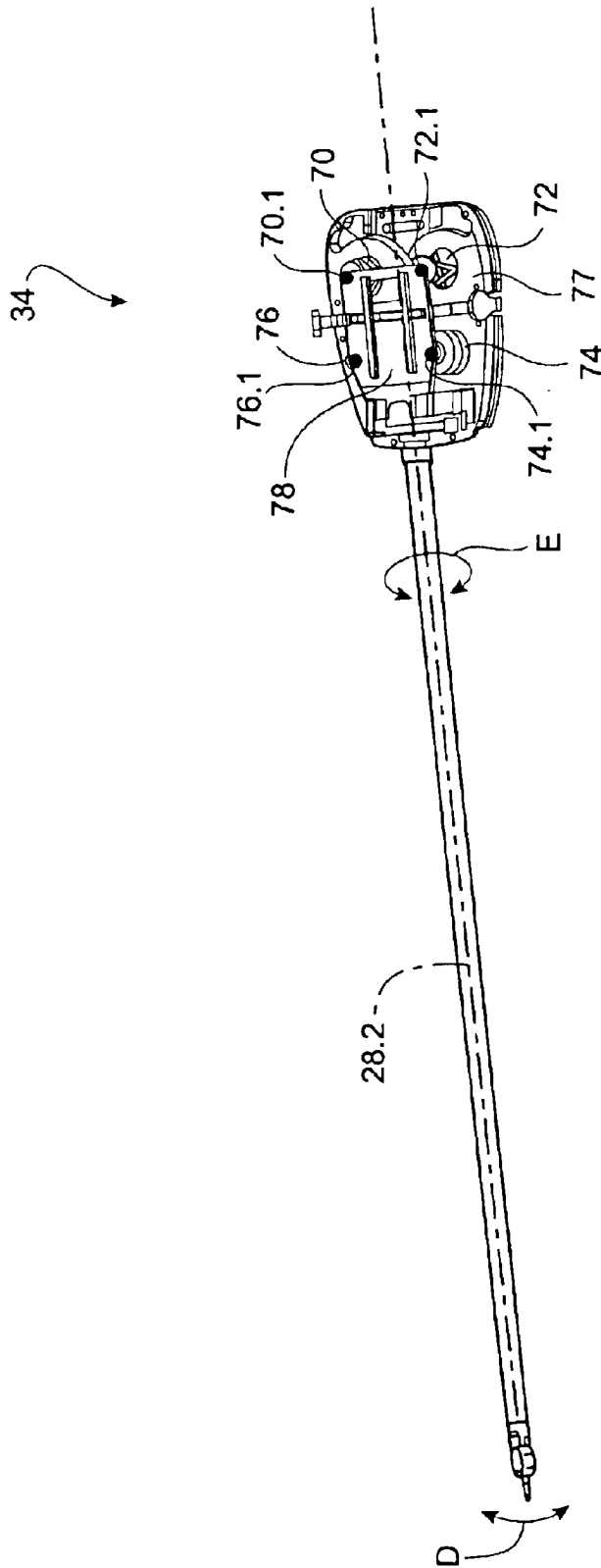


FIG. 3

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.