US009931131B2

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

(10) **Patent No.: US 9,931,131 B2**
(45) **Date of Patent: Apr. 3, 2018**

(54) **IN VIVO ATTACHABLE AND DETACHABLE END EFFECTOR ASSEMBLY AND LAPAROSCOPIC SURGICAL INSTRUMENT AND METHODS THEREFOR**

(71) Applicant: **COVIDIEN LP**, Mansfield, MA (US)

(72) Inventors: **Patrick L. Dumbauld**, Lyons, CO (US); **Edward Cosgriff**, Denver, CO (US)

(73) Assignee: **COVIDIEN LP**, Mansfield, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 319 days.

(21) Appl. No.: **14/708,950**

(22) Filed: **May 11, 2015**

(65) **Prior Publication Data**

US 2015/0245847 A1 Sep. 3, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/415,639, filed on Mar. 8, 2012, now Pat. No. 9,028,493, which is a (Continued)

(51) **Int. Cl.**
A61B 17/29 (2006.01)
A61B 17/28 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***A61B 17/2812*** (2013.01); ***A61B 18/1445*** (2013.01); ***A61B 18/1482*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC A61B 18/1445; A61B 18/1482; A61B 2018/00601; A61B 2018/0063;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

371,664 A 10/1887 Brannan et al.
702,472 A 6/1902 Pignolet
(Continued)

FOREIGN PATENT DOCUMENTS

CA 2104423 A1 2/1994
CA 2520413 A1 3/2007
(Continued)

OTHER PUBLICATIONS

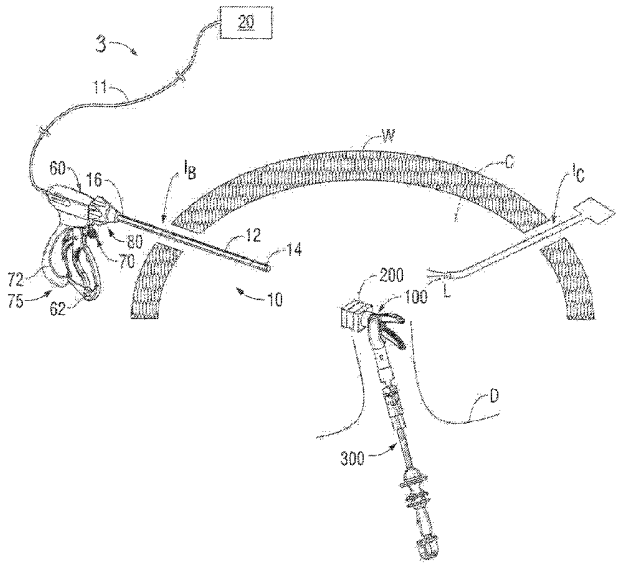
Michael Choti, "Abdominoperineal Resection with the LigaSure Vessel Sealing System and LigaSure Atlas 20 cm Open Instrument" ; Innovations That Work, Jun. 2003.
(Continued)

Primary Examiner — Michael Peffley

(57) **ABSTRACT**

A method of performing surgery includes the steps of providing a forceps having a housing including a shaft that extends therefrom and at least one handle moveable relative to the housing and providing an end effector assembly configured to selectively engage a distal end of the shaft. The method also includes the steps of inserting the forceps through a first opening formed in a body; inserting the end effector assembly through a second opening formed in the body; engaging the end effector assembly with the distal end of the shaft in vivo; and actuating the end effector assembly by moving the handle relative to the housing. The method may also include the steps of providing a coupling at the distal end of the shaft, and engaging, via the coupling, the distal end of the shaft with the end effector assembly.

12 Claims, 10 Drawing Sheets



Related U.S. Application Data

continuation of application No. 12/562,281, filed on Sep. 18, 2009, now Pat. No. 8,133,254.

(51) **Int. Cl.**

A61B 18/14	(2006.01)
A61B 17/00	(2006.01)
A61B 18/00	(2006.01)

(52) **U.S. Cl.**

CPC *A61B 2017/00473* (2013.01); *A61B 2017/2931* (2013.01); *A61B 2017/2945* (2013.01); *A61B 2017/2946* (2013.01); *A61B 2017/2947* (2013.01); *A61B 2018/0063* (2013.01); *A61B 2018/00601* (2013.01); *A61B 2018/1412* (2013.01); *A61B 2018/1432* (2013.01); *A61B 2018/1455* (2013.01)

(58) **Field of Classification Search**

CPC A61B 2018/1412; A61B 2018/1432; A61B 2018/1455; A61B 17/28; A61B 17/2812; A61B 17/29; A61B 2017/2931; A61B 2017/294; A61B 2017/2945; A61B 2017/2946; A61B 2017/2947; A61B 2017/00473

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

728,883	A	5/1903	Downes
1,586,645	A	6/1926	Bierman
1,813,902	A	7/1931	Bovie
1,822,330	A	9/1931	Ainslie
1,852,542	A	4/1932	Sovatkin
1,908,201	A	5/1933	Welch et al.
1,918,889	A	7/1933	Bacon
2,002,594	A	5/1935	Wappler et al.
2,011,169	A	8/1935	Wappler
2,031,682	A	2/1936	Wappler et al.
2,054,149	A	9/1936	Wappler
2,113,246	A	4/1938	Wappler
2,141,936	A	12/1938	Schmitt
2,176,479	A	10/1939	Willis
2,245,030	A	6/1941	Gottesfeld et al.
2,279,753	A	4/1942	Knopp
2,305,156	A	12/1942	Grubel
2,327,353	A	8/1943	Karle
2,632,661	A	3/1953	Cristofv
2,668,538	A	2/1954	Baker
2,796,065	A	6/1957	Kapp
2,824,915	A	2/1958	Buturuga
3,073,311	A	1/1963	Tibbs et al.
3,100,489	A	8/1963	Bagley
3,204,807	A	9/1965	Ramsing
3,372,288	A	3/1968	Wigington
3,459,187	A	8/1969	Pallotta
3,561,448	A	2/1971	Peternel
3,643,663	A	2/1972	Sutter
3,648,001	A	3/1972	Anderson et al.
3,651,811	A	3/1972	Hildebrandt et al.
3,678,229	A	7/1972	Osika
3,720,896	A	3/1973	Beierlein
3,763,726	A	10/1973	Hildebrand
3,779,918	A	12/1973	Ikeda et al.
3,798,688	A	3/1974	Wasson
3,801,766	A	4/1974	Morrison, Jr.
3,839,614	A	10/1974	Saganowski et al.
3,862,630	A	1/1975	Balamuth
3,863,339	A	2/1975	Reaney et al.
3,866,610	A	2/1975	Kletschka
3,875,945	A	4/1975	Friedman
3,897,786	A	8/1975	Garnett et al.
3,911,766	A	10/1975	Fridolph et al.
3,920,021	A	11/1975	Hiltebrandt
3,921,641	A	11/1975	Hulka
3,938,527	A	2/1976	Rioux et al.
3,952,749	A	4/1976	Fridolph et al.
3,970,088	A	7/1976	Morrison
3,987,795	A	10/1976	Morrison
4,005,714	A	2/1977	Hiltebrandt
4,016,881	A	4/1977	Rioux et al.
4,031,898	A	6/1977	Hiltebrandt et al.
4,041,952	A	8/1977	Morrison, Jr. et al.
4,043,342	A	8/1977	Morrison, Jr.
4,074,718	A	2/1978	Morrison, Jr.
4,076,028	A	2/1978	Simmons
4,080,820	A	3/1978	Allen
4,088,134	A	5/1978	Mazzariello
4,102,471	A	7/1978	Lore et al.
D249,549	S	9/1978	Pike
4,112,950	A	9/1978	Pike
4,127,222	A	11/1978	Adams
4,128,099	A	12/1978	Bauer
4,165,746	A	8/1979	Burgin
4,187,420	A	2/1980	Piber
4,200,104	A	4/1980	Harris
4,200,105	A	4/1980	Gonser
4,233,734	A	11/1980	Bies
4,236,470	A	12/1980	Stenson
4,274,413	A	6/1981	Hahn et al.
4,300,564	A	11/1981	Furihata
4,306,561	A	12/1981	de Medinaceli
4,311,145	A	1/1982	Esty et al.
D263,020	S	2/1982	Rau, III
4,315,510	A	2/1982	Kihn
4,363,944	A	12/1982	Poirier
4,370,980	A	2/1983	Lottick
4,375,218	A	3/1983	DiGeronimo
4,394,552	A	7/1983	Schlosser
4,416,276	A	11/1983	Newton et al.
4,418,692	A	12/1983	Guay
4,443,935	A	4/1984	Zamba et al.
4,452,246	A	6/1984	Bader et al.
4,470,786	A	9/1984	Sano et al.
4,492,231	A	1/1985	Auth
4,493,320	A	1/1985	Treat
4,503,855	A	3/1985	Maslanka
4,506,669	A	3/1985	Blake
4,509,518	A	4/1985	McGarry et al.
4,513,271	A	4/1985	Reisem
4,535,773	A	8/1985	Yoon
4,552,143	A	11/1985	Lottick
4,574,804	A	3/1986	Kurwa
4,597,379	A	7/1986	Kihn et al.
4,600,007	A	7/1986	Lahodny et al.
4,619,258	A	10/1986	Pool
4,624,254	A	11/1986	McGarry et al.
4,644,950	A	2/1987	Valli
4,655,215	A	4/1987	Pike
4,655,216	A	4/1987	Tischer
4,657,016	A	4/1987	Garito et al.
4,662,372	A	5/1987	Sharkany et al.
4,671,274	A	6/1987	Sorochenko
4,674,499	A	6/1987	Pao
4,685,459	A	8/1987	Koch et al.
4,733,662	A	3/1988	DeSatnick et al.
D295,893	S	5/1988	Sharkany et al.
D295,894	S	5/1988	Sharkany et al.
4,753,235	A	6/1988	Hasson
4,754,892	A	7/1988	Retief
4,763,669	A	8/1988	Jaeger
D298,353	S	11/1988	Manno
4,781,175	A	11/1988	McGreevy et al.
D299,413	S	1/1989	DeCarolis
4,805,616	A	2/1989	Pao
4,827,927	A	5/1989	Newton
4,827,929	A	5/1989	Hodge
4,829,313	A	5/1989	Taggart
4,846,171	A	7/1989	Kauphusman et al.
4,887,612	A	12/1989	Esser et al.
4,890,610	A	1/1990	Kirwan, Sr. et al.
4,938,761	A	7/1990	Ensslin

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,947,009 A 8/1990 Osika et al.
4,973,801 A 11/1990 Frick et al.
4,985,030 A 1/1991 Melzer et al.
5,007,908 A 4/1991 Rydell
5,026,370 A 6/1991 Lottick
5,026,371 A 6/1991 Rydell et al.
5,035,695 A 7/1991 Weber, Jr. et al.
5,037,433 A 8/1991 Wilk et al.
5,042,707 A 8/1991 Taheri
5,047,046 A 9/1991 Bodoia
5,052,402 A 10/1991 Bencini et al.
5,078,716 A 1/1992 Doll
5,084,057 A 1/1992 Green et al.
5,085,659 A 2/1992 Rydell
5,099,840 A 3/1992 Goble et al.
5,100,430 A 3/1992 Avellanet et al.
5,108,392 A 4/1992 Spingler
5,112,343 A 5/1992 Thornton
5,116,332 A 5/1992 Lottick
5,122,139 A 6/1992 Sutter
5,144,323 A 9/1992 Yonkers
5,147,357 A 9/1992 Rose et al.
5,151,102 A 9/1992 Kamiyama et al.
5,151,978 A 9/1992 Bronikowski et al.
5,158,561 A 10/1992 Rydell et al.
5,169,396 A 12/1992 Dowlatshahi et al.
5,176,695 A 1/1993 Dulebohn
5,190,541 A 3/1993 Abele et al.
5,196,009 A 3/1993 Kirwan, Jr.
5,197,964 A 3/1993 Parins
5,209,747 A 5/1993 Knoepfler
5,211,655 A 5/1993 Hasson
5,215,101 A 6/1993 Jacobs et al.
5,217,457 A 6/1993 Delahuerga et al.
5,217,458 A 6/1993 Parins
5,217,460 A 6/1993 Knoepfler
5,219,354 A 6/1993 Choudhury et al.
5,244,462 A 9/1993 Delahuerga et al.
5,250,047 A 10/1993 Rydell
5,250,056 A 10/1993 Hasson
5,250,063 A 10/1993 Abidin et al.
5,254,129 A 10/1993 Alexander
5,258,001 A 11/1993 Corman
5,258,006 A 11/1993 Rydell et al.
5,261,918 A 11/1993 Phillips et al.
5,267,998 A 12/1993 Hagen
5,269,780 A 12/1993 Roos
5,269,804 A 12/1993 Bales et al.
D343,453 S 1/1994 Noda
5,275,615 A 1/1994 Rose
5,277,201 A 1/1994 Stern
5,281,220 A 1/1994 Blake, III
5,282,799 A 2/1994 Rydell
5,282,800 A 2/1994 Foshee et al.
5,282,826 A 2/1994 Quadri
5,290,286 A 3/1994 Parins
5,290,287 A 3/1994 Boebel et al.
5,300,082 A 4/1994 Sharpe et al.
5,304,203 A 4/1994 El-Mallawany et al.
5,308,353 A 5/1994 Beurrier
5,308,357 A 5/1994 Lichtman
5,312,433 A 5/1994 Boebel et al.
5,313,027 A 5/1994 Inoue et al.
5,314,445 A 5/1994 Heidmueller et al.
5,314,463 A 5/1994 Camps et al.
5,318,589 A 6/1994 Lichtman
5,324,289 A 6/1994 Eggers
D348,930 S 7/1994 Olson
5,326,806 A 7/1994 Yokoshima et al.
5,330,471 A 7/1994 Eggers
5,330,502 A 7/1994 Hassler et al.
D349,341 S 8/1994 Lichtman et al.
5,334,166 A 8/1994 Palestrant
5,334,183 A 8/1994 Wuchinich
5,334,215 A 8/1994 Chen
5,336,220 A 8/1994 Ryan et al.
5,336,221 A 8/1994 Anderson
5,342,359 A 8/1994 Rydell
5,342,381 A 8/1994 Tidemand
5,342,393 A 8/1994 Stack
5,344,424 A 9/1994 Roberts et al.
5,350,391 A 9/1994 Iacovelli
5,352,222 A 10/1994 Rydell
5,354,271 A 10/1994 Voda
5,356,408 A 10/1994 Rydell
5,359,993 A 11/1994 Slater et al.
5,366,477 A 11/1994 LeMarie, III et al.
5,367,250 A 11/1994 Whisenand
5,368,600 A 11/1994 Failla et al.
5,374,277 A 12/1994 Hassler
5,376,089 A 12/1994 Smith
5,376,094 A 12/1994 Kline
D354,564 S 1/1995 Medema
5,383,875 A 1/1995 Bays et al.
5,383,880 A 1/1995 Hooven
5,383,897 A 1/1995 Wholey
5,389,098 A 2/1995 Tsuruta et al.
5,389,103 A 2/1995 Melzer et al.
5,389,104 A 2/1995 Hahnen et al.
5,391,166 A 2/1995 Eggers
5,391,183 A 2/1995 Janzen et al.
5,395,360 A 3/1995 Manoukian
5,396,900 A 3/1995 Slater et al.
5,397,325 A 3/1995 Della Badia et al.
5,403,312 A 4/1995 Yates et al.
5,403,342 A 4/1995 Tovey et al.
5,405,344 A 4/1995 Williamson et al.
5,409,763 A 4/1995 Serizawa et al.
D358,887 S 5/1995 Feinberg
5,411,519 A 5/1995 Tovey et al.
5,411,520 A 5/1995 Nash et al.
5,413,571 A 5/1995 Katsaros et al.
5,415,656 A 5/1995 Tihon et al.
5,415,657 A 5/1995 Taymor-Luria
5,417,709 A 5/1995 Slater
5,422,567 A 6/1995 Matsunaga
5,423,810 A 6/1995 Goble et al.
5,425,690 A 6/1995 Chang
5,425,739 A 6/1995 Jessen
5,429,616 A 7/1995 Schaffer
5,431,672 A 7/1995 Cote et al.
5,431,674 A 7/1995 Basile et al.
5,437,277 A 8/1995 Dumoulin et al.
5,437,292 A 8/1995 Kipshidze et al.
5,438,302 A 8/1995 Goble
5,439,478 A 8/1995 Palmer
5,441,059 A 8/1995 Dannan
5,441,517 A 8/1995 Kensey et al.
5,443,463 A 8/1995 Stern et al.
5,443,464 A 8/1995 Russell et al.
5,443,479 A 8/1995 Bressi, Jr.
5,443,480 A 8/1995 Jacobs et al.
5,445,638 A 8/1995 Rydell et al.
5,445,658 A 8/1995 Durrfeld et al.
5,449,480 A 9/1995 Kuriya et al.
5,451,224 A 9/1995 Goble et al.
5,454,809 A 10/1995 Janssen
5,454,823 A 10/1995 Richardson et al.
5,454,827 A 10/1995 Aust et al.
5,456,684 A 10/1995 Schmidt et al.
5,458,598 A 10/1995 Feinberg et al.
5,460,629 A 10/1995 Shlain et al.
5,461,765 A 10/1995 Linden et al.
5,462,546 A 10/1995 Rydell
5,472,442 A 12/1995 Klicek
5,472,443 A 12/1995 Cordis et al.
5,476,479 A 12/1995 Green et al.
5,478,351 A 12/1995 Meade et al.
5,480,406 A 1/1996 Nolan et al.
5,480,409 A 1/1996 Riza
5,482,054 A 1/1996 Slater et al.
5,484,436 A 1/1996 Eggers et al.
5,493,899 A 2/1996 Beck et al.
5,496,312 A 3/1996 Klicek

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,496,317 A 3/1996 Goble et al.
5,496,347 A 3/1996 Hashiguchi et al.
5,499,997 A 3/1996 Sharpe et al.
5,501,654 A 3/1996 Failla et al.
5,509,922 A 4/1996 Aranyi et al.
5,512,721 A 4/1996 Young et al.
5,514,134 A 5/1996 Rydell et al.
5,520,702 A 5/1996 Sauer et al.
5,527,313 A 6/1996 Scott et al.
5,528,833 A 6/1996 Sakuma
5,529,067 A 6/1996 Larsen et al.
5,531,744 A 7/1996 Nardella et al.
5,536,251 A 7/1996 Evard et al.
5,540,684 A 7/1996 Hassler, Jr.
5,540,685 A 7/1996 Parins et al.
5,540,706 A 7/1996 Aust et al.
5,540,715 A 7/1996 Katsaros et al.
5,542,945 A 8/1996 Fritzsch
5,549,604 A 8/1996 Sutcu et al.
5,554,172 A 9/1996 Homer et al.
5,558,671 A 9/1996 Yates
5,558,672 A 9/1996 Edwards et al.
5,562,619 A 10/1996 Mirarchi et al.
5,562,699 A 10/1996 Heimberger et al.
5,562,720 A 10/1996 Stern et al.
5,564,615 A 10/1996 Bishop et al.
5,568,859 A 10/1996 Levy et al.
5,569,241 A 10/1996 Edwards
5,569,243 A 10/1996 Kortenbach et al.
5,571,100 A 11/1996 Goble et al.
5,573,424 A 11/1996 Poppe
5,573,534 A 11/1996 Stone
5,573,535 A 11/1996 Viklund
5,575,799 A 11/1996 Bolanos et al.
5,575,805 A 11/1996 Li
5,578,052 A 11/1996 Koros et al.
5,579,781 A 12/1996 Cooke
5,582,611 A 12/1996 Tsuruta et al.
5,582,617 A 12/1996 Klieman et al.
5,585,896 A 12/1996 Yamazaki et al.
5,590,570 A 1/1997 LeMaire, III et al.
5,591,181 A 1/1997 Stone et al.
5,597,107 A 1/1997 Knodel et al.
5,599,350 A 2/1997 Schulze et al.
5,601,224 A 2/1997 Bishop et al.
5,601,601 A 2/1997 Tal et al.
5,601,641 A 2/1997 Stephens
5,603,711 A 2/1997 Parins et al.
5,603,723 A 2/1997 Aranyi et al.
5,607,436 A 3/1997 Pratt et al.
5,611,798 A 3/1997 Eggers
5,611,808 A 3/1997 Hossain et al.
5,611,813 A 3/1997 Lichtman
5,618,294 A 4/1997 Aust et al.
5,618,307 A 4/1997 Donlon et al.
5,620,415 A 4/1997 Lucey et al.
5,620,453 A 4/1997 Nallakrishnan
5,620,459 A 4/1997 Lichtman
5,624,452 A 4/1997 Yates
5,626,578 A 5/1997 Tihon
5,626,607 A 5/1997 Malecki et al.
5,626,609 A 5/1997 Zvenyatsky et al.
5,630,833 A 5/1997 Katsaros et al.
5,637,110 A 6/1997 Pennybacker et al.
5,637,111 A 6/1997 Sutcu et al.
5,638,003 A 6/1997 Hall
5,638,827 A 6/1997 Palmer et al.
5,639,403 A 6/1997 Ida et al.
5,643,294 A 7/1997 Tovey et al.
5,647,869 A 7/1997 Goble et al.
5,647,871 A 7/1997 Levine et al.
5,649,959 A 7/1997 Hannam et al.
5,655,650 A 8/1997 Naitou
5,658,281 A 8/1997 Heard
D384,413 S 9/1997 Zlock et al.
5,662,667 A 9/1997 Knodel
5,665,100 A 9/1997 Yoon
5,667,526 A 9/1997 Levin
5,673,841 A 10/1997 Schulze et al.
5,674,220 A 10/1997 Fox et al.
5,674,229 A 10/1997 Tovey et al.
5,681,282 A 10/1997 Eggers et al.
5,688,270 A 11/1997 Yates et al.
5,690,652 A 11/1997 Wurster et al.
5,690,653 A 11/1997 Richardson et al.
5,693,051 A 12/1997 Schulze et al.
5,693,920 A 12/1997 Maeda
5,695,522 A 12/1997 LeMaire, III et al.
5,700,261 A 12/1997 Brinkerhoff
5,700,270 A 12/1997 Peyser et al.
5,702,390 A 12/1997 Austin et al.
5,707,369 A 1/1998 Vaitekunas et al.
5,709,680 A 1/1998 Yates et al.
5,713,895 A 2/1998 Lontine et al.
5,716,366 A 2/1998 Yates
5,720,742 A 2/1998 Zacharias
5,720,744 A 2/1998 Eggleston et al.
5,722,421 A 3/1998 Francese et al.
5,725,536 A 3/1998 Oberlin et al.
5,727,428 A 3/1998 LeMaire, III et al.
H1745 H 4/1998 Paraschac
5,735,848 A 4/1998 Yates et al.
5,735,849 A 4/1998 Baden et al.
5,743,906 A 4/1998 Parins et al.
5,752,973 A 5/1998 Kieturakis
5,755,717 A 5/1998 Yates et al.
5,759,188 A 6/1998 Yoon
5,762,255 A 6/1998 Chrisman et al.
5,762,609 A 6/1998 Benaron et al.
5,766,130 A 6/1998 Selmonosky
5,766,166 A 6/1998 Hooven
5,766,170 A 6/1998 Eggers
5,766,196 A 6/1998 Griffiths
5,769,841 A * 6/1998 Odell A61B 18/1206 606/1
5,769,849 A 6/1998 Eggers
5,772,655 A 6/1998 Bauer et al.
5,772,670 A 6/1998 Brosa
5,776,128 A 7/1998 Eggers
5,776,130 A 7/1998 Buysse et al.
5,776,156 A 7/1998 Shikhman
5,779,646 A 7/1998 Koblish et al.
5,779,701 A 7/1998 McBrayer et al.
5,779,727 A 7/1998 Orejola
5,781,048 A 7/1998 Nakao et al.
5,791,231 A 8/1998 Cohn et al.
5,792,137 A 8/1998 Carr et al.
5,792,165 A 8/1998 Klieman et al.
5,792,177 A 8/1998 Kaseda
5,797,537 A 8/1998 Oberlin et al.
5,797,927 A 8/1998 Yoon
5,797,938 A 8/1998 Paraschac et al.
5,797,941 A 8/1998 Schulze et al.
5,797,958 A 8/1998 Yoon
5,797,959 A 8/1998 Castro et al.
5,800,448 A 9/1998 Banko
5,800,449 A 9/1998 Wales
5,807,393 A 9/1998 Williamson, IV et al.
5,810,764 A 9/1998 Eggers et al.
5,810,805 A 9/1998 Sutcu et al.
5,810,808 A 9/1998 Eggers
5,810,811 A 9/1998 Yates et al.
5,810,877 A 9/1998 Roth et al.
5,814,043 A 9/1998 Shapeton
5,814,054 A 9/1998 Kortenbach et al.
5,817,083 A 10/1998 Shemesh et al.
5,817,119 A 10/1998 Klieman et al.
5,820,630 A 10/1998 Lind
5,824,978 A 10/1998 Karasik et al.
5,827,271 A 10/1998 Buysse et al.
5,827,274 A 10/1998 Bonnet et al.
5,827,279 A 10/1998 Hughett et al.
5,827,281 A 10/1998 Levin
5,827,323 A 10/1998 Klieman et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,827,548 A 10/1998 Lavallee et al.
5,830,212 A 11/1998 Cartmell et al.
5,833,690 A 11/1998 Yates et al.
5,833,695 A 11/1998 Yoon
5,836,072 A 11/1998 Sullivan et al.
D402,028 S 12/1998 Grimm et al.
5,843,080 A 12/1998 Fleenor et al.
5,849,020 A 12/1998 Long et al.
5,849,022 A 12/1998 Sakashita et al.
5,851,214 A 12/1998 Larsen et al.
5,853,412 A 12/1998 Mayenberger
5,859,527 A 1/1999 Cook
5,860,976 A 1/1999 Billings et al.
5,865,361 A 2/1999 Milliman et al.
5,876,401 A 3/1999 Schulze et al.
5,876,410 A 3/1999 Petillo
5,876,412 A 3/1999 Piraka
5,882,567 A 3/1999 Cavallaro et al.
D408,018 S 4/1999 McNaughton
5,891,141 A 4/1999 Rydell
5,891,142 A 4/1999 Eggers et al.
5,893,848 A 4/1999 Negus et al.
5,893,863 A 4/1999 Yoon
5,893,875 A * 4/1999 O'Connor A61B 17/29 606/167
5,893,877 A 4/1999 Gampp, Jr. et al.
5,897,563 A 4/1999 Yoon et al.
5,902,301 A 5/1999 Olig
5,906,630 A 5/1999 Anderhub et al.
5,907,140 A 5/1999 Smith
5,908,420 A 6/1999 Parins et al.
5,908,432 A 6/1999 Pan
5,911,719 A 6/1999 Eggers
5,913,874 A 6/1999 Berns et al.
5,921,916 A 7/1999 Aeikens et al.
5,921,984 A 7/1999 Sutcu et al.
5,925,043 A 7/1999 Kumar et al.
5,928,136 A 7/1999 Barry
5,935,126 A 8/1999 Riza
5,938,589 A 8/1999 Wako et al.
5,941,869 A 8/1999 Patterson et al.
5,944,718 A 8/1999 Austin et al.
5,951,545 A 9/1999 Schilling et al.
5,951,546 A 9/1999 Lorentzen
5,951,549 A 9/1999 Richardson et al.
5,954,720 A 9/1999 Wilson et al.
5,954,731 A 9/1999 Yoon
5,954,733 A 9/1999 Yoon
5,957,923 A 9/1999 Hahnen et al.
5,957,937 A 9/1999 Yoon
5,960,544 A 10/1999 Beyers
5,961,514 A 10/1999 Long et al.
5,964,758 A 10/1999 Dresden
5,967,997 A 10/1999 Turturro et al.
D416,089 S 11/1999 Barton et al.
5,976,132 A 11/1999 Morris
5,984,932 A 11/1999 Yoon
5,984,938 A 11/1999 Yoon
5,984,939 A 11/1999 Yoon
5,989,277 A 11/1999 LeMaire, III et al.
5,993,466 A 11/1999 Yoon
5,993,467 A 11/1999 Yoon
5,993,474 A 11/1999 Ouchi
5,997,565 A 12/1999 Inoue
6,003,517 A 12/1999 Sheffield et al.
6,004,332 A 12/1999 Yoon et al.
6,004,335 A 12/1999 Vaitekunas et al.
6,010,516 A 1/2000 Hulka
6,010,519 A 1/2000 Mawhirt et al.
6,017,354 A 1/2000 Culp et al.
6,017,358 A 1/2000 Yoon et al.
6,021,693 A 2/2000 Feng-Sing
6,024,741 A 2/2000 Williamson, IV et al.
6,024,743 A 2/2000 Edwards
6,024,744 A 2/2000 Kese et al.
6,027,522 A 2/2000 Palmer
6,030,384 A 2/2000 Nezhat
6,033,399 A 3/2000 Gines
6,039,733 A 3/2000 Buysse et al.
6,041,679 A 3/2000 Slater et al.
6,050,995 A 4/2000 Durgin
6,050,996 A 4/2000 Schmaltz et al.
6,053,914 A 4/2000 Eggers et al.
6,053,933 A 4/2000 Balazs et al.
D424,694 S 5/2000 Tetzlaff et al.
D425,201 S 5/2000 Tetzlaff et al.
6,059,782 A 5/2000 Novak et al.
6,063,103 A 5/2000 Hashiguchi
6,066,139 A 5/2000 Ryan et al.
6,071,283 A 6/2000 Nardella et al.
6,074,386 A 6/2000 Goble et al.
6,077,287 A 6/2000 Taylor et al.
6,080,180 A 6/2000 Yoon et al.
RE36,795 E 7/2000 Rydell
6,083,150 A 7/2000 Aznoian et al.
6,083,223 A 7/2000 Baker
6,086,586 A 7/2000 Hooven
6,086,601 A 7/2000 Yoon
6,090,107 A 7/2000 Borgmeier et al.
6,090,123 A 7/2000 Culp et al.
6,096,037 A 8/2000 Mulier et al.
6,099,537 A 8/2000 Sugai et al.
6,099,550 A 8/2000 Yoon
6,102,909 A 8/2000 Chen et al.
6,106,542 A 8/2000 Toybin et al.
6,110,171 A 8/2000 Rydell
6,113,596 A 9/2000 Hooven et al.
6,113,598 A 9/2000 Baker
6,117,158 A 9/2000 Measamer et al.
6,122,549 A 9/2000 Sharkey et al.
6,123,701 A 9/2000 Nezhat
H1904 H 10/2000 Yates et al.
6,126,658 A 10/2000 Baker
6,126,665 A 10/2000 Yoon
6,139,563 A 10/2000 Cosgrove, III et al.
6,143,005 A 11/2000 Yoon et al.
6,152,923 A 11/2000 Ryan
6,152,924 A 11/2000 Parins
6,159,217 A 12/2000 Roble et al.
6,162,220 A 12/2000 Nezhat
6,171,316 B1 1/2001 Kovac et al.
6,174,309 B1 1/2001 Wrublewski et al.
6,174,310 B1 1/2001 Kirwan, Jr.
6,178,628 B1 1/2001 Clemens et al.
6,179,834 B1 1/2001 Buysse et al.
6,179,837 B1 1/2001 Hooven
6,183,467 B1 2/2001 Shapeton et al.
6,187,003 B1 2/2001 Buysse et al.
6,190,386 B1 2/2001 Rydell
6,190,399 B1 2/2001 Palmer et al.
6,190,400 B1 2/2001 Van De Moer et al.
6,193,709 B1 2/2001 Miyawaki et al.
6,193,718 B1 2/2001 Kortenbach et al.
6,206,876 B1 3/2001 Levine et al.
6,206,877 B1 3/2001 Kese et al.
6,206,893 B1 3/2001 Klein et al.
6,214,028 B1 4/2001 Yoon et al.
6,217,602 B1 4/2001 Redmon
6,217,615 B1 4/2001 Sioshansi et al.
6,221,039 B1 4/2001 Durgin et al.
6,223,100 B1 4/2001 Green
6,224,593 B1 5/2001 Ryan et al.
6,224,614 B1 5/2001 Yoon
6,228,080 B1 5/2001 Gines
6,228,083 B1 5/2001 Lands et al.
6,248,124 B1 6/2001 Pedros et al.
6,248,944 B1 6/2001 Ito
6,261,307 B1 7/2001 Yoon et al.
6,267,758 B1 7/2001 Daw et al.
6,267,761 B1 7/2001 Ryan
6,270,497 B1 8/2001 Sekino et al.
6,270,508 B1 8/2001 Klieman et al.
6,273,887 B1 8/2001 Yamauchi et al.
6,277,117 B1 8/2001 Tetzlaff et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,280,458 B1 8/2001 Bache et al.
6,283,961 B1 9/2001 Underwood et al.
D449,886 S 10/2001 Tetzlaff et al.
6,298,550 B1 10/2001 Kirwan, Jr.
6,302,424 B1 10/2001 Gisinger et al.
6,309,404 B1 10/2001 Krzyzanowski
6,319,262 B1 11/2001 Bates et al.
6,319,451 B1 11/2001 Brune
6,322,561 B1 11/2001 Eggers et al.
6,322,580 B1 11/2001 Kanner
6,325,795 B1 12/2001 Lindemann et al.
6,329,778 B1 12/2001 Culp et al.
6,334,860 B1 1/2002 Dorn
6,334,861 B1 1/2002 Chandler et al.
D453,923 S 2/2002 Olson
6,345,532 B1 2/2002 Coudray et al.
6,350,264 B1 2/2002 Hooven
D454,951 S 3/2002 Bon
6,352,536 B1 3/2002 Buysse et al.
6,358,249 B1 3/2002 Chen et al.
6,358,259 B1 3/2002 Swain et al.
6,358,268 B1 3/2002 Hunt et al.
6,361,534 B1 3/2002 Chen et al.
6,364,876 B1 4/2002 Erb et al.
6,364,879 B1 4/2002 Chen et al.
D457,958 S 5/2002 Dycus et al.
D457,959 S 5/2002 Tetzlaff et al.
6,385,265 B1 5/2002 Duffy et al.
6,387,094 B1 5/2002 Eitenmuller
6,391,035 B1 5/2002 Appleby et al.
6,398,779 B1 6/2002 Buysse et al.
6,402,747 B1 6/2002 Lindemann et al.
6,409,728 B1 6/2002 Ehr et al.
H2037 H 7/2002 Yates et al.
6,419,675 B1 7/2002 Gallo, Sr.
6,425,896 B1 7/2002 Baltschun et al.
6,432,112 B2 8/2002 Brock et al.
6,440,130 B1 8/2002 Mulier et al.
6,440,144 B1 8/2002 Bacher
6,443,952 B1 9/2002 Mulier et al.
6,443,970 B1 9/2002 Schulze et al.
6,451,018 B1 9/2002 Lands et al.
6,458,125 B1 10/2002 Cosmescu
6,458,128 B1 10/2002 Schulze
6,458,129 B2 10/2002 Scarfi
6,458,130 B1 10/2002 Frazier et al.
6,461,352 B2 10/2002 Morgan et al.
6,461,368 B2 10/2002 Fogarty et al.
6,464,701 B1 10/2002 Hooven et al.
6,464,702 B2 10/2002 Schulze et al.
6,464,704 B2 10/2002 Schmaltz et al.
6,471,696 B1 10/2002 Berube et al.
D465,281 S 11/2002 Lang
D466,209 S 11/2002 Bon
6,485,489 B2 11/2002 Teirstein et al.
6,488,680 B1 12/2002 Francischelli et al.
6,494,877 B2 12/2002 Odell et al.
6,494,888 B1 12/2002 Laufer et al.
6,500,176 B1 12/2002 Truckai et al.
6,506,196 B1 1/2003 Laufer
6,508,815 B1 1/2003 Strul et al.
6,511,480 B1 1/2003 Tetzlaff et al.
6,514,215 B1 2/2003 Ouchi
6,514,252 B2 2/2003 Nezhat et al.
6,517,536 B2 2/2003 Hooven et al.
6,517,539 B1 2/2003 Smith et al.
6,527,771 B1 3/2003 Weadock et al.
6,533,784 B2 3/2003 Truckai et al.
6,537,272 B2 3/2003 Christopherson et al.
6,540,745 B1 4/2003 Fairbourn et al.
6,545,239 B2 4/2003 Spedale et al.
6,554,844 B2 4/2003 Lee et al.
6,558,385 B1 5/2003 McClurken et al.
6,562,037 B2 5/2003 Paton et al.
6,569,105 B1 5/2003 Kortenbach et al.
6,582,450 B2 6/2003 Ouchi
6,585,735 B1 7/2003 Frazier et al.
6,602,252 B2 8/2003 Mollenauer
6,605,790 B2 8/2003 Yoshida
6,610,060 B2 8/2003 Mulier et al.
6,613,048 B2 9/2003 Mulier et al.
6,616,654 B2 9/2003 Mollenauer
6,616,658 B2 9/2003 Ineson
6,616,661 B2 9/2003 Wellman et al.
6,620,161 B2 9/2003 Schulze et al.
6,620,184 B2 9/2003 de Laforcade et al.
6,623,482 B2 9/2003 Pendekanti et al.
6,626,901 B1 9/2003 Treat et al.
6,629,534 B1 10/2003 St. Goar et al.
6,638,287 B2 10/2003 Danitz et al.
6,641,595 B1 11/2003 Moran et al.
6,652,514 B2 11/2003 Ellman et al.
6,652,518 B2 11/2003 Wellman et al.
6,652,521 B2 11/2003 Schulze
6,656,173 B1 12/2003 Palermo
6,656,175 B2 12/2003 Francischelli et al.
6,656,177 B2 12/2003 Truckai et al.
6,660,072 B2 12/2003 Chatterjee
6,663,639 B1 12/2003 Laufer et al.
6,663,641 B1 12/2003 Kovac et al.
6,666,854 B1 12/2003 Lange
6,669,696 B2 12/2003 Bacher et al.
6,673,092 B1 1/2004 Bacher
6,676,660 B2 1/2004 Wampler et al.
6,676,676 B2 1/2004 Danitz et al.
6,679,882 B1 1/2004 Kornerup
6,682,527 B2 1/2004 Strul
6,682,528 B2 1/2004 Frazier et al.
6,685,704 B2 2/2004 Greep
6,685,724 B1 2/2004 Haluck
6,689,131 B2 2/2004 McClurken
6,692,445 B2 2/2004 Roberts et al.
6,693,246 B1 2/2004 Rudolph et al.
6,695,840 B2 2/2004 Schulze
6,702,810 B2 3/2004 McClurken et al.
6,723,092 B2 4/2004 Brown et al.
6,726,068 B2 4/2004 Miller
6,726,686 B2 4/2004 Buysse et al.
6,726,694 B2 4/2004 Blatter et al.
6,733,498 B2 5/2004 Paton et al.
6,733,501 B2 5/2004 Levine
6,736,813 B2 5/2004 Yamauchi et al.
6,743,229 B2 6/2004 Buysse et al.
6,743,230 B2 6/2004 Lutze et al.
6,743,239 B1 6/2004 Kuehn et al.
6,743,240 B2 6/2004 Smith et al.
6,755,338 B2 6/2004 Hahnen et al.
6,755,824 B2 6/2004 Jain et al.
6,755,843 B2 6/2004 Chung et al.
6,756,553 B1 6/2004 Yamaguchi et al.
6,757,977 B2 7/2004 Dambal et al.
D493,888 S 8/2004 Reschke
6,770,072 B1 8/2004 Truckai et al.
6,773,409 B2 8/2004 Truckai et al.
6,773,432 B1 8/2004 Clayman et al.
6,773,434 B2 8/2004 Ciarrocca
6,773,435 B2 8/2004 Schulze et al.
6,773,441 B1 8/2004 Laufer et al.
6,775,575 B2 8/2004 Bommannan et al.
6,776,780 B2 8/2004 Mulier et al.
6,784,405 B2 8/2004 Flugstad et al.
6,786,905 B2 9/2004 Swanson et al.
6,790,217 B2 9/2004 Schulze et al.
6,796,981 B2 9/2004 Wham et al.
D496,997 S 10/2004 Dycus et al.
6,800,825 B1 10/2004 Sasaki et al.
6,802,843 B2 10/2004 Truckai et al.
6,808,525 B2 10/2004 Latterell et al.
D499,181 S 11/2004 Dycus et al.
6,818,000 B2 11/2004 Muller et al.
6,818,007 B1 11/2004 Dampney et al.
6,821,273 B2 11/2004 Mollenauer
6,821,285 B2 11/2004 Laufer et al.
6,824,547 B2 11/2004 Wilson, Jr. et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,830,174 B2 12/2004 Hillstead et al.
6,835,200 B2 12/2004 Laufer et al.
6,843,789 B2 1/2005 Goble
6,857,357 B2 2/2005 Fujii
6,858,028 B2 2/2005 Mulier et al.
D502,994 S 3/2005 Blake, III
6,860,880 B2 3/2005 Treat et al.
6,878,147 B2 4/2005 Prakash et al.
6,887,240 B1 5/2005 Lands et al.
6,889,116 B2 5/2005 Jinno
6,905,497 B2 6/2005 Truckai et al.
6,908,463 B2 6/2005 Treat et al.
6,914,201 B2 7/2005 Van Vooren et al.
6,916,314 B2 * 7/2005 Schneider A61B 17/00234 606/1
6,926,716 B2 8/2005 Baker et al.
6,929,644 B2 8/2005 Truckai et al.
6,932,810 B2 8/2005 Ryan
6,932,816 B2 8/2005 Phan
6,934,134 B2 8/2005 Mod et al.
6,936,061 B2 8/2005 Sasaki
D509,297 S 9/2005 Wells
6,942,662 B2 9/2005 Goble et al.
6,943,311 B2 9/2005 Miyako
6,951,559 B1 10/2005 Greep
6,953,430 B2 10/2005 Kidooka
6,953,461 B2 10/2005 McClurken et al.
6,958,070 B2 10/2005 Witt et al.
6,960,210 B2 11/2005 Lands et al.
6,964,662 B2 11/2005 Kidooka
6,966,907 B2 11/2005 Goble
6,972,017 B2 12/2005 Smith et al.
6,974,452 B1 12/2005 Gille et al.
6,976,492 B2 12/2005 Ingle et al.
6,977,495 B2 12/2005 Donofrio
6,979,786 B2 12/2005 Aukland et al.
6,981,628 B2 1/2006 Wales
6,987,244 B2 1/2006 Bauer
6,989,017 B2 1/2006 Howell et al.
6,994,707 B2 2/2006 Ellman et al.
6,994,709 B2 2/2006 Iida
6,997,931 B2 2/2006 Sauer et al.
7,001,381 B2 2/2006 Harano et al.
7,001,408 B2 2/2006 Knodel et al.
7,011,657 B2 3/2006 Truckai et al.
7,025,763 B2 4/2006 Karasawa et al.
7,033,354 B2 4/2006 Keppel
7,033,356 B2 4/2006 Latterell et al.
7,041,102 B2 5/2006 Truckai et al.
7,044,948 B2 5/2006 Keppel
7,052,489 B2 5/2006 Griego et al.
7,052,496 B2 5/2006 Yamauchi
7,063,699 B2 6/2006 Hess et al.
7,063,715 B2 6/2006 Onuki et al.
D525,361 S 7/2006 Hushka
7,070,597 B2 7/2006 Truckai et al.
7,083,618 B2 8/2006 Couture et al.
7,083,619 B2 8/2006 Truckai et al.
7,083,620 B2 8/2006 Jahns et al.
7,087,051 B2 8/2006 Bourne et al.
7,087,054 B2 8/2006 Truckai et al.
7,090,673 B2 8/2006 Dycus et al.
7,090,689 B2 8/2006 Nagase et al.
7,101,371 B2 9/2006 Dycus et al.
7,101,372 B2 9/2006 Dycus et al.
7,101,373 B2 9/2006 Dycus et al.
7,103,947 B2 9/2006 Sartor et al.
7,107,124 B2 9/2006 Green
7,108,694 B2 9/2006 Miura et al.
7,112,199 B2 9/2006 Cosmescu
7,112,201 B2 9/2006 Truckai et al.
D531,311 S 10/2006 Guerra et al.
7,115,123 B2 10/2006 Knowlton et al.
7,115,139 B2 10/2006 McClurken et al.
7,118,570 B2 10/2006 Tetzlaff et al.
7,118,587 B2 10/2006 Dycus et al.
7,131,860 B2 11/2006 Sartor et al.
7,131,970 B2 11/2006 Moses et al.
7,131,971 B2 11/2006 Dycus et al.
7,135,018 B2 11/2006 Ryan et al.
7,135,020 B2 11/2006 Lawes et al.
7,137,980 B2 11/2006 Buysse et al.
D533,274 S 12/2006 Visconti et al.
D533,942 S 12/2006 Kerr et al.
7,145,757 B2 12/2006 Shea et al.
7,147,632 B2 12/2006 Prakash et al.
7,147,638 B2 12/2006 Chapman et al.
7,150,097 B2 12/2006 Sremcich et al.
7,150,749 B2 12/2006 Dycus et al.
7,153,314 B2 12/2006 Laufer et al.
D535,027 S 1/2007 James et al.
7,156,842 B2 1/2007 Sartor et al.
7,156,846 B2 1/2007 Dycus et al.
7,160,298 B2 1/2007 Lawes et al.
7,160,299 B2 1/2007 Baily
7,166,106 B2 1/2007 Bartel et al.
7,169,145 B2 1/2007 Isaacson et al.
7,169,146 B2 1/2007 Truckai et al.
7,179,255 B2 2/2007 Lettice et al.
7,179,258 B2 2/2007 Buysse et al.
7,184,820 B2 2/2007 Jersey-Willuhn et al.
D538,932 S 3/2007 Malik
7,189,233 B2 3/2007 Truckai et al.
7,195,631 B2 3/2007 Dumbauld
D541,418 S 4/2007 Schechter et al.
7,204,835 B2 4/2007 Latterell et al.
7,207,990 B2 4/2007 Lands et al.
7,208,005 B2 4/2007 Frecker et al.
D541,611 S 5/2007 Aglassinger
D541,938 S 5/2007 Kerr et al.
7,211,084 B2 5/2007 Goble et al.
7,223,264 B2 5/2007 Daniel et al.
7,223,265 B2 5/2007 Keppel
D545,432 S 6/2007 Watanabe
7,232,440 B2 6/2007 Dumbauld et al.
D547,154 S 7/2007 Lee
7,238,184 B2 7/2007 Megerman et al.
7,241,288 B2 7/2007 Braun
7,241,296 B2 7/2007 Buysse et al.
7,244,257 B2 7/2007 Podhajsky et al.
7,246,734 B2 7/2007 Shelton, IV
7,248,944 B2 7/2007 Green
7,252,667 B2 8/2007 Moses et al.
7,254,433 B2 8/2007 Diab et al.
7,255,697 B2 8/2007 Dycus et al.
7,267,677 B2 9/2007 Johnson et al.
7,270,660 B2 9/2007 Ryan
7,270,664 B2 9/2007 Johnson et al.
7,276,068 B2 10/2007 Johnson et al.
7,288,103 B2 10/2007 Suzuki
7,291,161 B2 11/2007 Hooven
7,300,435 B2 11/2007 Wham et al.
7,303,557 B2 12/2007 Wham et al.
7,311,709 B2 12/2007 Truckai et al.
7,314,471 B2 1/2008 Holman
7,318,823 B2 1/2008 Sharps et al.
7,326,202 B2 2/2008 McGaffigan
7,329,256 B2 2/2008 Johnson et al.
7,329,257 B2 2/2008 Kanehira et al.
D564,662 S 3/2008 Moses et al.
7,338,526 B2 3/2008 Steinberg
7,342,754 B2 3/2008 Fitzgerald et al.
7,344,268 B2 3/2008 Jigamian
7,347,864 B2 3/2008 Vargas
D567,943 S 4/2008 Moses et al.
7,354,440 B2 4/2008 Truckal et al.
7,367,976 B2 5/2008 Lawes et al.
7,377,920 B2 5/2008 Buysse et al.
7,384,420 B2 6/2008 Dycus et al.
7,384,421 B2 6/2008 Hushka
7,396,265 B2 7/2008 Darley et al.
7,396,336 B2 7/2008 Orszulak et al.
7,396,356 B2 7/2008 Mollenauer
D575,395 S 8/2008 Hushka

(56) **References Cited**

U.S. PATENT DOCUMENTS

D575,401 S 8/2008 Hixson et al.
7,422,592 B2 9/2008 Morley et al.
7,425,835 B2 9/2008 Eisele
7,431,721 B2 10/2008 Paton et al.
7,435,249 B2 10/2008 Buysse et al.
7,438,714 B2 10/2008 Phan
7,442,193 B2 10/2008 Shields et al.
7,442,194 B2 10/2008 Dumbauld et al.
7,445,621 B2 11/2008 Dumbauld et al.
D582,038 S 12/2008 Swoyer et al.
7,458,972 B2 12/2008 Keppel
7,473,253 B2 1/2009 Dycus et al.
7,481,810 B2 1/2009 Dumbauld et al.
7,487,780 B2 2/2009 Hooven
7,491,201 B2 2/2009 Shields et al.
7,491,202 B2 2/2009 Odom et al.
7,500,975 B2 3/2009 Cunningham et al.
7,503,474 B2 3/2009 Hillstead et al.
7,510,556 B2 3/2009 Nguyen et al.
7,513,898 B2 4/2009 Johnson et al.
7,517,351 B2 4/2009 Culp et al.
7,540,872 B2 6/2009 Schechter et al.
7,549,995 B2 6/2009 Schultz
7,553,312 B2 6/2009 Tetzlaff et al.
7,553,686 B2 6/2009 George et al.
7,566,331 B2 * 7/2009 Looper A61B 17/320016 606/1
7,569,626 B2 8/2009 Truckai
7,582,087 B2 9/2009 Tetzlaff et al.
7,588,565 B2 9/2009 Marchitto et al.
7,594,313 B2 9/2009 Prakash et al.
7,594,916 B2 9/2009 Weinberg
7,597,693 B2 10/2009 Garrison
7,621,910 B2 11/2009 Sugi
7,624,186 B2 11/2009 Tanida
7,625,370 B2 12/2009 Hart et al.
7,628,791 B2 12/2009 Garrison et al.
7,628,792 B2 12/2009 Guerra
7,637,409 B2 12/2009 Marczyk
7,641,653 B2 1/2010 Dalla Betta et al.
7,651,493 B2 1/2010 Arts et al.
7,651,494 B2 1/2010 McClurken et al.
7,655,004 B2 2/2010 Long
7,655,007 B2 2/2010 Baily
7,668,597 B2 2/2010 Engmark et al.
7,678,111 B2 3/2010 Mulier et al.
7,686,804 B2 3/2010 Johnson et al.
7,686,827 B2 3/2010 Hushka
7,708,735 B2 5/2010 Chapman et al.
7,717,115 B2 5/2010 Barrett et al.
7,717,904 B2 5/2010 Suzuki et al.
7,717,914 B2 5/2010 Kimura
7,717,915 B2 5/2010 Miyazawa
7,722,607 B2 5/2010 Dumbauld et al.
D617,900 S 6/2010 Kingsley et al.
D617,901 S 6/2010 Unger et al.
D617,902 S 6/2010 Twomey et al.
D617,903 S 6/2010 Unger et al.
D618,798 S 6/2010 Olson et al.
7,727,231 B2 6/2010 Swanson
7,731,717 B2 6/2010 Odom et al.
7,736,374 B2 6/2010 Vaughan et al.
7,744,615 B2 6/2010 Couture
7,749,217 B2 7/2010 Podhajsky
7,753,908 B2 7/2010 Swanson
7,753,909 B2 7/2010 Chapman et al.
D621,503 S 8/2010 Otten et al.
7,766,910 B2 8/2010 Hixson et al.
7,771,425 B2 8/2010 Dycus et al.
7,776,036 B2 8/2010 Schechter et al.
7,776,037 B2 8/2010 Odom
7,780,662 B2 8/2010 Bahney
7,780,663 B2 8/2010 Yates et al.
7,789,878 B2 9/2010 Dumbauld et al.
7,799,026 B2 9/2010 Schechter et al.
7,799,028 B2 9/2010 Schechter et al.
7,811,283 B2 10/2010 Moses et al.
7,819,872 B2 10/2010 Johnson et al.
D627,462 S 11/2010 Kingsley
D628,289 S 11/2010 Romero
D628,290 S 11/2010 Romero
7,828,798 B2 11/2010 Buysse et al.
7,832,408 B2 11/2010 Shelton, IV et al.
7,837,685 B2 11/2010 Weinberg et al.
7,839,674 B2 11/2010 Lowrey et al.
7,842,033 B2 11/2010 Isaacson et al.
7,846,158 B2 12/2010 Podhajsky
7,846,161 B2 12/2010 Dumbauld et al.
7,857,812 B2 12/2010 Dycus et al.
D630,324 S 1/2011 Reschke
7,877,852 B2 2/2011 Unger et al.
7,877,853 B2 2/2011 Unger et al.
7,879,035 B2 2/2011 Garrison et al.
7,887,535 B2 2/2011 Lands et al.
7,887,536 B2 2/2011 Johnson et al.
7,896,878 B2 3/2011 Johnson et al.
7,898,288 B2 3/2011 Wong
7,900,805 B2 3/2011 Shelton, IV et al.
7,901,398 B2 3/2011 Stanczak et al.
7,901,400 B2 3/2011 Wham et al.
7,905,380 B2 3/2011 Shelton, IV et al.
7,905,881 B2 3/2011 Masuda et al.
7,909,820 B2 3/2011 Lipson et al.
7,909,823 B2 3/2011 Moses et al.
7,909,824 B2 3/2011 Masuda et al.
7,918,848 B2 4/2011 Lau et al.
7,922,718 B2 4/2011 Moses et al.
7,922,742 B2 4/2011 Hillstead et al.
7,922,953 B2 4/2011 Guerra
7,931,649 B2 4/2011 Couture et al.
7,935,052 B2 5/2011 Dumbauld
7,945,332 B2 5/2011 Schechter
7,947,041 B2 5/2011 Tetzlaff et al.
7,949,407 B2 5/2011 Kaplan et al.
7,951,149 B2 5/2011 Carlton
7,951,150 B2 5/2011 Johnson et al.
7,955,326 B2 6/2011 Paul et al.
7,955,327 B2 6/2011 Sartor et al.
7,955,331 B2 6/2011 Truckai et al.
7,955,332 B2 6/2011 Arts et al.
7,963,965 B2 6/2011 Buysse et al.
7,967,839 B2 6/2011 Flock et al.
7,972,328 B2 7/2011 Wham et al.
7,972,331 B2 7/2011 Hafner
7,976,544 B2 7/2011 McClurken et al.
7,981,113 B2 7/2011 Truckai et al.
7,988,507 B2 8/2011 Darley et al.
7,998,095 B2 8/2011 McAuley
8,012,150 B2 9/2011 Wham et al.
8,016,827 B2 9/2011 Chojin
8,034,049 B2 10/2011 Odom et al.
D649,249 S 11/2011 Guerra
D649,643 S 11/2011 Allen, IV et al.
8,048,074 B2 11/2011 Masuda
8,070,746 B2 12/2011 Orton et al.
8,070,748 B2 12/2011 Hixson et al.
8,075,580 B2 12/2011 Makower
8,089,417 B2 1/2012 Popovic et al.
8,092,451 B2 1/2012 Schechter et al.
8,104,956 B2 1/2012 Blaha
8,112,871 B2 2/2012 Brandt et al.
8,114,122 B2 2/2012 Nau, Jr.
8,123,743 B2 2/2012 Arts et al.
8,128,624 B2 3/2012 Couture et al.
8,128,625 B2 3/2012 Odom
8,133,224 B2 3/2012 Geiselhart
8,133,254 B2 3/2012 Dumbauld et al.
8,147,489 B2 4/2012 Moses et al.
8,192,433 B2 6/2012 Johnson et al.
8,241,282 B2 8/2012 Unger et al.
8,333,765 B2 12/2012 Johnson et al.
8,454,602 B2 6/2013 Kerr et al.
8,512,371 B2 8/2013 Kerr et al.
8,523,898 B2 9/2013 Bucciaglia et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,529,566 B2 9/2013 Kappus et al.
8,568,408 B2 10/2013 Townsend et al.
8,568,412 B2 10/2013 Brandt et al.
8,591,510 B2 11/2013 Allen, IV et al.
8,628,557 B2 1/2014 Collings et al.
8,668,689 B2 3/2014 Dumbauld et al.
8,679,098 B2 3/2014 Hart
8,679,114 B2 3/2014 Chapman et al.
8,679,115 B2 3/2014 Reschke
8,679,140 B2 3/2014 Butcher
8,685,009 B2 4/2014 Chernov et al.
8,685,056 B2 4/2014 Evans et al.
8,696,667 B2 4/2014 Guerra et al.
8,702,737 B2 4/2014 Chojin et al.
8,702,749 B2 4/2014 Twomey
8,745,840 B2 6/2014 Hempstead et al.
8,747,413 B2 6/2014 Dycus
8,747,434 B2 6/2014 Larson et al.
8,752,264 B2 6/2014 Ackley et al.
8,756,785 B2 6/2014 Allen, IV et al.
8,777,945 B2 7/2014 Floume et al.
8,845,636 B2 9/2014 Allen, IV et al.
8,852,185 B2 10/2014 Twomey
8,864,753 B2 10/2014 Nau, Jr. et al.
8,864,795 B2 10/2014 Kerr et al.
8,887,373 B2 11/2014 Brandt et al.
8,888,771 B2 11/2014 Twomey
8,900,232 B2 12/2014 Ourada
8,920,461 B2 12/2014 Unger et al.
8,939,972 B2 1/2015 Twomey
8,961,313 B2 2/2015 Zalewski
8,961,514 B2 2/2015 Garrison
8,961,515 B2 2/2015 Twomey et al.
8,967,305 B2 3/2015 Manganaro
8,968,283 B2 3/2015 Kharin
8,968,298 B2 3/2015 Twomey
8,968,306 B2 3/2015 Unger
8,968,307 B2 3/2015 Evans et al.
8,968,308 B2 3/2015 Homer et al.
8,968,309 B2 3/2015 Roy et al.
8,968,310 B2 3/2015 Twomey et al.
8,968,311 B2 3/2015 Allen, IV et al.
8,968,317 B2 3/2015 Evans et al.
8,968,360 B2 3/2015 Garrison et al.
9,011,435 B2 4/2015 Brandt et al.
9,023,035 B2 5/2015 Allen, IV et al.
9,024,237 B2 5/2015 Bonn
9,028,492 B2 5/2015 Kerr et al.
9,028,493 B2 5/2015 Dumbauld et al.
9,033,981 B2 5/2015 Olson et al.
9,034,009 B2 5/2015 Twomey et al.
9,039,691 B2 5/2015 Moua et al.
9,039,704 B2 5/2015 Joseph
9,039,732 B2 5/2015 Sims et al.
9,060,780 B2 6/2015 Twomey et al.
9,060,798 B2 6/2015 Harper et al.
9,072,524 B2 7/2015 Heard et al.
9,113,882 B2 8/2015 Twomey et al.
9,113,899 B2 8/2015 Garrison et al.
9,113,901 B2 8/2015 Allen, IV et al.
9,113,909 B2 8/2015 Twomey et al.
9,113,933 B2 8/2015 Chernova et al.
9,113,934 B2 8/2015 Chernov et al.
9,113,938 B2 8/2015 Kerr
9,161,807 B2 10/2015 Garrison
2002/0107517 A1 8/2002 Witt et al.
2002/0111624 A1 8/2002 Witt et al.
2002/0165469 A1 11/2002 Murakami
2003/0014052 A1 1/2003 Buysse et al.
2003/0014053 A1 1/2003 Nguyen et al.
2003/0018332 A1 1/2003 Schmaltz et al.
2003/0069570 A1 4/2003 Witzel et al.
2003/0109875 A1 6/2003 Tetzlaff et al.
2003/0114851 A1 6/2003 Truckai et al.
2003/0130653 A1 7/2003 Sixto et al.
2003/0139741 A1 7/2003 Goble et al.
2003/0158548 A1 8/2003 Phan et al.
2003/0171747 A1 9/2003 Kanehira et al.
2003/0181910 A1 9/2003 Dycus et al.
2003/0191396 A1 10/2003 Sanghvi et al.
2003/0216732 A1 11/2003 Truckai et al.
2003/0229344 A1 12/2003 Dycus et al.
2003/0236325 A1 12/2003 Bonora
2004/0030330 A1 2/2004 Brassell et al.
2004/0064151 A1 4/2004 Mollenauer
2004/0073238 A1 4/2004 Makower
2004/0073256 A1 4/2004 Marchitto et al.
2004/0115296 A1 6/2004 Duffin
2004/0176779 A1 9/2004 Casutt et al.
2004/0199181 A1 10/2004 Knodel et al.
2004/0224590 A1 11/2004 Rawa et al.
2004/0236326 A1 11/2004 Schulze et al.
2004/0249374 A1 12/2004 Tetzlaff et al.
2004/0260281 A1 12/2004 Baxter et al.
2005/0004564 A1 1/2005 Wham et al.
2005/0004569 A1 1/2005 Witt et al.
2005/0033278 A1 2/2005 McClurken et al.
2005/0059858 A1 3/2005 Frith et al.
2005/0059934 A1 3/2005 Wenchell et al.
2005/0090817 A1 4/2005 Phan
2005/0096645 A1 5/2005 Wellman et al.
2005/0149017 A1 7/2005 Dycus
2005/0254081 A1 11/2005 Ryu et al.
2005/0283148 A1 12/2005 Janssen et al.
2006/0052779 A1 3/2006 Hammill
2006/0064086 A1 3/2006 Odom
2006/0079933 A1 4/2006 Hushka et al.
2006/0084973 A1 4/2006 Hushka
2006/0111711 A1 5/2006 Goble
2006/0173452 A1 8/2006 Buysse et al.
2006/0190035 A1 8/2006 Hushka et al.
2006/0217709 A1 9/2006 Couture et al.
2006/0224053 A1 10/2006 Black et al.
2006/0253126 A1 11/2006 Bjerken et al.
2006/0259036 A1 11/2006 Tetzlaff et al.
2006/0264922 A1 11/2006 Sartor et al.
2006/0271030 A1 11/2006 Francis et al.
2006/0283093 A1 12/2006 Petrovic et al.
2006/0287641 A1 12/2006 Perlin
2007/0027447 A1 2/2007 Theroux et al.
2007/0043337 A1 2/2007 McAuley
2007/0043353 A1 2/2007 Dycus et al.
2007/0062017 A1 3/2007 Dycus et al.
2007/0118115 A1 5/2007 Artale et al.
2007/0173811 A1 7/2007 Couture et al.
2007/0173813 A1 7/2007 Odom
2007/0198011 A1 8/2007 Sugita
2007/0225695 A1 9/2007 Mayer et al.
2007/0255279 A1 11/2007 Buysse et al.
2007/0260238 A1 11/2007 Guerra
2007/0260242 A1 11/2007 Dycus et al.
2007/0265616 A1 11/2007 Couture et al.
2007/0265620 A1 11/2007 Kraas et al.
2008/0004616 A1 1/2008 Patrick
2008/0004656 A1* 1/2008 Livneh A61B 17/29 606/205
2008/0015575 A1 1/2008 Odom et al.
2008/0033428 A1 2/2008 Artale et al.
2008/0039831 A1 2/2008 Odom et al.
2008/0039835 A1 2/2008 Johnson et al.
2008/0046122 A1 2/2008 Manzo et al.
2008/0058802 A1 3/2008 Couture et al.
2008/0082100 A1 4/2008 Orton et al.
2008/0125767 A1 5/2008 Blaha
2008/0125797 A1 5/2008 Kelleher
2008/0171938 A1 7/2008 Masuda et al.
2008/0172051 A1 7/2008 Masuda et al.
2008/0208289 A1 8/2008 Darley et al.
2008/0215050 A1 9/2008 Bakos
2008/0234701 A1 9/2008 Morales et al.
2008/0243106 A1 10/2008 Coe et al.
2008/0243120 A1 10/2008 Lawes et al.
2008/0243158 A1 10/2008 Morgan
2008/0249523 A1 10/2008 McPherson et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0249527 A1 10/2008 Couture
2008/0271360 A1 11/2008 Barfield
2008/0281311 A1 11/2008 Dunning et al.
2008/0300580 A1 12/2008 Shelton, IV et al.
2008/0312653 A1 12/2008 Arts et al.
2008/0319292 A1 12/2008 Say et al.
2009/0012520 A1 1/2009 Hixson et al.
2009/0012556 A1 1/2009 Boudreaux et al.
2009/0015832 A1 1/2009 Popovic et al.
2009/0024126 A1 1/2009 Artale et al.
2009/0036881 A1 2/2009 Artale et al.
2009/0036899 A1 2/2009 Carlton et al.
2009/0043304 A1 2/2009 Tetzlaff et al.
2009/0048596 A1 2/2009 Shields et al.
2009/0054894 A1 2/2009 Yachi
2009/0062794 A1 3/2009 Buysse et al.
2009/0065565 A1 3/2009 Cao
2009/0076506 A1 3/2009 Baker
2009/0076534 A1 3/2009 Shelton, IV et al.
2009/0082766 A1 3/2009 Unger et al.
2009/0088738 A1 4/2009 Guerra et al.
2009/0088739 A1 4/2009 Hushka et al.
2009/0088740 A1 4/2009 Guerra et al.
2009/0088741 A1 4/2009 Hushka et al.
2009/0088744 A1 4/2009 Townsend
2009/0088745 A1 4/2009 Hushka et al.
2009/0088746 A1 4/2009 Hushka et al.
2009/0088747 A1 4/2009 Hushka et al.
2009/0088748 A1 4/2009 Guerra et al.
2009/0088749 A1 4/2009 Hushka et al.
2009/0088750 A1 4/2009 Hushka et al.
2009/0105750 A1 4/2009 Price et al.
2009/0112200 A1 4/2009 Eggers
2009/0112206 A1 4/2009 Dumbauld et al.
2009/0112229 A1 4/2009 Omori et al.
2009/0131934 A1 5/2009 Odom et al.
2009/0138006 A1 5/2009 Bales et al.
2009/0149853 A1 6/2009 Shields et al.
2009/0149854 A1 6/2009 Cunningham et al.
2009/0157071 A1 6/2009 Wham et al.
2009/0157072 A1 6/2009 Wham et al.
2009/0157075 A1 6/2009 Wham et al.
2009/0171350 A1 7/2009 Dycus et al.
2009/0171354 A1 7/2009 Deville et al.
2009/0177094 A1 7/2009 Brown et al.
2009/0182327 A1 7/2009 Unger
2009/0182329 A1 7/2009 Dycus
2009/0187188 A1 7/2009 Guerra et al.
2009/0198233 A1 8/2009 Chojin
2009/0204114 A1 8/2009 Odom
2009/0204137 A1 8/2009 Maxwell
2009/0206126 A1 8/2009 Huitema et al.
2009/0209957 A1 8/2009 Schmaltz et al.
2009/0209960 A1 8/2009 Chojin
2009/0234354 A1 9/2009 Johnson et al.
2009/0248007 A1 10/2009 Falkenstein et al.
2009/0248013 A1 10/2009 Falkenstein et al.
2009/0248019 A1 10/2009 Falkenstein et al.
2009/0248020 A1 10/2009 Falkenstein et al.
2009/0248021 A1 10/2009 McKenna
2009/0248022 A1 10/2009 Falkenstein et al.
2009/0248050 A1 10/2009 Hirai
2009/0248051 A1 10/2009 Masuda
2009/0254080 A1 10/2009 Honda
2009/0254081 A1 10/2009 Allison et al.
2009/0261804 A1 10/2009 McKenna et al.
2009/0270771 A1 10/2009 Takahashi
2009/0292282 A9 11/2009 Dycus
2009/0318912 A1 12/2009 Mayer et al.
2010/0016857 A1 1/2010 McKenna et al.
2010/0023009 A1 1/2010 Moses et al.
2010/0030028 A1 2/2010 Cabrera et al.
2010/0036375 A1 2/2010 Regadas
2010/0042140 A1 2/2010 Cunningham
2010/0042142 A1 2/2010 Cunningham
2010/0042143 A1 2/2010 Cunningham
2010/0049187 A1 2/2010 Carlton et al.
2010/0049194 A1 2/2010 Hart et al.
2010/0057078 A1 3/2010 Arts et al.
2010/0057081 A1 3/2010 Hanna
2010/0057082 A1 3/2010 Hanna
2010/0057083 A1 3/2010 Hanna
2010/0057084 A1 3/2010 Hanna
2010/0063500 A1 3/2010 Muszala
2010/0069903 A1 3/2010 Allen, IV et al.
2010/0069904 A1 3/2010 Cunningham
2010/0069953 A1 3/2010 Cunningham et al.
2010/0076427 A1 3/2010 Heard
2010/0076430 A1 3/2010 Romero
2010/0076431 A1 3/2010 Allen, IV
2010/0076432 A1 3/2010 Horner
2010/0087816 A1 4/2010 Roy
2010/0087818 A1 4/2010 Cunningham
2010/0094271 A1 4/2010 Ward et al.
2010/0094286 A1 4/2010 Chojin
2010/0094287 A1 4/2010 Cunningham et al.
2010/0094289 A1 4/2010 Taylor et al.
2010/0100122 A1 4/2010 Hinton
2010/0130971 A1 5/2010 Baily
2010/0130977 A1 5/2010 Garrison et al.
2010/0145334 A1 6/2010 Olson et al.
2010/0179539 A1 7/2010 Nau, Jr.
2010/0179543 A1 7/2010 Johnson et al.
2010/0179545 A1 7/2010 Twomey et al.
2010/0179546 A1 7/2010 Cunningham
2010/0179547 A1 7/2010 Cunningham et al.
2010/0198215 A1 8/2010 Julian et al.
2010/0198218 A1 8/2010 Manzo
2010/0198248 A1 8/2010 Vakharia
2010/0217264 A1 8/2010 Odom et al.
2010/0228249 A1 9/2010 Mohr et al.
2010/0228250 A1 9/2010 Brogna
2010/0249769 A1 9/2010 Nau, Jr. et al.
2010/0249776 A1 9/2010 Kerr
2010/0256635 A1 10/2010 McKenna et al.
2010/0274160 A1 10/2010 Yachi et al.
2010/0274244 A1 10/2010 Heard
2010/0274265 A1 10/2010 Wingardner et al.
2010/0280511 A1 11/2010 Rachlin et al.
2010/0280515 A1 11/2010 Hixson et al.
2010/0286691 A1 11/2010 Kerr et al.
2010/0292691 A1 11/2010 Brogna
2010/0307934 A1 12/2010 Chowaniec et al.
2010/0312235 A1 12/2010 Bahney
2010/0312238 A1 12/2010 Schechter et al.
2010/0312242 A1 12/2010 Odom
2010/0331742 A1 12/2010 Masuda
2010/0331839 A1 12/2010 Schechter et al.
2011/0004209 A1 1/2011 Lawes et al.
2011/0004210 A1 1/2011 Johnson et al.
2011/0009864 A1 1/2011 Bucciaglia et al.
2011/0015632 A1 1/2011 Artale
2011/0018164 A1 1/2011 Sartor et al.
2011/0034918 A1 2/2011 Reschke
2011/0036183 A1 2/2011 Artale et al.
2011/0054467 A1 3/2011 Mueller et al.
2011/0054468 A1 3/2011 Dycus
2011/0054469 A1 3/2011 Kappus et al.
2011/0054471 A1 3/2011 Gerhardt et al.
2011/0054472 A1 3/2011 Romero
2011/0060333 A1 3/2011 Mueller
2011/0060335 A1 3/2011 Harper et al.
2011/0060356 A1 3/2011 Reschke et al.
2011/0066174 A1 3/2011 Gilbert
2011/0071522 A1 3/2011 Dumbauld et al.
2011/0071523 A1 3/2011 Dickhans
2011/0071525 A1 3/2011 Dumbauld et al.
2011/0072638 A1 3/2011 Brandt et al.
2011/0073246 A1 3/2011 Brandt et al.
2011/0077649 A1 3/2011 Kingsley
2011/0082457 A1 4/2011 Kerr et al.
2011/0087221 A1 4/2011 Siebrecht et al.
2011/0098689 A1 4/2011 Nau, Jr. et al.
2011/0106079 A1 5/2011 Garrison et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0162796 A1 7/2011 Guerra
2011/0178519 A1 7/2011 Couture et al.
2011/0184405 A1 7/2011 Mueller
2011/0190653 A1 8/2011 Harper et al.
2011/0190765 A1 8/2011 Chojin
2011/0193608 A1 8/2011 Krapohl
2011/0218530 A1 9/2011 Reschke
2011/0230880 A1 9/2011 Chojin et al.
2011/0238066 A1 9/2011 Olson
2011/0238067 A1 9/2011 Moses et al.
2011/0251605 A1 10/2011 Hoarau et al.
2011/0251606 A1 10/2011 Kerr
2011/0251611 A1 10/2011 Horner et al.
2011/0270245 A1 11/2011 Horner et al.
2011/0270250 A1 11/2011 Horner et al.
2011/0270251 A1 11/2011 Horner et al.
2011/0270252 A1 11/2011 Horner et al.
2011/0276048 A1 11/2011 Kerr et al.
2011/0276049 A1 11/2011 Gerhardt
2011/0295251 A1 12/2011 Garrison
2011/0295313 A1 12/2011 Kerr
2011/0301592 A1 12/2011 Kerr et al.
2011/0301599 A1 12/2011 Roy et al.
2011/0301600 A1 12/2011 Garrison et al.
2011/0301601 A1 12/2011 Garrison et al.
2011/0301602 A1 12/2011 Roy et al.
2011/0301603 A1 12/2011 Kerr et al.
2011/0301604 A1 12/2011 Horner et al.
2011/0301605 A1 12/2011 Homer
2011/0301606 A1 12/2011 Kerr
2011/0301637 A1 12/2011 Kerr et al.
2011/0319886 A1 12/2011 Chojin et al.
2011/0319888 A1 12/2011 Mueller et al.
2012/0004658 A1 1/2012 Chojin
2012/0010614 A1 1/2012 Couture
2012/0022532 A1 1/2012 Garrison
2012/0029515 A1 2/2012 Couture
2012/0041438 A1 2/2012 Nau, Jr. et al.
2012/0046659 A1 2/2012 Mueller
2012/0046660 A1 2/2012 Nau, Jr.
2012/0046662 A1 2/2012 Gilbert
2012/0059371 A1 3/2012 Anderson et al.
2012/0059372 A1 3/2012 Johnson
2012/0059374 A1 3/2012 Johnson et al.
2012/0059375 A1 3/2012 Couture et al.
2012/0059408 A1 3/2012 Mueller
2012/0059409 A1 3/2012 Reschke et al.
2012/0078250 A1 3/2012 Orton et al.
2012/0083785 A1 4/2012 Roy et al.
2012/0083786 A1 4/2012 Artale et al.
2012/0083827 A1 4/2012 Artale et al.
2012/0095456 A1 4/2012 Schechter et al.
2012/0095460 A1 4/2012 Rooks et al.
2012/0239034 A1 9/2012 Homer et al.
2012/0259331 A1 10/2012 Garrison
2012/0265241 A1 10/2012 Hart et al.
2012/0296205 A1 11/2012 Chernov et al.
2012/0296238 A1 11/2012 Chernov et al.
2012/0296239 A1 11/2012 Chernov et al.
2012/0296323 A1 11/2012 Chernov et al.
2012/0296371 A1 11/2012 Kappus et al.
2012/0303026 A1 11/2012 Dycus et al.
2012/0323238 A1 12/2012 Tyrrell et al.
2012/0330308 A1 12/2012 Joseph
2013/0018364 A1 1/2013 Chernov et al.
2013/0022495 A1 1/2013 Allen, IV et al.
2013/0071282 A1 3/2013 Fry
2013/0072927 A1 3/2013 Allen, IV et al.
2013/0079760 A1 3/2013 Twomey et al.
2013/0079774 A1 3/2013 Whitney et al.
2013/0085496 A1 4/2013 Unger et al.
2013/0103030 A1 4/2013 Garrison
2013/0103031 A1 4/2013 Garrison
2013/0138101 A1 5/2013 Kerr
2013/0144284 A1 6/2013 Behnke, II et al.
2013/0197503 A1 8/2013 Orszulak
2013/0253489 A1 9/2013 Nau, Jr. et al.
2013/0255063 A1 10/2013 Hart et al.
2013/0274736 A1 10/2013 Garrison
2013/0289561 A1 10/2013 Waaler et al.
2013/0296922 A1 11/2013 Allen, IV et al.
2013/0304058 A1 11/2013 Kendrick
2013/0304066 A1 11/2013 Kerr et al.
2013/0325057 A1 12/2013 Larson et al.

FOREIGN PATENT DOCUMENTS

CA 2590520 A1 11/2007
CN 201299462 9/2009
DE 2415263 A1 10/1975
DE 02514501 A1 10/1976
DE 2627679 A1 1/1977
DE 03423356 C2 6/1986
DE 03612646 A1 4/1987
DE 8712328 U1 2/1988
DE 04303882 C2 2/1995
DE 04403252 A1 8/1995
DE 19515914 C1 7/1996
DE 19506363 A1 8/1996
DE 29616210 U1 11/1996
DE 19608716 C1 4/1997
DE 19751106 A1 5/1998
DE 19751108 A1 5/1999
DE 19946527 C1 7/2001
DE 10045375 C2 10/2002
DE 202007009165 U1 8/2007
DE 202007009317 U1 8/2007
DE 202007016233 U1 1/2008
DE 19738457 B4 1/2009
DE 102004026179 B4 1/2009
DE 102008018406 B3 7/2009
EP 0467501 A1 1/1992
EP 0509670 A3 12/1992
EP 0306123 B1 8/1993
EP 0572131 A1 12/1993
EP 0584787 A1 3/1994
EP 0589555 A1 3/1994
EP 0589453 A3 4/1994
EP 0648475 A1 4/1995
EP 0624348 A3 6/1995
EP 0364216 B1 1/1996
EP 0518230 B1 5/1996
EP 0517243 B1 9/1997
EP 0541930 B1 3/1998
EP 0878169 A1 11/1998
EP 0623316 B1 3/1999
EP 0650701 B1 3/1999
EP 0923907 A1 6/1999
EP 0640317 B1 9/1999
EP 0950378 A1 10/1999
EP 0986990 A1 3/2000
EP 1034747 A1 9/2000
EP 1034748 9/2000
EP 0694290 B1 11/2000
EP 1050278 11/2000
EP 1053719 11/2000
EP 1053720 11/2000
EP 1055399 11/2000
EP 1055400 11/2000
EP 1080694 3/2001
EP 1082944 3/2001
EP 1177771 2/2002
EP 1278007 A1 1/2003
EP 1159926 A3 3/2003
EP 0717966 B1 4/2003
EP 1301135 4/2003
EP 0887046 B1 7/2003
EP 1330991 A1 7/2003
EP 1486177 6/2004
EP 0913126 B1 10/2004
EP 1472984 11/2004
EP 0754437 B2 12/2004
EP 0888747 B1 12/2004
EP 1025807 B1 12/2004

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

EP	0774232	B1	1/2005
EP	0853922	B1	2/2005
EP	1527747		5/2005
EP	1530952		5/2005
EP	1532932	A1	5/2005
EP	1535581		6/2005
EP	1545360	A1	6/2005
EP	1609430		12/2005
EP	1201192		2/2006
EP	1034746	B1	3/2006
EP	1632192		3/2006
EP	1186274		4/2006
EP	1642543		4/2006
EP	1645238	A1	4/2006
EP	1645240	A2	4/2006
EP	1649821		4/2006
EP	0875209	B1	5/2006
EP	1707143	A1	10/2006
EP	1767163	A1	3/2007
EP	1769765	A1	4/2007
EP	1769766		4/2007
EP	1772109		4/2007
EP	1785097		5/2007
EP	1785098		5/2007
EP	1785101		5/2007
EP	1787597		5/2007
EP	1810625	A1	7/2007
EP	1810628	A1	7/2007
EP	1842500		10/2007
EP	1878400		1/2008
EP	1894535		3/2008
EP	1929970		6/2008
EP	1946715		7/2008
EP	1958583	A2	8/2008
EP	1990019		11/2008
EP	1683496		12/2008
EP	1997438		12/2008
EP	1997439		12/2008
EP	1527744		2/2009
EP	2103268		9/2009
EP	2105104		9/2009
EP	2147649		1/2010
EP	2153791		2/2010
EP	2206474		7/2010
EP	1920725		10/2010
EP	2243439		10/2010
EP	2294998		3/2011
EP	2301467		3/2011
EP	1628586		7/2011
GB	623316		5/1949
GB	1490585		11/1977
GB	2213416	A	8/1989
GB	2214430	A	9/1989
JP	61-501068		9/1984
JP	10-24051	A	1/1989
JP	11-47150	A	6/1989
JP	6-502328		3/1992
JP	5-5106		1/1993
JP	05-40112		2/1993
JP	0006030945	A	2/1994
JP	6-121797	A	5/1994
JP	6-285078	A	10/1994
JP	6-511401		12/1994
JP	06343644	A	12/1994
JP	07265328	A	10/1995
JP	8-56955		5/1996
JP	08252263	A	10/1996
JP	8-289895	A	11/1996
JP	8-317934	A	12/1996
JP	8-317936	A	12/1996
JP	9-10223	C	1/1997
JP	9-122138	A	5/1997
JP	10-155798	A	6/1998
JP	11-070124	A	3/1999
JP	11-169381	A	6/1999
JP	11-192238	A	7/1999
JP	11244298	A	9/1999
JP	2000-102545	A	4/2000
JP	2000342599	A	12/2000
JP	2000350732	A	12/2000
JP	2001-8944		1/2001
JP	2001-29356		2/2001
JP	2001128990	A	5/2001
JP	2001-190564	A	7/2001
JP	2001-3400		11/2001
JP	2002-528166	A	9/2002
JP	2003245285	A	9/2003
JP	2004-517668	A	6/2004
JP	2004-528869	A	9/2004
JP	2011125195	A	6/2011
SU	401367	A1	10/1973
WO	89/00757		1/1989
WO	92/04873		4/1992
WO	92/06642		4/1992
WO	93/19681		10/1993
WO	93/21845		11/1993
WO	94/00059	A1	1/1994
WO	94/08524		4/1994
WO	94/20025		9/1994
WO	95/02369		1/1995
WO	95/07662		3/1995
WO	95/15124		6/1995
WO	95/20360		8/1995
WO	95/20921		8/1995
WO	96/05776		2/1996
WO	96/11635		4/1996
WO	96-22056	A1	7/1996
WO	96/13218		9/1996
WO	97/00646		1/1997
WO	97/00647		1/1997
WO	97/10764		3/1997
WO	97/18768		5/1997
WO	97/24073		7/1997
WO	97/24993		7/1997
WO	98/14124		4/1998
WO	98/27880		7/1998
WO	98/31290		7/1998
WO	98/43264		10/1998
WO	99/03407		1/1999
WO	99/03408		1/1999
WO	99/03409		1/1999
WO	99/03414		1/1999
WO	99/12488		3/1999
WO	99-23933	A2	5/1999
WO	99/23959		5/1999
WO	99-25261	A1	5/1999
WO	99/40857		8/1999
WO	99/40861		8/1999
WO	99/51158		10/1999
WO	99/66850		12/1999
WO	00/24322		5/2000
WO	00/24330		5/2000
WO	00/24331		5/2000
WO	00/33753		6/2000
WO	0036986	A1	6/2000
WO	00/41638		7/2000
WO	00/47124		8/2000
WO	00/53112		9/2000
WO	0059392	A1	10/2000
WO	01/01847		1/2001
WO	01/17448		3/2001
WO	0115614	A1	3/2001
WO	0154604	A1	8/2001
WO	01/66025		9/2001
WO	02/07627		1/2002
WO	02/058544		8/2002
WO	02/067798		9/2002
WO	02/080783		10/2002
WO	02/080784		10/2002
WO	02/080785		10/2002
WO	02/080786		10/2002
WO	02/080793		10/2002
WO	02/080794		10/2002
WO	02/080795		10/2002

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	02/080796		10/2002
WO	02/080797		10/2002
WO	02/080798		10/2002
WO	02/080799	A1	10/2002
WO	02/081170		10/2002
WO	02/085218		10/2002
WO	03/061500		7/2003
WO	03/068046		8/2003
WO	03/096880		11/2003
WO	03/101311		12/2003
WO	03/090630	A3	4/2004
WO	2004-028585	A2	4/2004
WO	2004/032776	A1	4/2004
WO	2004/032777	A1	4/2004
WO	2004/052221	A1	6/2004
WO	2004/073488	A2	9/2004
WO	2004/073490	A2	9/2004
WO	2004/073753	A2	9/2004
WO	2004/082495	A1	9/2004
WO	2004/098383	A2	11/2004
WO	2004/103156	A2	12/2004
WO	2005/004734	A1	1/2005
WO	2005/004735	A1	1/2005
WO	2005-009255	A1	2/2005
WO	2005/011049	A2	2/2005
WO	2005-030071	A1	4/2005
WO	2005/048809	A1	6/2005
WO	2005/050151	A1	6/2005
WO	2005/110264	A2	11/2005
WO	2006021269	A1	3/2006
WO	2008/008457	A2	1/2008
WO	2008/045348	A2	4/2008
WO	2008/045350	A2	4/2008
WO	2008040483	A1	4/2008
WO	20080112147	A1	9/2008
WO	20090005850	A1	1/2009
WO	2009032623	A2	3/2009
WO	20090039179	A1	3/2009
WO	20090039510	A1	3/2009
WO	2009124097	A1	10/2009
WO	2010/104753		9/2010

OTHER PUBLICATIONS

Chung et al., "Clinical Experience of Sutureless Closed Hemorrhoidectomy with LigaSure" Diseases of the Colon & Rectum vol. 46, No. 1 Jan. 2003.

Tinkcler L.F., "Combined Diathermy and Suction Forceps" , Feb. 6, 1967, British Medical Journal Feb. 6, 1976, vol. 1, nr. 5431 p. 361, ISSN: 0007-1447.

Carbonell et al., "Comparison of the Gyrus PlasmaKinetic Sealer and the Valleylab LigaSure Device in the Hemostasis of Small, Medium, and Large-Sized Arteries" Carolinas Laparoscopic and Advanced Surgery Program, Carolinas Medical Center, Charlotte,NC; Date: Aug. 2003.

Peterson et al. "Comparison of Healing Process Following Ligation with Sutures and Bipolar Vessel Sealing" Surgical Technology International (2001).

"Electrosurgery: A Historical Overview" Innovations in Electrosurgery; Sales/Product Literature; Dec. 31, 2000.

Johnson et al. "Evaluation of a Bipolar Electrothermal Vessel Sealing Device in Hemorrhoidectomy" Sales/Product Literature; Jan. 2004.

E. David Crawford "Evaluation of a New Vessel Sealing Device in Urologic Cancer Surgery" Sales/Product Literature 2000.

Johnson et al. "Evaluation of the LigaSure Vessel Sealing System in Hemorrhoidectormy" American College of Surgeons (ACS) Clinicla Congress Poster (2000).

Muller et al., "Extended Left Hemicolectomy Using the LigaSure Vessel Sealing System" Innovations That Work, Sep. 1999.

Kennedy et al. "High-burst-strength, feedback-controlled bipolar vessel sealing" Surgical Endoscopy (1998) 12: 876-878.

Burdette et al. "In Vivo Probe Measurement Technique for Determining Dielectric Properties at VHF Through Microwave Frequencies", IEEE Transactions on Microwave Theory and Techniques, vol. MTT-28, No. 4, Apr. 1980 pp. 414-427.

Carus et al., "Initial Experience With the LigaSure Vessel Sealing System in Abdominal Surgery", Innovations That Work, Jun. 2002.

Heniford et al. "Initial Research and Clinical Results with an Electrothermal Bipolar Vessel Sealer" Oct. 1999.

Heniford et al. "Initial Results with an Electrothermal Bipolar Vessel Sealer" Surgical Endoscopy (2000) 15:799-801.

Herman et al., "Laparoscopic Intestinal Resection With the LigaSure Vessel Sealing System: A Case Report"; Innovations That Work, Feb. 2002.

Koyle et al., "Laparoscopic Palomo Varicocele Ligation in Children and Adolescents" Pediatric Endosurgery & Innovative Techniques, vol. 6, No. 1, 2002.

W. Scott Helton, "LigaSure Vessel Sealing System: Revolutionary Hemostasis Product for General Surgery"; Sales/Product Literature 1999.

LigaSure Vessel Sealing System, the Seal of Confidence in General, Gynecologic, Urologic, and Laparaoscopic Surgery; Sales/Product Literature; Apr. 2002.

Joseph Ortenberg "LigaSure System Used in Laparoscopic 1st and 2nd Stage Orchiopexy" Innovations That Work, Nov. 2002.

Sigel et al. "The Mechanism of Blood Vessel Closure by High Frequency Electrocoagulation" Surgery Gynecology & Obstetrics, Oct. 1965 pp. 823-831.

Sampayan et al, "Multilayer Ultra-High Gradient Insulator Technology" Discharges and Electrical Insulation in Vacuum, 1998. Netherlands Aug. 17-21, 1998; vol. 2, pp. 740-743.

Paul G. Horgan, "A Novel Technique for Parenchymal Division During Hepatectomy" The American Journal of Surgery, vol. 181, No. 3, Apr. 2001 pp. 236-237.

Benaron et al., "Optical Time-Of-Flight and Absorbance Imaging of Biologic Media", Science, American Association for the Advancement of Science, Washington, DC, vol. 259, Mar. 5, 1993, pp. 1463-1466.

Olsson et al. "Radical Cystectomy in Females" Current Surgical Techniques in Urology, vol. 14, Issue 3, 2001.

Palazzo et al. "Randomized clinical trial of Ligasure versus open haemorrhoidectomy" British Journal of Surgery 2002, 89, 154-157.

Levy et al. "Randomized Trial of Suture Versus Electrosurgical Bipolar Vessel Sealing in Vaginal Hysterectomy" Obstetrics & Gynecology, vol. 102, No. 1, Jul. 2003.

"Reducing Needlestick Injuries in the Operating Room" Sales/Product Literature 2001.

Bergdahl et al. "Studies on Coagulation and the Development of an Automatic Computerized Bipolar Coagulator" J. Neurosurg, vol. 75, Jul. 1991, pp. 148-151.

Strasberg et al. "A Phase I Study of the LigaSure Vessel Sealing System in Hepatic Surgery" Section of HBP Surger, Washington University School of Medicine, St. Louis MO, Presented at AHPBA, Feb. 2001.

Sayfan et al. "Sutureless Closed Hemorrhoidectomy: A New Technique" Annals of Surgery vol. 234 No. 1 Jul. 2001; pp. 21-24.

Levy et al., "Update on Hysterectomy—New Technologies and Techniques" OBG Management, Feb. 2003.

Dulemba et al. "Use of a Bipolar Electrothermal Vessel Sealer in Laparoscopically Assisted Vaginal Hysterectomy" Sales/Product Literature; Jan. 2004.

Strasberg et al., "Use of a Bipolar Vessel-Sealing Device for Parenchymal Transection During Liver Surgery" Journal of Gastrointestinal Surgery, vol. 6, No. 4, Jul./Aug. 2002 pp. 569-574.

Sengupta et al., "Use of a Computer-Controlled Bipolar Diathermy System in Radical Prostatectomies and Other Open Urological Surgery" ANZ Journal of Surgery (2001) 71.9 pp. 538-540.

Rothenberg et al. "Use of the LigaSure Vessel Sealing System in Minimally Invasive Surgery in Children" Int'l Pediatric Endosurgery Group (IPEG) 2000.

Crawford et al. "Use of the LigaSure Vessel Sealing System in Urologic Cancer Surgery" Grand Rounds in Urology 1999 vol. 1 Issue 4 pp. 10-17.

(56) **References Cited**

OTHER PUBLICATIONS

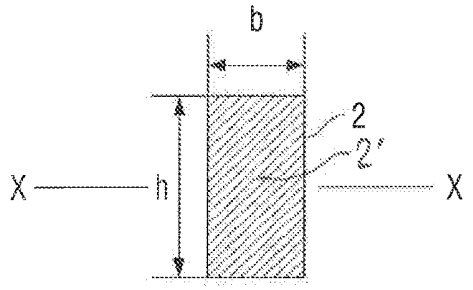
Craig Johnson, "Use of the LigaSure Vessel Sealing System in Bloodless Hemorrhoidectomy" Innovations That Work, Mar. 2000.
Levy et al. "Use of a New Energy-based Vessel Ligation Device During Vaginal Hysterectomy" Int'l Federation of Gynecology and Obstetrics (FIGO) World Congress 1999.
Barbara Levy, "Use of a New Vessel Ligation Device During Vaginal Hysterectomy" FIGO 2000, Washington, D.C.
E. David Crawford "Use of a Novel Vessel Sealing Technology in Management of the Dorsal Veinous Complex" Sales/Product Literature 2000.
Jarrett et al., "Use of the LigaSure Vessel Sealing System for Peri-Hilar Vessels in Laparoscopic Nephrectomy" Sales/Product Literature 2000.
Crouch et al. "A Velocity-Dependent Model for Needle Insertion in Soft Tissue" MICCAI 2005; LNCS 3750 pp. 624-632, Dated: 2005.
McLellan et al. "Vessel Sealing for Hemostasis During Pelvic Surgery" Int'l Federation of Gynecology and Obstetrics FIGO World Congress 2000, Washington, D.C.
McLellan et al. "Vessel Sealing for Hemostasis During Gynecologic Surgery" Sales/Product Literature 1999.
Int'l Search Report EP 98944778.4 dated Oct. 31, 2000.
Int'l Search Report EP 98957771 dated Aug. 9, 2001.
Int'l Search Report EP 98957773 dated Aug. 1, 2001.
Int'l Search Report EP 98958575.7 dated Sep. 20, 2002.
Int'l Search Report EP 04013772.1 dated Apr. 1, 2005.
Int'l Search Report EP 04027314.6 dated Mar. 10, 2005.
Int'l Search Report EP 04027479.7 dated Mar. 8, 2005.
Int'l Search Report EP 04027705.5 dated Feb. 3, 2005.
Int'l Search Report EP 04709033.7 dated Dec. 8, 2010.
Int'l Search Report EP 04752343.6 dated Jul. 20, 2007.
Int'l Search Report EP 05002671.5 dated Dec. 22, 2008.
Int'l Search Report EP 05002674.9 dated Jan. 16, 2009.
Int'l Search Report EP 05013463.4 dated Oct. 7, 2005.
Int'l Search Report EP 05013894 dated Feb. 3, 2006.
Int'l Search Report EP 05013895.7 dated Oct. 21, 2005.
Int'l Search Report EP 05016399.7 dated Jan. 13, 2006.
Int'l Search Report EP 05017281.6 dated Nov. 24, 2005.
Int'l Search Report EP 05019130.3 dated Oct. 27, 2005.
Int'l Search Report EP 05019429.9 dated May 6, 2008.
Int'l Search Report EP 05020532 dated Jan. 10, 2006.
Int'l Search Report EP 05020665.5 dated Feb. 27, 2006.
Int'l Search Report EP 05020666.3 dated Feb. 27, 2006.
Int'l Search Report EP 05021197.8 dated Feb. 20, 2006.
Int'l Search Report EP 05021779.3 dated Feb. 2, 2006.
Int'l Search Report EP 05021780.1 dated Feb. 23, 2006.
Int'l Search Report EP 05021937.7 dated Jan. 23, 2006.
Int'l Search Report—extended—EP 05021937.7 dated Mar. 15, 2006.
Int'l Search Report EP 05023017.6 dated Feb. 24, 2006.
Int'l Search Report EP 06002279.5 dated Mar. 30, 2006.
Int'l Search Report EP 06005185.1 dated May 10, 2006.
Int'l Search Report EP 06006716.2 dated Aug. 4, 2006.
Int'l Search Report EP 06008515.6 dated Jan. 8, 2009.
Int'l Search Report EP 06008779.8 dated Jul. 13, 2006.
Int'l Search Report EP 06014461.5 dated Oct. 31, 2006.
Int'l Search Report EP 06020574.7 dated Oct. 2, 2007.
Int'l Search Report EP 06020583.8 dated Feb. 7, 2007.
Int'l Search Report EP 06020584.6 dated Feb. 1, 2007.
Int'l Search Report EP 06020756.0 dated Feb. 16, 2007.
Int'l Search Report EP 06 024122.1 dated Apr. 16, 2007.
Int'l Search Report EP 06024123.9 dated Mar. 6, 2007.
Int'l Search Report EP 07 001480.8 dated Apr. 19, 2007.
Int'l Search Report EP 07 001488.1 dated Jun. 5, 2007.
Int'l Search Report EP 07 004429.2 dated Nov. 2, 2010.
Int'l Search Report EP 07 009026.1 dated Oct. 8, 2007.
Int'l Search Report Extended—EP 07 009029.5 dated Jul. 20, 2007.
Int'l Search Report EP 07 009321.6 dated Aug. 28, 2007.
Int'l Search Report EP 07 010672.9 dated Oct. 16, 2007.
Int'l Search Report EP 07 013779.9 dated Oct. 26, 2007.
Int'l Search Report EP 07 014016 dated Jan. 28, 2008.
Int'l Search Report EP 07 015191.5 dated Jan. 23, 2008.
Int'l Search Report EP 07 015601.3 dated Jan. 4, 2008.
Int'l Search Report EP 07 016911 dated May 28, 2010.
Int'l Search Report EP 07 016911.5 extended dated Mar. 2, 2011.
Int'l Search Report EP 07 020283.3 dated Feb. 5, 2008.
Int'l Search Report EP 07 021646.0 dated Mar. 20, 2008.
Int'l Search Report EP 07 021646.0 dated Jul. 9, 2008.
Int'l Search Report EP 07 021647.8 dated May 2, 2008.
Int'l Search Report EP 08 002692.5 dated Dec. 12, 2008.
Int'l Search Report EP 08 004655.0 dated Jun. 24, 2008.
Int'l Search Report EP 08 006732.5 dated Jul. 29, 2008.
Int'l Search Report EP 08 006917.2 dated Jul. 3, 2008.
Int'l Search Report EP 08 016539.2 dated Jan. 8, 2009.
Int'l Search Report EP 08 020807.7 dated Apr. 24, 2009.
Int'l Search Report EP 09 003677.3 dated May 4, 2009.
Int'l Search Report EP 09 003813.4 dated Aug. 3, 2009.
Int'l Search Report EP 09 004491.8 dated Sep. 9, 2009.
Int'l Search Report EP 09 005051.9 dated Jul. 6, 2009.
Int'l Search Report EP 09 005575.7 dated Sep. 9, 2009.
Int'l Search Report EP 09 010521.4 dated Dec. 16, 2009.
Int'l Search Report EP 09 011745.8 dated Jan. 5, 2010.
Int'l Search Report EP 09 012629.3 dated Dec. 8, 2009.
Int'l Search Report EP 09 012687.1 dated Dec. 23, 2009.
Int'l Search Report EP 09 012688.9 dated Dec. 28, 2009.
Int'l Search Report EP 09 152267.2 dated Jun. 15, 2009.
Int'l Search Report Ep 09 152898.4 dated Jun. 10, 2009.
Int'l Search Report EP 09 154850.3 dated Jul. 20, 2009.
Int'l Search Report EP 09 160476.9 dated Aug. 4, 2009.
Int'l Search Report EP 09 164903.8 dated Aug. 21, 2009.
Int'l Search Report EP 09 165753.6 dated Nov. 11, 2009.
Int'l Search Report EP 09 168153.6 dated Jan. 14, 2010.
Int'l Search Report EP 09 168810.1 dated Feb. 2, 2010.
Int'l Search Report EP 09 172749.5 dated Dec. 4, 2009.
Int'l Search Report EP 10 000259.1 dated Jun. 30, 2010.
Int'l Search Report EP 10 011750.6 dated Feb. 1, 2011.
Int'l Search Report EP 10 157500.9 dated Jul. 30, 2010.
Int'l Search Report EP 10 159205.3 dated Jul. 7, 2010.
Int'l Search Report EP 10 160870.1 dated Aug. 9, 2010.
Int'l Search Report EP 10 161596.1 dated Jul. 28, 2010.
Int'l Search Report EP 10 167655.9 dated Aug. 31, 2011.
Int'l Search Report EP 10 168705.1 dated Oct. 4, 2010.
Int'l Search Report EP 10 169647.4 dated Oct. 29, 2010.
Int'l Search Report EP 10 172005.0 dated Sep. 30, 2010.
Int'l Search Report EP 10 175956.1 dated Nov. 12, 2010.
Int'l Search Report EP 10 181034.9 dated Jan. 26, 2011.
Int'l Search Report EP 10 181575.1 dated Apr. 5, 2011.
Int'l Search Report EP 10 181969.6 dated Feb. 4, 2011.
Int'l Search Report EP 10 182019 dated Aug. 4, 2011.
Int'l Search Report EP 10 182022.3 dated Mar. 11, 2011.
Int'l Search Report EP 10 185386.9 dated Jan. 10, 2011.
Int'l Search Report EP 10 185405.7 dated Jan. 5, 2011.
Int'l Search Report EP 10 186527.7 dated Jun. 17, 2011.
Int'l Search Report EP 10 189206.5 dated Mar. 17, 2011.
Int'l Search Report EP 10 191320.0 dated Feb. 15, 2011.
Int'l Search Report EP 11 151509.4 dated Jun. 6, 2011.
Int'l Search Report EP 11 152220.7 dated May 19, 2011.
Int'l Search Report EP 11 152360.1 dated Jun. 6, 2011.
Int'l Search Report EP 11 159771.2 dated May 28, 2010.
Int'l Search Report EP 11 161117.4 dated Jun. 30, 2011.
Int'l Search Report EP 11 161118.2 dated Oct. 12, 2011.
Int'l Search Report EP 11 164274.0 dated Aug. 3, 2011.
Int'l Search Report EP 11 164275.7 dated Aug. 25, 2011.
Int'l Search Report EP 11 167437.0 dated Aug. 8, 2011.
Int'l Search Report EP 11 168458.5 dated Jul. 29, 2011.
Int'l Search Report EP 11 173008.1 dated Nov. 4, 2011.
Int'l Search Report EP 11 179514 dated Nov. 4, 2011.
Int'l Search Report EP 11 180182.5 dated Nov. 15, 2011.
Int'l Search Report PCT/US98/18640 dated Jan. 29, 1999.
Int'l Search Report PCT/US98/23950 dated Jan. 14, 1999.
Int'l Search Report PCT/US98/24281 dated Feb. 22, 1999.
Int'l Search Report PCT/US99/24869 dated Feb. 3, 2000.
Int'l Search Report PCT/US01/11218 dated Aug. 14, 2001.

(56) **References Cited**

OTHER PUBLICATIONS

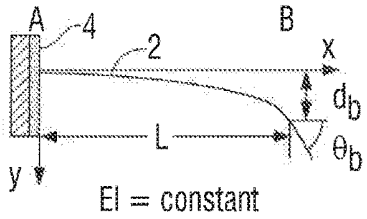
Int'l Search Report PCT/US01/11224 dated Nov. 13, 2001.
Int'l Search Report PCT/US01/11340 dated Aug. 16, 2001.
Int'l Search Report PCT/US01/11420 dated Oct. 16, 2001.
Int'l Search Report PCT/US02/01890 dated Jul. 25, 2002.
Int'l Search Report PCT/US02/11100 dated Jul. 16, 2002.
Int'l Search Report PCT/US03/08146 dated Aug. 8, 2003.
Int'l Search Report PCT/US03/18674 dated Sep. 18, 2003.
Int'l Search Report PCT/US03/18676 dated Sep. 19, 2003.
Int'l Search Report PCT/US03/28534 dated Dec. 19, 2003.
Int'l Search Report PCT/US03/28539 dated Jan. 6, 2004.
Int'l Search Report PCT/US04/03436 dated Mar. 3, 2005.
Int'l Search Report PCT/US04/13273 dated Dec. 15, 2004.
Int'l Search Report PCT/US04/15311dated Jan. 12, 2005.
Int'l Search Report PCT/US07/021438 dated Apr. 1, 2008.
Int'l Search Report PCT/US07/021440 dated Apr. 8, 2008.
Int'l Search Report PCT/US08/52460 dated Apr. 24, 2008.
Int'l Search Report PCT/US08/61498 dated Sep. 22, 2008.
Int'l Search Report PCT/US09/032690 dated Jun. 16, 2009.

* cited by examiner



$$I_X = \frac{b \cdot h^3}{12}$$

FIG. 1A



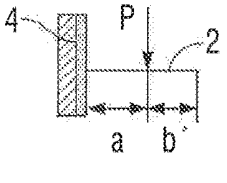
v = deflection in y direction

$v' = dv/dx$ = slope of deflection curve

$d_b = v(L)$ = deflection at right end of beam

$\theta_b = v'(L)$ = angle at right end of beam

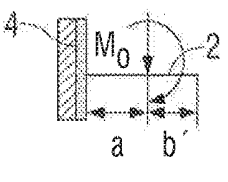
FIG. 1B



$0 < X < A$		$A < X < L$	
$v = \frac{Px^2}{6EI}(3a - x)$	$v' = \frac{Px}{2EI}(2a - x)$	$v = \frac{Pa^2}{6EI}(3x - a)$	$v' = \frac{Pa^2}{6EI}$

$$\delta_b = \frac{Pa^2}{6EI}(3L - a) \qquad \theta_b = \frac{Pa^2}{2EI}$$

FIG. 1C



$$v = \frac{M_0 x^2}{2EI} \qquad v' = \frac{M_0 x}{EI}$$

$$v = \frac{M_0 a}{2EI}(2x - a) \qquad v' = \frac{M_0 a}{EI}$$

$$\delta_b = \frac{M_0 a}{6EI}(2L - a) \qquad \theta_b = \frac{M_0 a}{EI}$$

FIG. 1D

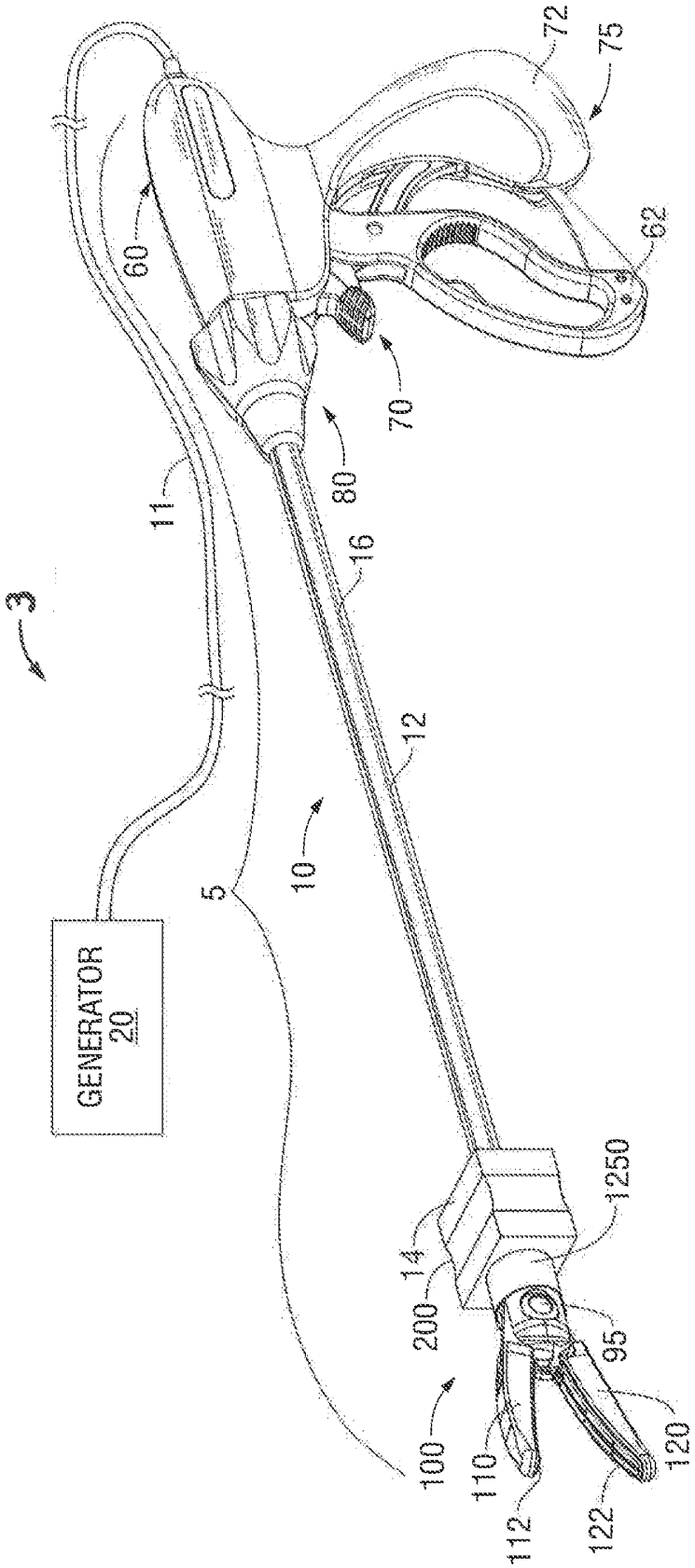

72
75
62
60
70
80
11
16
3
12
10
5
GENERATOR
20
1250
14
200
95
120
100
110
112
122

FIG. 2

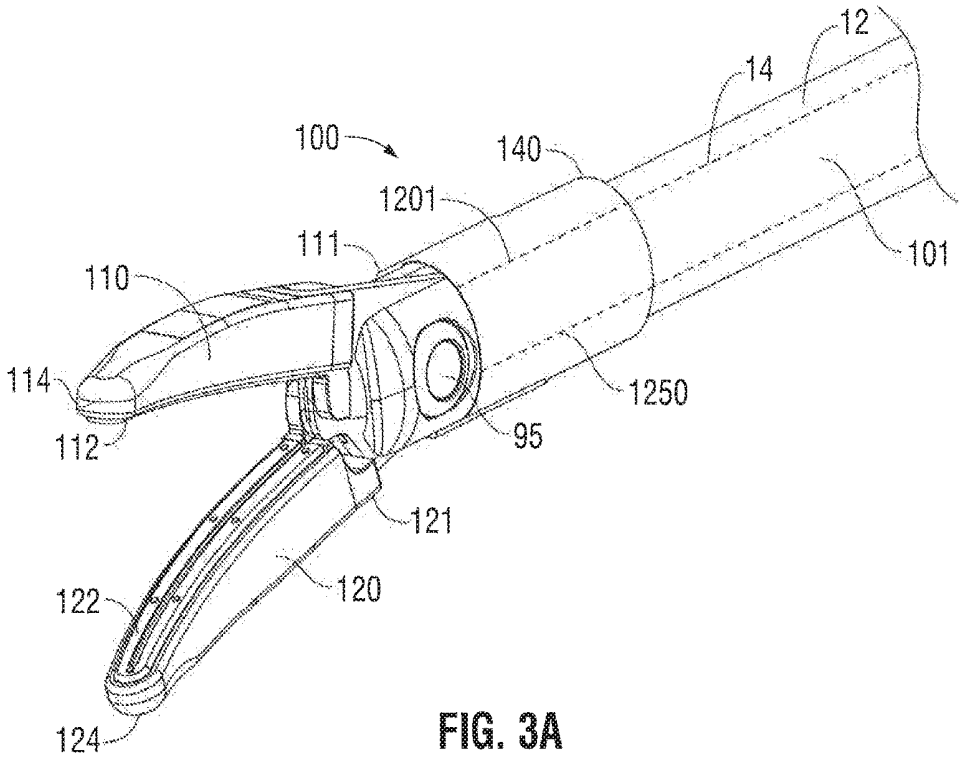

12
14
100
140
1201
111
110
101
114
1250
112
95
121
120
122
124

FIG. 3A

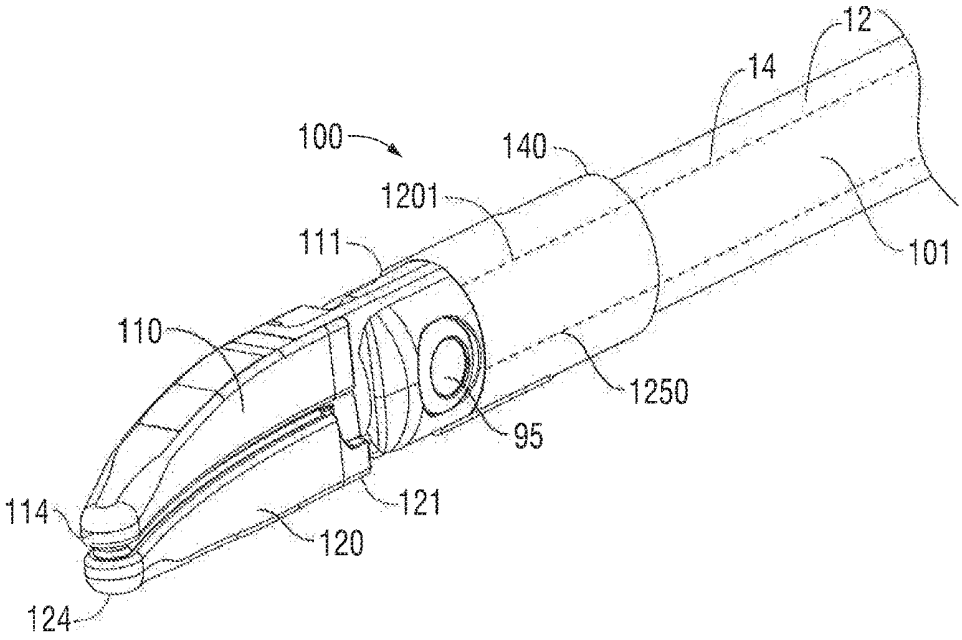

12
14
100
140
1201
111
101
110
1250
95
114
121
120
124

FIG. 3B

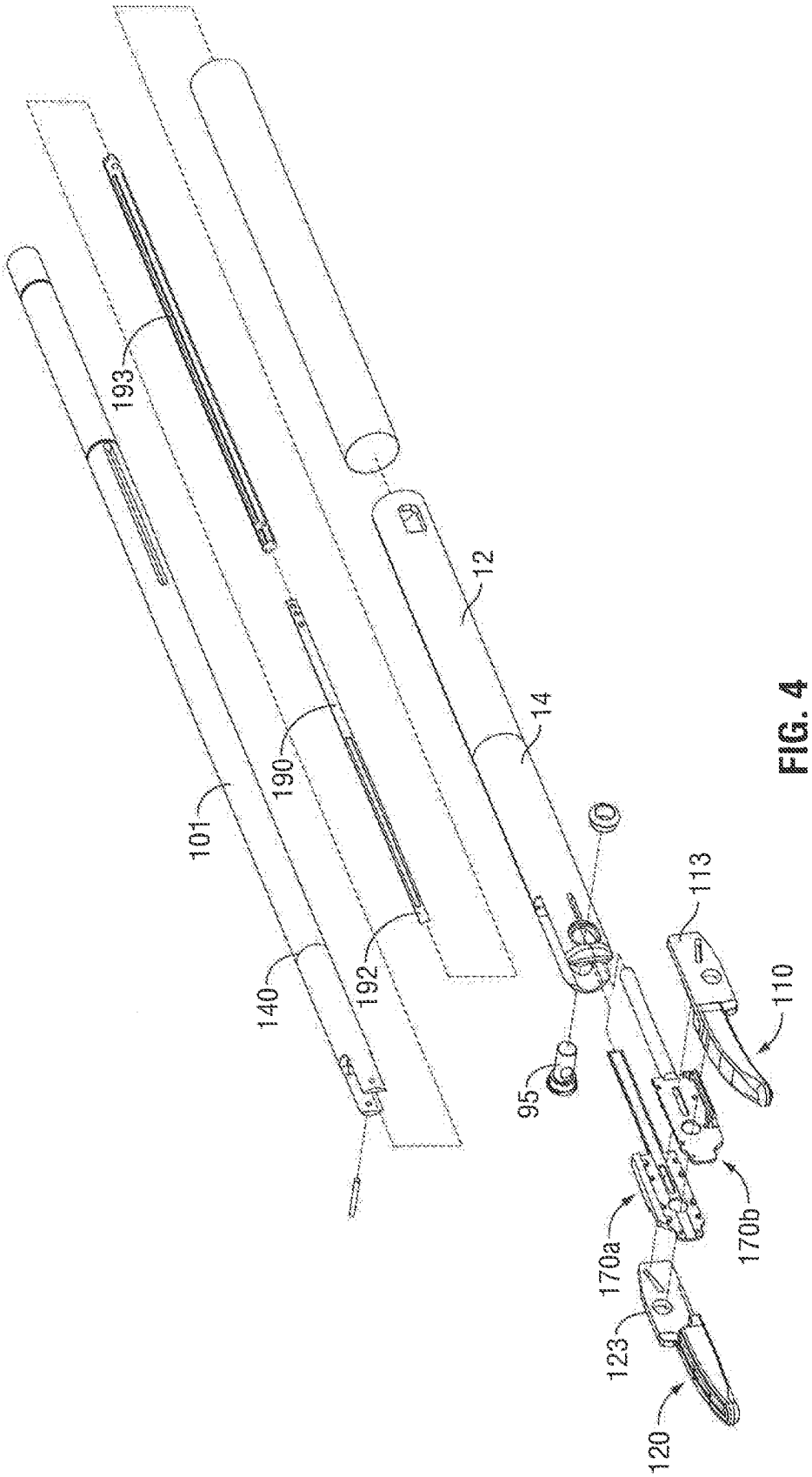


FIG. 4

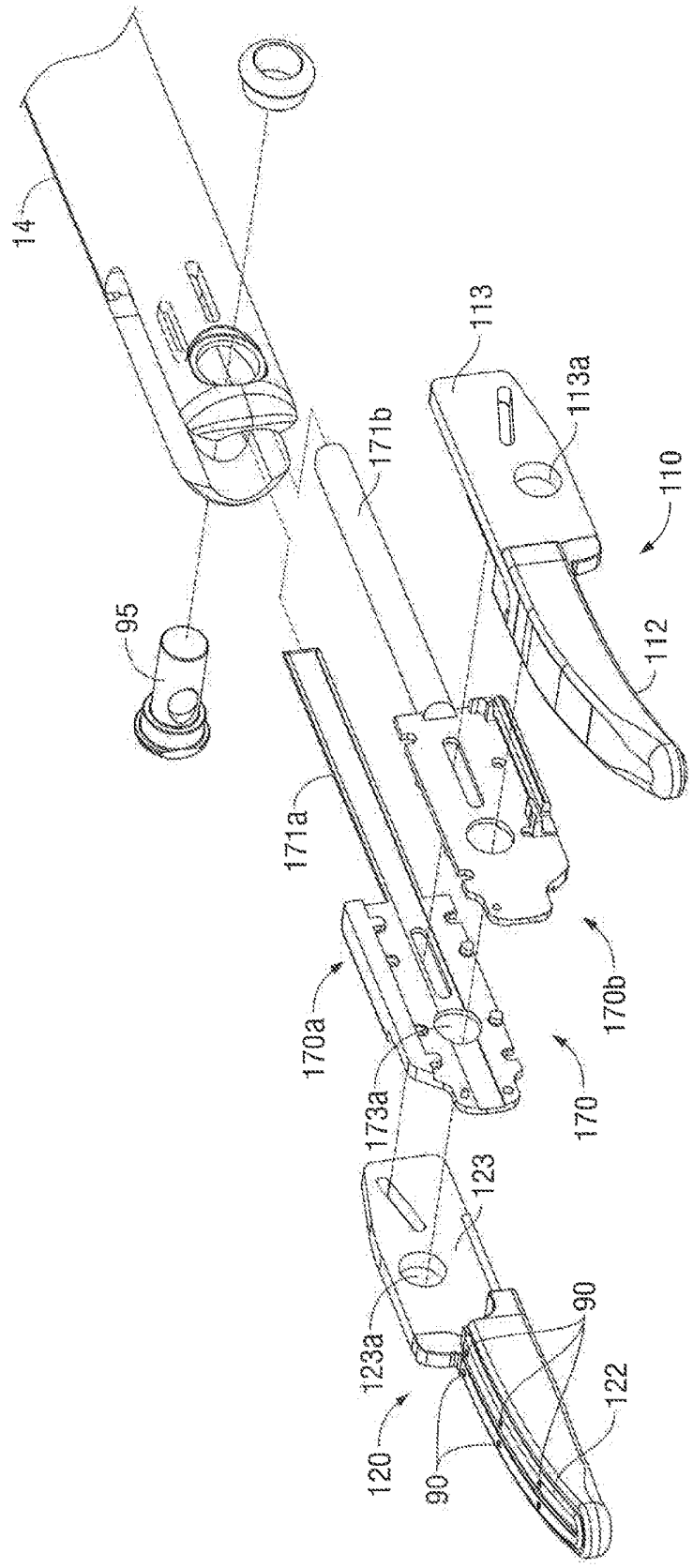

14
95
171b
113
113a
110
112
171a
170a
170b
170
173a
123
123a
120
90
90
122

FIG. 5

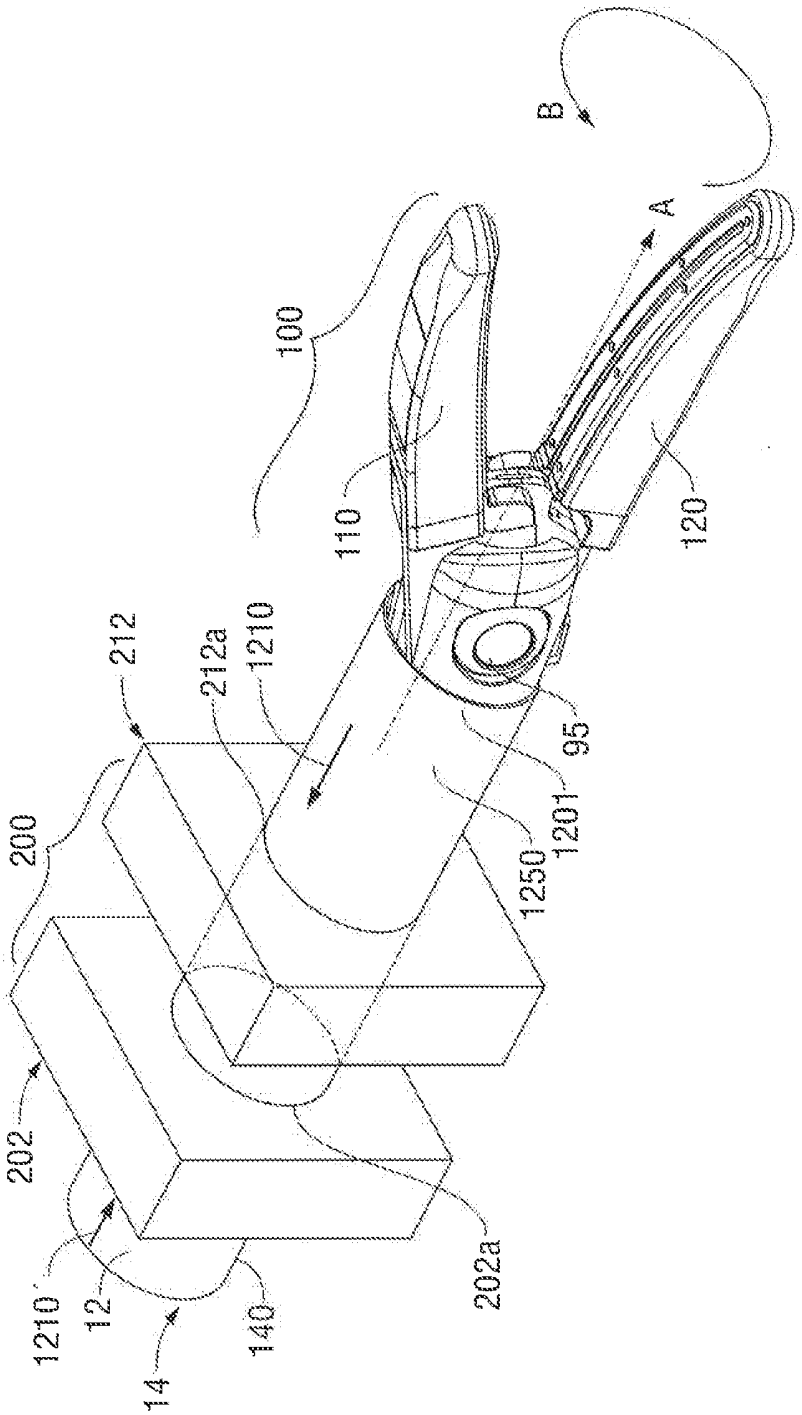

B
A
100
110
120
212
212a
1210
95
200
1201
1250
202
1210
12
14
140
202a

FIG. 6

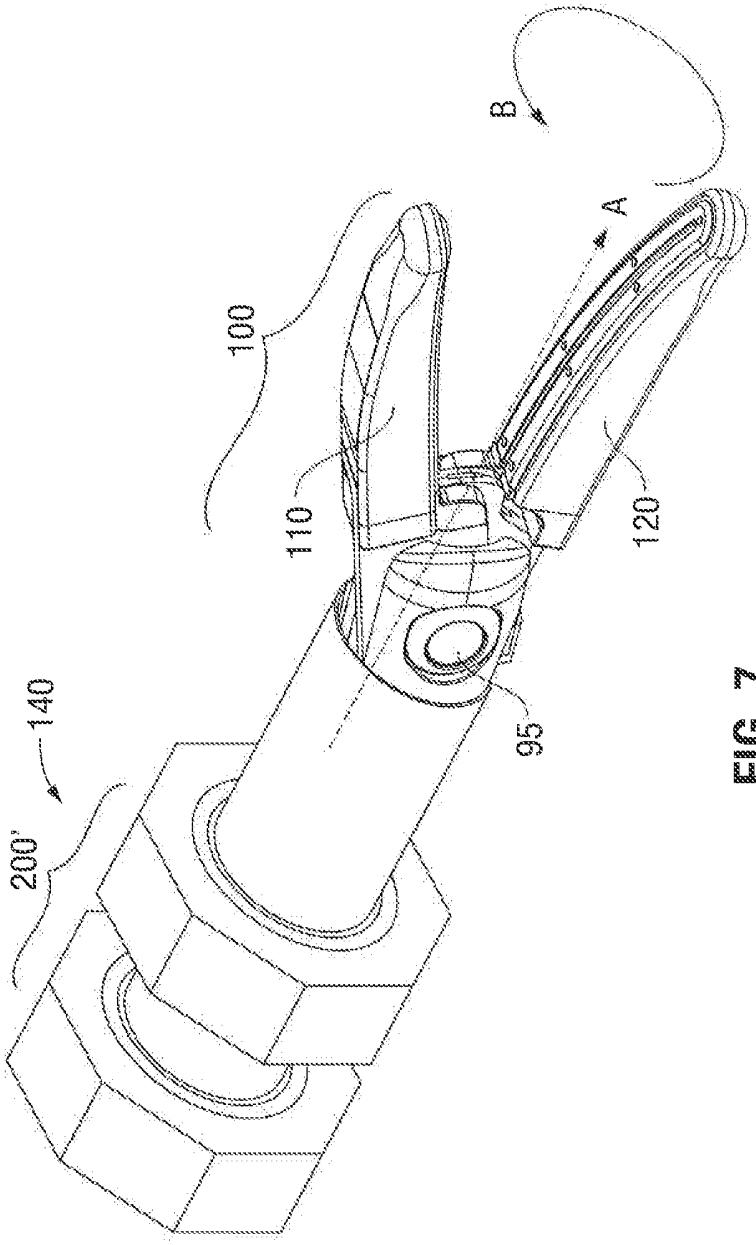


FIG. 7

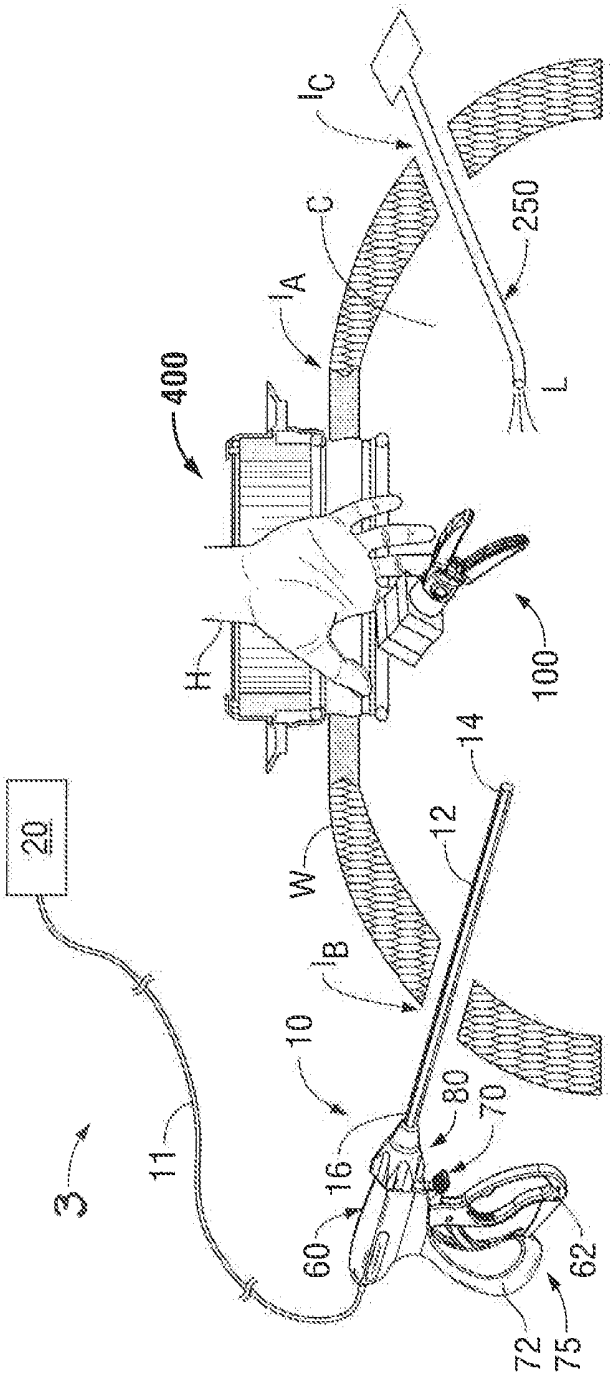


FIG. 8

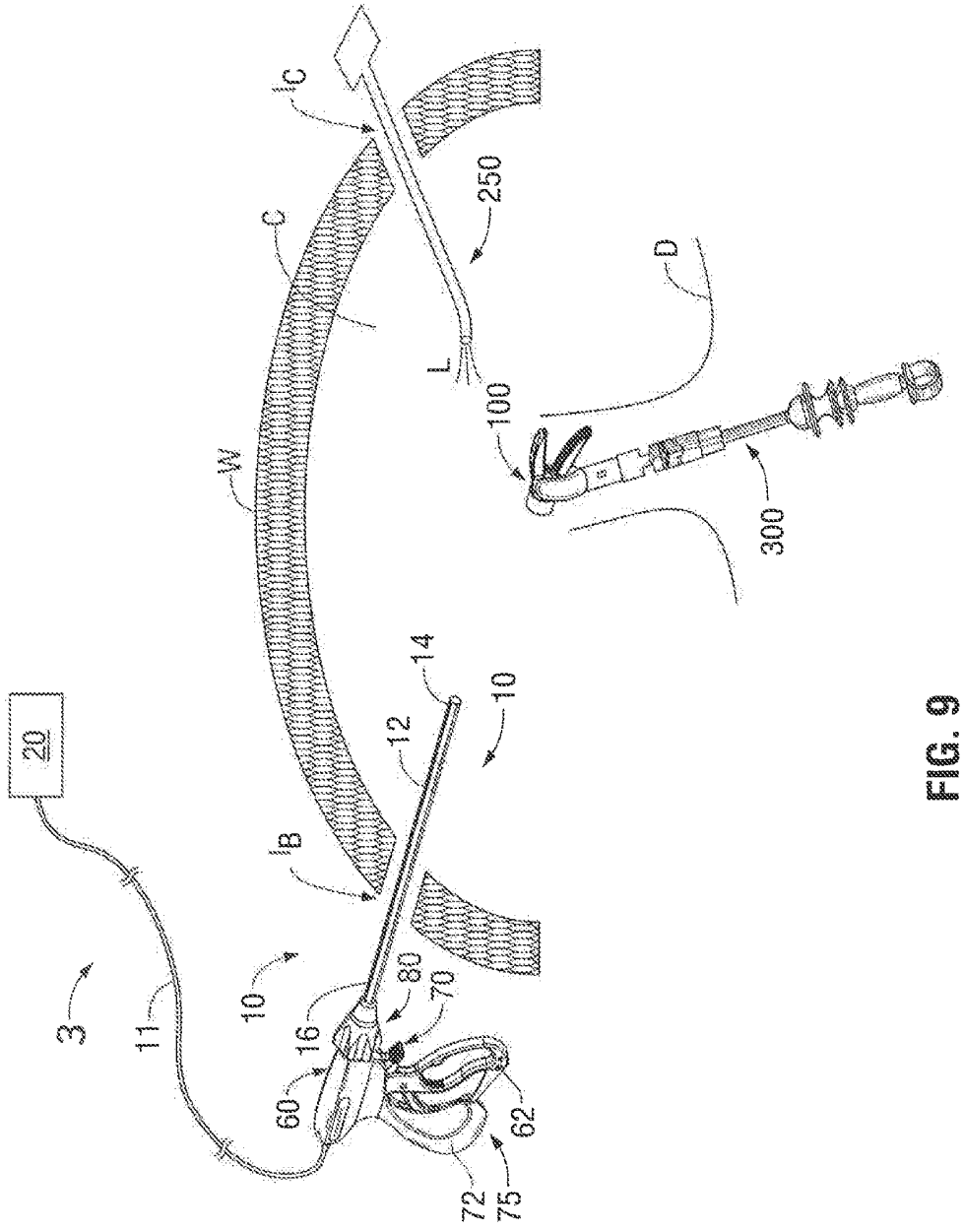


FIG. 9

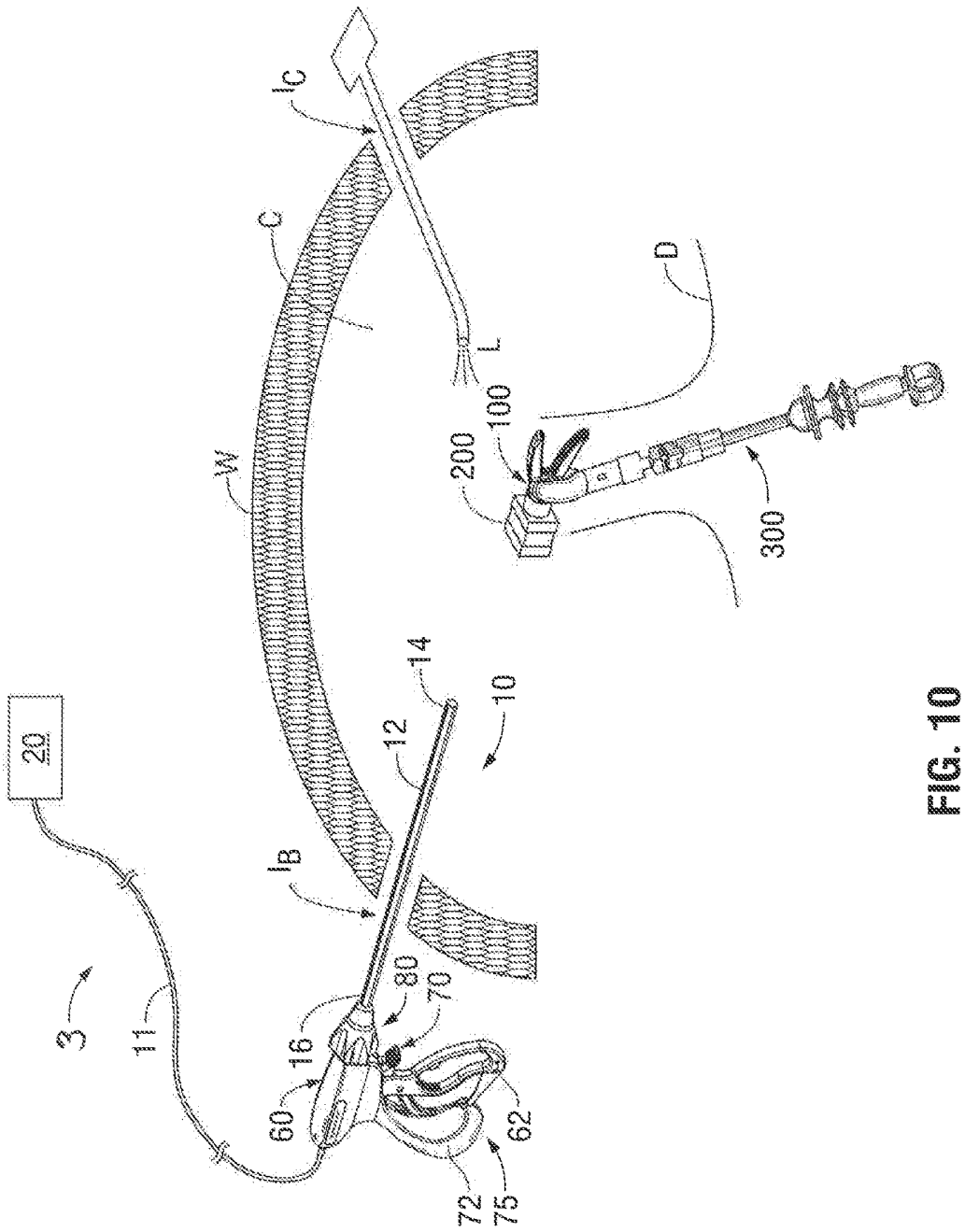


FIG. 10

IN VIVO ATTACHABLE AND DETACHABLE END EFFECTOR ASSEMBLY AND LAPAROSCOPIC SURGICAL INSTRUMENT AND METHODS THEREFOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 13/415,639, filed on Mar. 8, 2012, now U.S. Pat. No. 9,028,493, which is a continuation of U.S. application Ser. No. 12/562,281, filed on Sep. 18, 2009, now U.S. Pat. No. 8,133,254, the entire contents of each of which is incorporated by reference herein.

BACKGROUND

1. Technical Field

The present disclosure relates to endoscopic or laparoscopic surgery and more particularly to end effector assemblies for surgical instruments used therein.

2. Description of the Related Art

The trend in surgical procedures is to reduce the invasiveness of the procedure by reducing the size of the surgical incision. More and more frequently, the surgical incision is performed in the navel of the patient. For a laparoscopic surgical instrument, the outer shaft diameter is determined by the inner diameter of the ports (cannulae) with which the instrument will be used. As port size decreases to accommodate the reduced size of the surgical incision, the diameter/cross-sectional area of the end effectors of the surgical instrument must be reduced while the length of the end effectors must also be reduced to provide greater rigidity to reduce the susceptibility of the end effectors to deflection.

The resulting rigidity of the end effectors of the instrument thereby necessitates tight dimensional tolerances and a corresponding increase in material and manufacturing costs to provide the necessary rigidity.

SUMMARY

To advance the state of the art of surgery, the present disclosure relates to a method of performing surgery that includes the steps of providing a forceps having a housing including a shaft that extends therefrom and at least one handle moveable relative to the housing and providing an end effector assembly configured to selectively engage a distal end of the shaft. The method also includes the steps of inserting the forceps through a first opening formed in a body; inserting the end effector assembly through a second opening formed in the body; engaging the end effector assembly with the distal end of the shaft in vivo; and actuating the end effector assembly by moving the handle relative to the housing.

The method may include the step of providing a coupling at the distal end of the shaft, and may further include the step of engaging, via the coupling, the distal end of the shaft with the end effector assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of the present disclosure are described herein with reference to the drawings wherein:

FIG. **1**A illustrates a beam having a rectangular cross-section and the corresponding equation and dimensions to calculate the moment of inertia of the beam around a particular axis;

FIG. **1**B illustrates a cantilevered beam and the corresponding mathematical factors related to calculating the deflection of the beam along the length of the beam with respect to the anchor point;

FIG. **1**C illustrates the cantilevered beam of FIG. **1**B and the equations to calculate the deflection of the beam under a load as a function of the distance along the length of the beam with respect to the anchor point;

FIG. **1**D illustrates the cantilevered beam of FIG. **1**B and the equations to calculate the deflection of the beam under a bending moment as a function of the distance along the length of the beam with respect to the anchor point;

FIG. **2** is a left, perspective view of an endoscopic bipolar forceps showing a housing, a shaft and an in vivo detachable end effector assembly according to one embodiment of the present disclosure;

FIG. **3**A is an enlarged, left, perspective view of the end effector assembly and shaft of FIG. **1** in which the in vivo detachable end effector assembly is in an open position;

FIG. **3**B is a an enlarged, left, perspective view of the end effector assembly and shaft of FIG. **1** in which the in vivo detachable end effector assembly is in a closed position;

FIG. **4** is a left, perspective, exploded view of the shaft and push rod of the in vivo detachable end effector assembly;

FIG. **5** is a detailed, left, perspective, exploded view of the jaw members of the in vivo detachable end effector assembly;

FIG. **6** is a right, perspective view of the in vivo detachable end effector assembly and the shaft generally joined by a coupling according to one embodiment of the present disclosure;

FIG. **7** is a right, perspective view of the in vivo detachable end effector assembly and the shaft joined by a compression coupling according to one embodiment of the present disclosure;

FIG. **8** is a simplified view of an abdominal cavity in a subject illustrating an in vivo method of attaching a detachable end effector assembly to an endoscopic surgical instrument during a laparoscopic procedure according to one embodiment of the present disclosure;

FIG. **9** is a simplified view of an abdominal cavity in a subject illustrating an in vivo method of attaching, via a grasping device, a detachable end effector assembly to an endoscopic surgical instrument during a laparoscopic procedure according to another embodiment of the present disclosure; and

FIG. **10** is a simplified view of an abdominal cavity in a subject illustrating an in vivo method of attaching a detachable end effector assembly to an endoscopic surgical instrument during a laparoscopic procedure via a coupling that is configured to interface with the end effector assembly and the endoscopic surgical instrument according to still another embodiment of the present disclosure.

DETAILED DESCRIPTION

Various embodiments of the present disclosure are described hereinbelow with reference to the accompanying drawings. Well-known functions or constructions are not described in detail to avoid obscuring the present disclosure in unnecessary detail.

The present disclosure relates to a laparoscopic surgical instrument having a mating joint to enable attachment and detachment of a detachable end effector. The detachable end effector may be introduced into the abdominal cavity through a surgical incision such as at the navel while the

laparoscopic surgical instrument is introduced, without the detachable end effector, into the abdominal cavity through another surgical incision. Alternatively, the detachable end effector may be introduced through a natural orifice such as the anal canal, while the laparoscopic surgical instrument is introduced, without the detachable end effector, through a surgical incision in the abdominal cavity.

The detachable end effector may be introduced by a second instrument, such as a grasper, which is used to attach or connect the detachable end effector to the mating joint of the instrument.

As compared to conventional laparoscopic surgical instruments, since the detachable end effector is introduced through a natural orifice of the patient, the length and the diameter of the detachable end effector of the laparoscopic surgical instrument according to the embodiments of the present disclosure may be increased.

Removal of the diameter and length constraints of the end effectors of the prior art generally allows for looser tolerances and more cost effective end effector fabrication processes. As the diameter is a significant factor in determining the necessary rigidity of the end effector assembly, a larger-diameter end effector assembly can be a longer end effector assembly because the end effector assembly will be less susceptible to deflection and thus provide a more uniform distribution of sealing pressure to the tissue.

As is well-known in the art, deflection of a cantilevered beam, which can approximate the deflection of the end effector assembly with respect to the shaft of the endoscopic instrument, is directly proportional to the distance of the applied load from an anchor point, in this case, the joint between the end effector assembly and the shaft, and inversely proportional to Young's modulus of elasticity E and the moment of inertia I of the end effector assembly, as illustrated in FIGS. **1**A-**1**D. For an assumed rectangular cross-section **2'** of the beam **2** as illustrated in FIG. **1**A, since the moment of inertia I_x around the x-axis is proportional to the width b times the cube of the height h, i.e., h^3, it can be seen that an increase in height h, while b remains constant, significantly increases the moment of inertia I_x. As can then be seen from FIGS. **1**B-**1**C, if the beam **2** is assumed to be a cantilevered beam anchored at anchor point **4**, representing the distal end of a shaft of an endoscopic instrument, the deflection v in the y-direction is directly proportional to the applied load P and the cube of the distance a from the anchor point **4**, i.e., a^3. Since the load P and the cube of the distance a are independent of the moment of inertia I_x, it can then be understood that any increase in moment of inertia I_x (while the other factors remain the same) will reduce the deflection v. FIG. **1**D simply illustrates the same effect if one assumes a bending moment M_0 around anchor point **4** instead of load P.

Following completion of the surgical procedure, the detachable end effector having an enlarged moment of inertia and rigidity is detached from the mating joint via the second instrument, which may again be introduced through the natural orifice and used to withdraw the detachable end effector from the abdominal cavity while the laparoscopic surgical instrument is withdrawn through the surgical incision.

In the drawings and in the descriptions which follow, the term "proximal", as is traditional, will refer to the end of the forceps **10** which is closer to the user, while the term "distal" will refer to the end which is further from the user. It should be noted that with respect to the end effector assembly **100**, reference to proximal end and distal end will be with respect to configuration of the end effector assembly **100** following attachment to the distal end **14** of the shaft **12** and corresponding actual use via the endoscopic bipolar forceps **10** during the surgical procedure, as opposed to the position of the end effector assembly **100** during the attachment process.

Referring now to FIG. **2**, a tissue sealing system **3** having a combination forceps and in vivo detachable end effector assembly **5** according to the present disclosure is shown. The combination forceps and in vivo detachable end effector assembly **5** includes a forceps **10** coupled to a generator **20**. Upon attachment and engagement of end effector assembly **100**, as described in more detail below, the combination forceps and in vivo detachable end effector assembly **5** is adapted to seal tissue using electrosurgical energy. The generator **20** may be configured to output various types of electrosurgical energy (e.g., from about 300 MHz to about 10,000 MHz).

The forceps **10** is coupled to the generator **20** via a cable **11** adapted to transmit energy and control signals therebetween. Various embodiments of the forceps **10** utilizing the aforementioned types of energy are discussed in more detail below.

As indicated, the forceps **10** is configured to support an in vivo detachable end effector assembly **100**. Forceps **10** typically includes various conventional features (e.g., a housing **60**, a handle assembly **75**, a rotating assembly **80**, a trigger assembly **70**) which enable forceps **10** and detachable end effector assembly **100** to mutually cooperate to grasp, seal and, if warranted, divide tissue. Forceps **10** generally includes housing **60** and handle assembly **75**, which includes moveable handle **62** and handle **72** that is integral with housing **60**. Handle **62** is moveable relative to handle **72** to actuate detachable end effector assembly **100** to grasp and treat tissue. Forceps **10** also includes a shaft **12** that has distal end **14** that mechanically engages detachable end effector assembly **100** and proximal end **16** that mechanically engages housing **60** proximate rotating assembly **80** disposed at the distal end of housing **60**. Rotating assembly **80** is mechanically associated with shaft **12**. Movement of rotating assembly **80** imparts similar rotational movement to shaft **12** which, in turn, rotates detachable end effector assembly **100**.

Referring also to FIGS. **3**A-**3**B, detachable end effector assembly **100** includes a proximal end **1250** comprising a shaft **1201** at proximal end **1250** that is configured to engage distal end **14** of the shaft **12** of the forceps **10** at interface joint **140**. The engagement between the shaft **12** and the shaft **1201** at interface joint **140** enables the attachment and detachment of the end effector assembly **100** with the forceps **10**.

Detachable end effector assembly **100** also includes two jaw members **110** and **120** having proximal ends **111**, **121** and distal ends **114**, **124**. Jaw members **110** and **120** are pivotable about a post or pivot pin **95** and are movable from a first position wherein jaw members **110** and **120** are spaced relative to another, to a second position wherein jaw members **110** and **120** are closed and cooperate to grasp tissue therebetween. As discussed in more detail below, the detachable end effector assembly **100** may be adapted for use with various energy sources.

In the illustrated embodiment, the shaft **12** houses a pushrod **101** that is operatively coupled to the movable handle **62** such that when the handle **62** is moved relative to the handle **72** the pushrod **101** moves longitudinally, either proximally or distally within the shaft **12**. The pushrod **101** may include one or more pins disposed at the distal end **16** of shaft **12**. Each of the jaw members **110** and **120** includes a corresponding slot disposed at the proximal ends thereof

that mechanically cooperates with the push pins in a cam-follower mechanical arrangement. Motion of the pushrod **101** causes the pins to slide within respective slots **105** to actuate the jaw members. Other ways of opening/closing the jaws **110** and **120** are contemplated such as any known combinations of mechanical or electro-mechanical arrangement of gears, cams, pulleys, springs and sleeves.

The forceps **10** may also include a trigger assembly **70** that advances a knife **190** disposed within the detachable end effector assembly **100**. Once a tissue seal is formed, the user activates the trigger assembly **70** to separate the tissue along the tissue seal.

Each jaw member **110** and **120** also includes a sealing surface **112** and **122**, respectively, disposed on an inner-facing surface thereof. Sealing surfaces **112** and **122** cooperate to seal tissue held therebetween upon the application of energy. Sealing surfaces **112** and **122** are connected to generator **20** that communicates energy through the tissue held therebetween.

As best seen in FIG. **2**, forceps **10** also includes an electrosurgical cable **11** which connects the forceps **10** to generator **20**. Cable **11** is internally divided into cable leads (not shown) which each transmit electrosurgical energy through their respective feed paths through the forceps **10** to the detachable end effector assembly **100**.

As mentioned above, detachable end effector assembly **100** is attached at the distal end **14** of shaft **12** and includes a pair of opposing jaw members **110** and **120**. As described above, movable handles **62** and **72** mechanically cooperate to impart movement of the jaw members **110** and **120** from an open position, wherein the jaw members **110** and **120** are disposed in spaced relation relative to one another, to a clamping or closed position wherein the jaw members **110** and **120** cooperate to grasp tissue therebetween.

As shown best in FIGS. **3**A-**3**B, **4** and **5**, the detachable end effector assembly **100** is designed as a bilateral assembly, i.e., both jaw members **110** and **120** pivot relative to one another about a pivot pin **95** disposed therethrough. The jaw members **110** and **120** are curved to facilitate manipulation of tissue and to provide better "line of sight" for accessing organs and large tissue structures. In other embodiments, the jaw members **110** and **120** may have a straight configuration.

Push rod **101**, which ultimately connects to a drive assembly (not shown), is dimensioned to slidingly receive knife drive rod **193**, knife **190** and posts **171***a* and **171***b* of halves **170***a* and **170***b* of knife guide **170**. Push rod **101**, in turn, is received within shaft **12**. Upon actuation of the drive assembly, the push rod **101** reciprocates which, in turn, causes the pins to ride within slots to open and close the jaw members **110** and **120** as desired. The jaw members **110** and **120**, in turn, pivot about pivot pin **95** disposed through respective pivot holes **113***a* and **123***a* disposed within flanges **113** and **123**.

Jaw members **110** and **120** are electrically isolated from one another such that electrosurgical energy can be effectively transferred through the tissue to form a tissue seal. Jaw members **110** and **120** are engaged to the end of rotating shaft **12** by pivot pin **95** such that rotation of the rotating assembly **80** correspondingly rotates shaft **12** (along with push rod **101** and knife **190**) which, in turn, rotates detachable end effector assembly **100** (See FIG. **2**).

FIG. **6** illustrates the in vivo detachable end effector assembly **100** and the distal end **14** of shaft **12** of the endoscopic surgical instrument or forceps **10** that is generally joined by a coupling **200** according to one embodiment of the present disclosure. The coupling **200** has an orifice **202***a* at proximal end **202** and an orifice **212***a* at distal end **212**. The orifice **202***a* at proximal end **202** is configured to receive the distal end **14** of shaft **12** of the endoscopic surgical instrument or forceps **10** while the orifice **212***a* at distal end **212** is configured to receive proximal end **1250** of the shaft **1201** of the detachable end effector assembly **100**. As previously described above with respect to FIGS. **3**A and **3**B, detachable end effector assembly **100** includes proximal end **1250** comprising shaft **1201** at proximal end **1250** that is configured to engage distal end **14** of the shaft **12** of the forceps **10** at interface joint **140**. The engagement between the shaft **12** and the shaft **1201** enables the attachment and detachment of the end effector assembly **100** with the forceps **10** during an in vivo surgical procedure. The installation of the coupling **200** during the in vivo surgical procedure thereby secures the joint **140** and enables the attachment of the end effector assembly **100** to the shaft **12** of the forceps **10**. Conversely, release of the coupling **200** upon completion of activities required using the forceps **10** during the in vivo surgical procedure enables the detachment of the end effector assembly **100** from the shaft **12** of the forceps **10**. To assist in the installation of the coupling **200**, one or more alignment indicators, e.g., an arrow **1210** formed at an appropriate location on the shaft **1201** of the end effector assembly **100** and a corresponding arrow **1210'** formed on the shaft **12** of the forceps **10**, facilitate engagement of the end effector assembly **100** with the forceps **10** during an in vivo surgical procedure.

FIG. **7** illustrates the in vivo detachable end effector assembly **100** and the shaft **12** of forceps **10** joined at interface joint **140** by an example coupling, e.g., a compression coupling **200'** that may have a compression fitting at one or both ends or a compression fitting at one end and another type of fitting such as a screw threaded fitting at the other end, according to one embodiment of the present disclosure. Numerous other suitable couplings may be employed to perform the joining of the end effector assembly **100** and the shaft **12**, including, but not limited to, Luer lock fittings, snap-fit coupling, ball and socket fittings and the like.

The shaft **12** and the end effector assembly **100** are configured such that engagement of the end effector assembly **100** with the distal end **14** of the shaft **12** establishes electrical communication between the forceps **10** and the tissue sealing surface **112** and/or **122** of the end effector assembly **100**.

As also described above previously, the distal end **14** of the shaft **12** is configured to interface with coupling **200**. The coupling **200** is configured to interface with the end effector assembly **100**. The end effector assembly **100** is configured to detachably engage and disengage from the distal end **14** of the shaft **12** via engagement of the end effector assembly **100** with the coupling **200**.

The shaft **12** and the end effector assembly **100** are configured such that engagement of the end effector assembly **100** with the distal end **14** of the shaft **12** via the coupling **200** establishes electrical communication between the forceps **10** and the end effector assembly **100**.

To accomplish the intended purpose of the combination forceps and in vivo detachable end effector assembly **5** (see FIG. **2**), the end effector assembly **100** may be configured to vary the ratio between the moment of inertia of the cross-section of the end effector assembly and the moment of inertia of the cross-section of the shaft **12** depending on any particular surgical purpose.

In addition, coupling **200** may be configured to selectively engage a first end effector assembly having a cross-sectional moment of inertia value and a second end effector assembly

having a cross-sectional moment of inertia value that differs from the cross-sectional moment of inertia value of the first end effector assembly. That is, the coupling may be a universal type coupling configured to selectively engage end effector assemblies of different or various sizes.

FIGS. **8-10** illustrate simplified views of portions of the in vivo method of attaching the detachable end effector assembly **100** to the forceps **10** to form the combination forceps and end effector assembly **5** (see FIG. **2**) for use during the surgical procedure to seal and cut tissue.

More particularly, FIG. **8** is a simplified view of an abdominal cavity C in a subject illustrating the in vivo method of attaching detachable end effector assembly **100** to forceps **10** during a laparoscopic procedure according to one embodiment of the present disclosure. A surgical hand access apparatus **400** is shown installed within an opening or surgical incision I_A in abdominal wall W located at a position such as at the navel of the subject as shown. Such a surgical hand access apparatus and the method of installation are described in commonly-owned U.S. Patent Application Publication US 2006/0229501 A1, by Jensen et al., entitled "SURGICAL HAND ACCESS APPARATUS", now U.S. Pat. No. 7,766,824 issued on Aug. 3, 2010. The hand H of a surgeon is illustrated grasping the in vivo detachable end effector assembly **100** and inserting or positioning the end effector assembly **100** through the incision I_A and into the abdominal cavity C. The end effector assembly **100** is grasped and oriented in a position to facilitate attachment and engagement of the end effector assembly **100** with the forceps **10**.

The forceps **10** is provided and inserted, minus the detachable end effector assembly **100**, through another opening or incision I_B in the body that allows the surgeon to position the distal end **14** of the shaft **12** such that upon attachment and engagement of the end effector assembly **100** to the shaft **12**, the resulting combination forceps and end effector assembly **5** (see FIG. **2**) is advantageously positioned to perform the desired surgical procedure.

Although not shown, the method further includes the step of engaging the end effector assembly **100** with the distal end **14** of the shaft **12**. The step of engaging the end effector assembly **100** with the distal end **14** of the shaft **12** enables establishment of electrical communication between the forceps **10** and the tissue sealing surface **112** and/or **122** of jaw members **110** and/or **120** of the end effector assembly **100**.

When at least one jaw member, e.g., lower jaw member **120**, of the end effector assembly **100** further includes a mechanical cutting element, e.g., knife blade **190**, the step of engaging the end effector assembly **100** with the distal end **14** of the shaft **12** also enables establishment of mechanical communication between the forceps **10** and the mechanical cutting element of the jaw member **120** to enable mechanical cutting of tissue.

As described above to assist in the installation of the coupling **200**, the method may include providing one or more alignment indicators, e.g., arrow **1210** formed at an appropriate location on the shaft **1201** of the end effector assembly **100** and/or corresponding arrow **1210'** formed on the shaft **12** of the forceps **10**, to facilitate engagement of the end effector assembly **100** with the forceps **10** during an in vivo surgical procedure. The step of aligning the end effector assembly **100** with the forceps **10** may include rotating the end effector assembly **100**, in the direction indicated by arrow B around longitudinal axis A of the end effector assembly **100**, and also translating the end effector assembly **100** in the direction of the longitudinal axis A, as illustrated in FIGS. **6** and **7**.

To further assist the surgeon in implementing the attachment and engagement of the end effector assembly **100** to the shaft **12** and in implementing the surgical procedure, an endoscopic camera **250** may be positioned and inserted through the abdominal wall W into the abdominal cavity C through another opening or incision I_C in the body at an opposite side of the abdominal wall W to facilitate transmission of light L towards the end effector assembly **100** and the distal end **14** of the shaft **12** and to facilitate reception of cinematic images.

FIG. **9** is a simplified view of the abdominal cavity C in a subject illustrating an in vivo method of attaching, via a grasping device, the detachable end effector assembly **100** to the forceps **10** during a laparoscopic procedure according to another embodiment of the present disclosure. A grasping device **300**, such as the endoscopic surgical device having an articulating handle assembly that is disclosed in commonly-owned U.S. patent application Ser. No. 12/193,864 by De Santis et al., filed on Aug. 19, 2008, entitled "ENDOSCOPIC SURGICAL DEVICE", published on Feb. 26, 2009 as U.S. Patent Application Publication No. US 2009/0054734 A1, the entire contents of which are hereby incorporated by reference herein, is positioned and inserted through an opening in the body such as a natural orifice D, Again, the end effector assembly **100** is grasped and oriented in a position to facilitate attachment and engagement of the end effector assembly **100** with the forceps **10**.

In a similar manner as described above with respect to FIG. **8**, the forceps **10** is provided and inserted, minus the detachable end effector assembly **100**, through opening or incision I_B in the body that allows the surgeon to position the distal end **14** of the shaft **12** such that upon attachment and engagement of the end effector assembly **100** to the shaft **12**, the resulting combination forceps and end effector assembly **5** (see FIG. **2**) is advantageously positioned to perform the desired surgical procedure.

Again, although not shown, the method may further include the step of engaging the end effector assembly **100** with the distal end **14** of the shaft **12**. The step of engaging the end effector assembly **100** with the distal end **14** of the shaft **12** enables establishment of electrical communication between the forceps **10** and the end effector assembly **100**.

In a similar manner, when at least one jaw member, e.g., lower jaw member **120**, of the end effector assembly **100** further includes a mechanical cutting element, e.g., knife blade **190**, the step of engaging the end effector assembly **100** with the distal end **14** of the shaft **12** also enables establishment of mechanical communication between the forceps **10** and the mechanical cutting element (knife blade **190**) of the jaw member **120** to enable mechanical cutting of tissue.

FIG. **10** is a simplified view of the abdominal cavity C in a subject illustrating an alternative in viva method of attaching the detachable end effector assembly **100** to forceps **10** during a laparoscopic procedure, as compared to the in vivo method described above with respect to FIG. **9**, via the coupling **200** that is configured to interface with the end effector assembly **100** and the forceps **10**, according to still another embodiment of the present disclosure.

As described previously above with respect to FIGS. **6** and **7**, the end effector assembly **100** and the distal end **14** of the shaft **12** of the forceps **10** are configured to interface with the coupling **200**. As can be appreciated, the previous steps of implementing the method of engaging the forceps **10** with the end effector assembly **100** described above with respect to FIG. **9** are each implemented by interfacing the

coupling **200** with the end effector assembly **100** and with the distal end **14** of the shaft **12**.

The methods described above with respect to FIGS. **8-10** may be implemented wherein forceps **10** includes trigger assembly **70** (that includes a trigger—see FIG. **2**) operably coupled to the housing **60** and the end effector assembly **100** includes a knife **192** (see FIG. **4**) and the method includes the step of actuating the trigger **70** to advance the knife **192** to separate tissue disposed in the end effector assembly **100**.

Additionally, the method may be implemented by providing coupling **200** configured to selectively engage a first end effector assembly having a cross-sectional moment of inertia value and a second end effector assembly having a cross-sectional moment of inertia value that differs from the cross-sectional moment of inertia value of the first end effector assembly depending on a surgical need. That is, as described previously, the coupling **200** may be a universal type coupling configured to selectively engage end effector assemblies of different or various sizes depending on the requirements for a particular surgical procedure or need.

Actuation of the handles **62** and **72** closes the jaw members **110** and **120** about tissue with a pre-determinable and consistent closure pressure to effect a tissue seal. Closure pressures for sealing large tissue structures fall within the range of about 3 kg/cm^2 to about 16 kg/cm^2.

Stop members **90** which extend from the sealing surface **122** provide a consistent and accurate gap distance "G" (not shown) between the electrically conductive sealing surfaces **112** and in the range from about 0.001 inches (about 0.0254 millimeters) to about 0.006 inches (about 0.1524 millimeters) which is also effective for sealing tissue.

After the tissue is grasped between jaw members **110** and **120**, the forceps **10** is ready for selective application of electrosurgical energy and subsequent separation of the tissue. By controlling the intensity, frequency and duration of the electrosurgical energy and pressure applied to the tissue, the user can effectively seal tissue.

Referring to FIG. **2**, it can be appreciated from the foregoing that the embodiments of the present disclosure may include a kit for an in vivo surgical procedure that includes forceps **10** having housing **60** including shaft **12** that extends therefrom and at least one handle **62** that is movable relative to the housing **60**. The kit also includes the selectively engageable end effector assembly **100** that is configured to selectively engage the distal end **14** of the shaft **12**. The kit may further include coupling **200** that is configured to facilitate engagement of the end effector assembly **100** to the forceps **10**.

The state of the art of endoscopic surgery is advanced by the embodiments of the present disclosure, since the embodiments of the present disclosure enable removing the diameter and length constraints of the end effectors of the prior art to generally allow for looser tolerances and more cost effective end effector fabrication processes. As described above, the diameter is a significant factor in determining the necessary rigidity of the end effector assembly, so that a larger-diameter end effector assembly can be a longer end effector assembly because the end effector assembly will be less susceptible to deflection and thus will provide a more uniform distribution of sealing pressure to the tissue.

While several embodiments of the disclosure have been shown in the drawings and/or discussed herein, it is not intended that the disclosure be limited thereto, as it is intended that the disclosure be as broad in scope as the art will allow and that the specification be read likewise. Therefore, the above description should not be construed as limiting, but merely as exemplifications of particular embodiments. Those skilled in the art will envision other modifications within the scope and spirit of the claims appended hereto.

What is claimed is:

1. A kit for an in vivo surgical procedure, comprising:

a forceps including:

a housing having a shaft that extends therefrom, the shaft including a proximal end that is configured to operably couple to the housing and a distal end that extends therefrom; and

a handle operably associated with the housing and selectively movable relative thereto;

a selectively engageable end effector assembly configured to selectively engage the distal end of the shaft in vivo, wherein the shaft defines a cross-sectional moment of inertia, and wherein the selectively engageable end effector assembly defines a cross-sectional moment of inertia; and

a coupling configured to facilitate engagement and disengagement of the end effector assembly in vivo to and from the shaft, respectively, wherein the coupling is configured with a cross-sectional moment of inertia that is greater than the cross-sectional moments of inertia of both the shaft and the selectively engageable end effector assembly to yield an enlarged moment of inertia and rigidity to the forceps via the coupling.

2. The kit according to claim **1**, wherein the coupling is configured to selectively engage a first end effector assembly having a cross-sectional moment of inertia value and the coupling is configured to selectively engage a replacement, second end effector assembly having a cross-sectional moment of inertia value that is the same as the cross-sectional moment of inertia value of the first end effector assembly.

3. The kit according to claim **1**, wherein the coupling is configured to selectively engage a first end effector assembly having a cross-sectional moment of inertia value and the coupling is configured to selectively engage a replacement, second end effector assembly having a cross-sectional moment of inertia value that is different from the cross-sectional moment of inertia value of the first end effector assembly.

4. The kit according to claim **1**, wherein the coupling is a compression coupling that includes first and second ends that are compression fittings.

5. The kit according to claim **1**, wherein the coupling includes a first end that is a compression coupling and a second end that is a threaded fitting.

6. The kit according to claim **1**, wherein the coupling includes first and second ends that are selected from the group consisting of Luer lock fittings, snap-fit couplings, and ball and socket fittings.

7. A surgical forceps, comprising:

a housing having a shaft that extends therefrom, the shaft including a proximal end that is configured to operably couple to the housing and a distal end that extends therefrom;

a handle operably associated with the housing and selectively movable relative thereto;

a selectively engageable end effector assembly configured to selectively engage the distal end of the shaft in vivo, wherein the shaft defines a cross-sectional moment of inertia, and wherein the selectively engageable end effector assembly defines a cross-sectional moment of inertia; and

a coupling configured to facilitate engagement and disengagement of the end effector assembly in vivo to and from the shaft, respectively, wherein the coupling is configured with a cross-sectional moment of inertia that is greater than the cross-sectional moments of inertia of both the shaft and the selectively engageable end effector assembly to yield an enlarged moment of inertia and rigidity to the forceps via the coupling.

8. The surgical forceps according to claim **7**, wherein the coupling is configured to selectively engage a first end effector assembly having a cross-sectional moment of inertia value and the coupling is configured to selectively engage a replacement, second end effector assembly having a cross-sectional moment of inertia value that is the same as the cross-sectional moment of inertia value of the first end effector assembly.

9. The surgical forceps according to claim **7**, wherein the coupling is configured to selectively engage a first end effector assembly having a cross-sectional moment of inertia value and the coupling is configured to selectively engage a replacement, second end effector assembly having a cross-sectional moment of inertia value that is different from the cross-sectional moment of inertia value of the first end effector assembly.

10. The surgical forceps according to claim **7**, wherein the coupling is a compression coupling that includes first and second ends that are compression fittings.

11. The surgical forceps according to claim **7**, wherein the coupling includes a first end that is a compression coupling and a second end that is a threaded fitting.

12. The surgical forceps according to claim **1**, wherein the coupling includes first and second ends that are selected from the group consisting of luer lock fittings, snap-fit couplings, and ball and socket fittings.

* * * * *

专利名称(译)	体内可附接和可拆卸的末端执行器组件和腹腔镜手术器械及其方法		
公开(公告)号	US9931131	公开(公告)日	2018-04-03
申请号	US14/708950	申请日	2015-05-11
[标]申请(专利权)人(译)	柯惠有限合伙公司		
申请(专利权)人(译)	COVIDIEN LP		
当前申请(专利权)人(译)	COVIDIEN LP		
[标]发明人	DUMBAULD PATRICK L COSGRIFF EDWARD		
发明人	DUMBAULD, PATRICK L. COSGRIFF, EDWARD		
IPC分类号	A61B17/29 A61B18/14 A61B17/28 A61B18/00 A61B17/00		
CPC分类号	A61B17/2812 A61B18/1445 A61B18/1482 A61B2017/00473 A61B2017/2931 A61B2017/2945 A61B2018/1455 A61B2017/2947 A61B2018/0063 A61B2018/00601 A61B2018/1412 A61B2018/1432 A61B2017/2946		
其他公开文献	US20150245847A1		
外部链接	Espacenet USPTO		

摘要(译)

执行手术的方法包括以下步骤：提供钳子，所述钳子具有壳体，所述壳体包括从所述壳体延伸的轴;至少一个手柄，所述手柄相对于所述壳体可移动并且提供端部执行器组件，所述端部执行器组件构造成选择性地接合所述轴的远端。该方法还包括以下步骤：将镊子插入形成在主体中的第一开口;将末端执行器组件穿过形成在主体中的第二开口插入;在体内使末端执行器组件与轴的远端接合;以及通过相对于壳体移动手柄来致动末端执行器组件。该方法还可以包括以下步骤：在轴的远端处提供联接件，并且经由联接件将轴的远端与端部执行器组件接合。