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(54) **MOTOR-DRIVEN SURGICAL CUTTING AND FASTENING INSTRUMENT WITH MECHANICAL CLOSURE SYSTEM**

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3,266,494	A	8/1966	Brownrigg et al.
3,269,630	A	8/1966	Fleischer
3,357,296	A	12/1967	Lefever
3,490,675	A	1/1970	Green et al.
3,551,987	A	1/1971	Wilkinson
3,598,943	A	8/1971	Barrett
3,643,851	A	2/1972	Green et al.

(Continued)

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**FOREIGN PATENT DOCUMENTS**

CA	2458946	A1	3/2003
CA	2512960	A1	1/2006

(Continued)

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**OTHER PUBLICATIONS**

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(56) **References Cited**

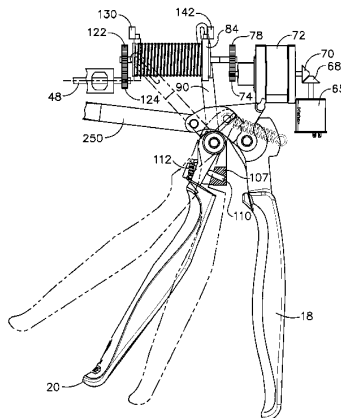
**U.S. PATENT DOCUMENTS**

66,052	A	6/1867	Smith
2,037,727	A	4/1936	La Chapelle
2,214,870	A	9/1940	West
2,441,096	A	5/1948	Happe
2,526,902	A	10/1950	Rublee
2,804,848	A	9/1957	O'Farrell et al.
2,808,482	A	10/1957	Zanichkowsky et al.
2,853,074	A	9/1958	Olson
3,032,769	A	5/1962	Palmer
3,075,062	A	1/1963	Iaccarino
3,078,465	A	2/1963	Bobrov

(57) **ABSTRACT**

A surgical cutting and fastening instrument is disclosed. According to various embodiments, the instrument includes an end effector comprising an elongate channel, a clamping member pivotably connected to the channel, and a moveable cutting instrument for traversing the channel to cut an object clamped in the end effector by the clamping member when the clamping member is in a clamped position. The instrument may also comprise a main drive shaft assembly for actuating the cutting instrument in the end effector, a gear drive train connected to the main drive shaft assembly, and a motor for actuating the gear drive train. The instrument may also include a closure trigger and a firing trigger, separate from the closure trigger, for actuating the motor when the firing trigger is retracted. Also, the instrument may comprise a mechanical closure system connected to the closure trigger and to the clamping member for causing the clamping member to pivot to the clamped position when the closure trigger is retracted.

**22 Claims, 39 Drawing Sheets**



# US 8,186,555 B2

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U.S. PATENT DOCUMENTS					
3,662,939 A	5/1972	Bryan	4,728,876 A	3/1988	Mongeon et al.
3,717,294 A	2/1973	Green	4,729,260 A	3/1988	Dudden
3,734,207 A	5/1973	Fishbein	4,741,336 A	5/1988	Failla et al.
3,751,902 A	8/1973	Kingsbury et al.	4,752,024 A	6/1988	Green et al.
3,819,100 A	6/1974	Noiles et al.	4,754,909 A	7/1988	Barker et al.
3,821,919 A	7/1974	Knohl	4,767,044 A	8/1988	Green
3,892,228 A	7/1975	Mitsui	4,777,780 A	10/1988	Holzwarth
3,894,174 A	7/1975	Cartun	4,787,387 A	11/1988	Burbank, III et al.
3,940,844 A	3/1976	Colby et al.	4,805,617 A	2/1989	Bedi et al.
4,129,059 A	12/1978	Van Eck	4,805,823 A	2/1989	Rothfuss
4,250,436 A	2/1981	Weissman	4,809,695 A	3/1989	Gwathmey et al.
4,261,244 A	4/1981	Becht et al.	4,817,847 A	4/1989	Redtenbacher et al.
4,272,662 A	6/1981	Simpson	4,819,853 A	4/1989	Green
4,275,813 A	6/1981	Noiles	4,821,939 A	4/1989	Green
4,289,133 A	9/1981	Rothfuss	4,827,911 A	5/1989	Broadwin et al.
4,305,539 A	12/1981	Korolkov et al.	4,844,068 A	7/1989	Arata et al.
4,317,451 A	3/1982	Cerwin et al.	4,869,414 A	9/1989	Green et al.
4,321,002 A	3/1982	Froehlich	4,869,415 A	9/1989	Fox
4,331,277 A	5/1982	Green	4,880,015 A	11/1989	Nierman
4,340,331 A	7/1982	Savino	4,892,244 A	1/1990	Fox et al.
4,347,450 A	8/1982	Colligan	4,915,100 A	4/1990	Green
4,353,371 A	10/1982	Cosman	4,938,408 A	7/1990	Bedi et al.
4,379,457 A	4/1983	Gravener et al.	4,941,623 A	7/1990	Pruitt
4,380,312 A	4/1983	Landrus	4,944,443 A	7/1990	Oddsden et al.
4,383,634 A	5/1983	Green	4,955,959 A	9/1990	Tompkins et al.
4,396,139 A	8/1983	Hall et al.	4,978,049 A	12/1990	Green
4,415,112 A	11/1983	Green	4,986,808 A	1/1991	Broadwin et al.
4,428,376 A	1/1984	Mericle	4,988,334 A	1/1991	Hornlein et al.
4,429,695 A	2/1984	Green	5,002,553 A	3/1991	Shiber
4,442,964 A	4/1984	Becht	5,009,661 A	4/1991	Michelson
4,451,743 A	5/1984	Suzuki et al.	5,014,899 A	5/1991	Presty et al.
4,454,887 A	6/1984	Krueger	5,015,227 A	5/1991	Broadwin et al.
4,467,805 A	8/1984	Fukuda	5,027,834 A	7/1991	Pruitt
4,475,679 A	10/1984	Fleury, Jr.	5,031,814 A	7/1991	Tompkins et al.
4,485,816 A	12/1984	Krumme	5,040,715 A	8/1991	Green et al.
4,489,875 A	12/1984	Crawford et al.	5,042,707 A	8/1991	Taheri
4,500,024 A	2/1985	DiGiovanni et al.	5,061,269 A *	10/1991	Muller ..... 606/83
4,505,273 A	3/1985	Braun et al.	5,062,563 A	11/1991	Green et al.
4,505,414 A	3/1985	Filipi	5,065,929 A	11/1991	Schulze et al.
4,506,671 A	3/1985	Green	5,071,052 A	12/1991	Rodak et al.
4,520,817 A	6/1985	Green	5,071,430 A	12/1991	de Salis et al.
4,522,327 A	6/1985	Korthoff et al.	5,080,556 A	1/1992	Carreno
4,526,174 A	7/1985	Froehlich	5,083,695 A	1/1992	Foslien et al.
4,527,724 A	7/1985	Chow et al.	5,084,057 A	1/1992	Green et al.
4,530,453 A	7/1985	Green	5,088,979 A	2/1992	Filipi et al.
4,548,202 A	10/1985	Duncan	5,088,997 A	2/1992	Delahuerga et al.
4,565,189 A	1/1986	Mabuchi	5,094,247 A	3/1992	Hernandez et al.
4,566,620 A	1/1986	Green et al.	5,100,420 A	3/1992	Green et al.
4,573,469 A	3/1986	Golden et al.	5,104,025 A	4/1992	Main et al.
4,573,622 A	3/1986	Green et al.	5,106,008 A	4/1992	Tompkins et al.
4,576,167 A	3/1986	Noiles et al.	5,111,987 A	5/1992	Moeinzadeh et al.
4,580,712 A	4/1986	Green	5,116,349 A	5/1992	Aranyi
4,589,416 A	5/1986	Green	5,129,570 A	7/1992	Schulze et al.
4,591,085 A	5/1986	Di Giovanni	5,137,198 A	8/1992	Nobis et al.
4,604,786 A	8/1986	Howie, Jr.	5,139,513 A	8/1992	Segato
4,605,001 A	8/1986	Rothfuss et al.	5,156,315 A	10/1992	Green et al.
4,606,343 A	8/1986	Conta et al.	5,156,614 A	10/1992	Green et al.
4,607,638 A	8/1986	Crainich	5,158,567 A	10/1992	Green
4,608,981 A	9/1986	Rothfuss et al.	5,163,598 A	11/1992	Peters et al.
4,610,250 A	9/1986	Green	5,171,247 A	12/1992	Hughett et al.
4,610,383 A	9/1986	Rothfuss et al.	5,171,249 A	12/1992	Stefanchik et al.
4,619,262 A	10/1986	Taylor	5,188,111 A	2/1993	Yates et al.
4,629,107 A	12/1986	Fedotov et al.	5,190,517 A	3/1993	Zieve et al.
4,632,290 A	12/1986	Green et al.	5,195,968 A	3/1993	Lundquist et al.
4,633,874 A	1/1987	Chow et al.	5,197,648 A	3/1993	Gingold
4,641,076 A	2/1987	Linden	5,200,280 A	4/1993	Karasa
4,646,722 A	3/1987	Silverstein et al.	5,205,459 A	4/1993	Brinkerhoff et al.
4,655,222 A	4/1987	Florez et al.	5,207,697 A	5/1993	Carusillo et al.
4,664,305 A	5/1987	Blake, III et al.	5,211,649 A	5/1993	Kohler et al.
4,665,916 A	5/1987	Green	5,217,457 A	6/1993	Delahuerga et al.
4,667,674 A	5/1987	Korthoff et al.	5,217,478 A	6/1993	Rexroth
4,671,445 A	6/1987	Barker et al.	5,219,111 A	6/1993	Bilotti et al.
4,676,245 A	6/1987	Fukuda	5,221,036 A	6/1993	Takase
4,693,248 A	9/1987	Failla	5,221,281 A	6/1993	Klicek
4,709,120 A	11/1987	Pearson	5,222,963 A	6/1993	Brinkerhoff et al.
4,715,520 A	12/1987	Roehr, Jr. et al.	5,222,975 A	6/1993	Crainich
4,719,917 A	1/1988	Barrows et al.	5,222,976 A	6/1993	Yoon
4,728,020 A	3/1988	Green et al.	5,223,675 A	6/1993	Taft
			5,234,447 A	8/1993	Kaster et al.

# US 8,186,555 B2

Page 3

5,236,440 A	8/1993	Hlavacek	5,421,829 A	6/1995	Olichney et al.
5,242,457 A	9/1993	Akopov et al.	5,422,567 A	6/1995	Matsunaga
5,244,462 A	9/1993	Delahueriga et al.	5,423,809 A	6/1995	Klicek
5,246,156 A	9/1993	Rothfuss et al.	5,425,745 A	6/1995	Green et al.
5,246,443 A	9/1993	Mai	5,431,322 A	7/1995	Green et al.
5,253,793 A	10/1993	Green et al.	5,431,668 A	7/1995	Burbank, III et al.
5,258,009 A	11/1993	Connors	5,433,721 A	7/1995	Hooven et al.
5,259,366 A	11/1993	Reydel et al.	5,438,302 A	8/1995	Goble
5,260,637 A	11/1993	Pizzi	5,441,193 A	8/1995	Gravener
5,263,629 A	11/1993	Trumbull et al.	5,441,494 A	8/1995	Ortiz
5,263,973 A	11/1993	Cook	5,445,304 A	8/1995	Plyley et al.
5,268,622 A	12/1993	Philipp	5,445,644 A	8/1995	Pietrafitta et al.
5,271,543 A	12/1993	Grant et al.	5,447,417 A	9/1995	Kuhl et al.
5,271,544 A	12/1993	Fox et al.	5,447,513 A	9/1995	Davison et al.
RE34,519 E	1/1994	Fox et al.	5,449,355 A	9/1995	Rhum et al.
5,275,323 A	1/1994	Schulze et al.	5,449,365 A	9/1995	Green et al.
5,275,608 A	1/1994	Forman et al.	5,452,836 A	9/1995	Huitema et al.
5,281,216 A	1/1994	Klicek	5,454,827 A	10/1995	Aust et al.
5,282,806 A	2/1994	Haber et al.	5,456,401 A	10/1995	Green et al.
5,282,829 A	2/1994	Hermes	5,462,215 A	10/1995	Viola et al.
5,297,714 A	3/1994	Kramer	5,465,894 A	11/1995	Clark et al.
5,304,204 A	4/1994	Bregen	5,465,895 A	11/1995	Knodel et al.
5,307,976 A	5/1994	Olson et al.	5,465,896 A	11/1995	Allen et al.
5,309,927 A	5/1994	Welch	5,466,020 A	11/1995	Page et al.
5,312,023 A	5/1994	Green et al.	5,467,911 A	11/1995	Tsuruta et al. .... 227/175.1
5,312,329 A	5/1994	Beaty et al.	5,470,006 A	11/1995	Rodak
5,314,424 A	5/1994	Nicholas	5,470,007 A	11/1995	Plyley et al.
5,318,221 A	6/1994	Green et al.	5,472,132 A	12/1995	Savage et al.
5,330,502 A	7/1994	Hassler et al.	5,472,442 A	12/1995	Klicek
5,332,142 A	7/1994	Robinson et al.	5,473,204 A	12/1995	Temple
5,333,422 A	8/1994	Warren et al.	5,474,057 A	12/1995	Makower et al.
5,334,183 A	8/1994	Wuchinich	5,474,566 A	12/1995	Alesi et al.
5,339,799 A	8/1994	Kami et al.	5,476,479 A	12/1995	Green et al.
5,341,724 A	8/1994	Vatel	5,478,003 A	12/1995	Green et al.
5,342,395 A	8/1994	Jarrett et al.	5,478,354 A	12/1995	Tovey et al.
5,342,396 A	8/1994	Cook	5,480,089 A	1/1996	Blewett
5,344,060 A	9/1994	Gravener et al.	5,480,409 A	1/1996	Riza ..... 606/205
5,350,400 A	9/1994	Esposito et al.	5,482,197 A	1/1996	Green et al.
5,352,235 A	10/1994	Koros et al.	5,484,095 A	1/1996	Green et al.
5,352,238 A	10/1994	Green et al.	5,484,398 A	1/1996	Stoddard
5,354,303 A	10/1994	Spaeth et al.	5,484,451 A	1/1996	Akopov et al.
5,356,006 A	10/1994	Alpern et al.	5,485,947 A	1/1996	Olson et al.
5,358,510 A	10/1994	Luscombe et al.	5,485,952 A	1/1996	Fontayne
5,359,231 A	10/1994	Flowers et al.	5,487,499 A	1/1996	Sorrentino et al.
D352,780 S	11/1994	Glaeser et al.	5,487,500 A	1/1996	Knodel et al.
5,360,428 A	11/1994	Hutchinson, Jr.	5,489,058 A	2/1996	Plyley et al.
5,364,003 A	11/1994	Williamson, IV	5,489,256 A	2/1996	Adair
5,366,134 A	11/1994	Green et al.	5,496,312 A	3/1996	Klicek
5,366,479 A	11/1994	McGarry et al.	5,496,317 A	3/1996	Goble et al.
5,370,645 A	12/1994	Klicek et al.	5,503,320 A	4/1996	Webster et al.
5,372,596 A	12/1994	Klicek et al.	5,503,635 A	4/1996	Sauer et al.
5,372,602 A	12/1994	Burke	5,503,638 A	4/1996	Cooper et al.
5,374,277 A	12/1994	Hassler	5,505,363 A	4/1996	Green et al.
5,379,933 A	1/1995	Green et al.	5,509,596 A	4/1996	Green et al.
5,381,782 A	1/1995	DeLaRama et al.	5,509,916 A	4/1996	Taylor
5,382,247 A	1/1995	Cimino et al.	5,511,564 A	4/1996	Wilk
5,383,880 A	1/1995	Hooven	5,514,129 A	5/1996	Smith
5,383,881 A	1/1995	Green et al.	5,514,157 A	5/1996	Nicholas et al.
5,383,888 A	1/1995	Zvenyatsky et al.	5,518,163 A	5/1996	Hooven
5,383,895 A	1/1995	Holmes et al.	5,518,164 A	5/1996	Hooven
5,389,098 A	2/1995	Tsuruta et al.	5,520,700 A	5/1996	Beyar et al.
5,391,180 A	2/1995	Tovey et al.	5,522,817 A	6/1996	Sander et al.
5,392,979 A	2/1995	Green et al.	5,527,320 A	6/1996	Carruthers et al.
5,395,030 A	3/1995	Kuramoto et al.	5,529,235 A	6/1996	Boiarski et al.
5,395,033 A	3/1995	Byrne et al.	D372,086 S	7/1996	Grasso et al.
5,395,312 A	3/1995	Desai	5,531,744 A	7/1996	Nardella et al.
5,397,046 A	3/1995	Savage et al.	5,533,521 A	7/1996	Granger
5,397,324 A	3/1995	Carroll et al.	5,533,581 A	7/1996	Barth et al.
5,403,312 A	4/1995	Yates et al.	5,533,661 A	7/1996	Main et al.
5,405,072 A	4/1995	Zlock et al.	5,535,934 A	7/1996	Boiarski et al.
5,405,344 A	4/1995	Williamson et al.	5,535,935 A	7/1996	Vidal et al.
5,409,498 A	4/1995	Braddock et al.	5,535,937 A	7/1996	Boiarski et al.
5,411,508 A	5/1995	Bessler et al.	5,540,375 A	7/1996	Bolanos et al.
5,413,267 A	5/1995	Solyntjes et al.	5,541,376 A	7/1996	Ladtchow et al.
5,413,268 A	5/1995	Green et al.	5,542,594 A	8/1996	McKean et al.
5,413,272 A	5/1995	Green et al.	5,543,119 A	8/1996	Sutter et al.
5,415,334 A	5/1995	Williamson, IV et al.	5,547,117 A	8/1996	Hamblin et al.
5,415,335 A	5/1995	Knodel, Jr.	5,549,628 A	8/1996	Cooper et al.
5,417,361 A	5/1995	Williamson, IV	5,549,637 A	8/1996	Crainich

# US 8,186,555 B2

Page 4

5,553,675 A	9/1996	Pitzen et al.	5,667,517 A	9/1997	Hooven
5,553,765 A	9/1996	Knodel et al.	5,667,527 A	9/1997	Cook
5,554,169 A	9/1996	Green et al.	5,669,544 A	9/1997	Schulze et al.
5,556,416 A	9/1996	Clark et al.	5,669,904 A	9/1997	Platt, Jr. et al.
5,558,665 A	9/1996	Kieturakis	5,669,907 A	9/1997	Platt, Jr. et al.
5,558,671 A	9/1996	Yates	5,669,918 A	9/1997	Balazs et al.
5,560,530 A	10/1996	Bolanos et al.	5,673,840 A	10/1997	Schulze et al.
5,560,532 A	10/1996	DeFonzo et al.	5,673,841 A	10/1997	Schulze et al.
5,562,239 A	10/1996	Boiarski et al.	5,673,842 A	10/1997	Bittner et al.
5,562,241 A	10/1996	Knodel et al.	5,678,748 A	10/1997	Plyley et al.
5,562,682 A	10/1996	Oberlin et al.	5,680,981 A	10/1997	Mililli et al.
5,562,701 A	10/1996	Huitema et al.	5,680,982 A	10/1997	Schulze et al.
5,562,702 A	10/1996	Huitema et al.	5,680,983 A	10/1997	Plyley et al.
5,564,615 A	10/1996	Bishop et al.	5,683,349 A	11/1997	Makower et al.
5,571,090 A	11/1996	Sherts	5,685,474 A	11/1997	Seeber
5,571,100 A	11/1996	Goble et al.	5,688,270 A	11/1997	Yates et al.
5,571,116 A	11/1996	Bolanos et al.	5,692,668 A	12/1997	Schulze et al.
5,573,543 A	11/1996	Akopov et al.	5,693,042 A	12/1997	Boiarski et al.
5,574,431 A	11/1996	McKeown et al.	5,693,051 A	12/1997	Schulze et al.
5,575,789 A	11/1996	Bell et al.	5,695,494 A	12/1997	Becker
5,575,803 A	11/1996	Cooper et al.	5,695,504 A	12/1997	Gifford, III et al.
5,577,654 A	11/1996	Bishop	5,697,943 A	12/1997	Sauer et al.
5,579,978 A	12/1996	Green et al.	5,700,270 A	12/1997	Peyser et al.
5,580,067 A	12/1996	Hamblin et al.	5,702,387 A	12/1997	Arts et al.
5,582,611 A	12/1996	Tsuruta et al.	5,702,408 A	12/1997	Wales et al.
5,582,617 A	12/1996	Klieman et al.	5,702,409 A	12/1997	Rayburn et al.
5,584,425 A	12/1996	Savage et al.	5,704,087 A	1/1998	Strub
5,586,711 A	12/1996	Plyley et al.	5,704,534 A	1/1998	Huitema et al.
5,588,579 A	12/1996	Schnut et al.	5,706,997 A	1/1998	Green et al.
5,588,580 A	12/1996	Paul et al.	5,706,998 A	1/1998	Plyley et al.
5,588,581 A	12/1996	Conlon et al.	5,707,392 A	1/1998	Kortenbach
5,591,170 A *	1/1997	Spievack et al. .... 606/82	5,709,334 A	1/1998	Sorrentino et al.
5,591,187 A	1/1997	Dekel	5,709,680 A	1/1998	Yates et al.
5,597,107 A	1/1997	Knodel et al.	5,711,472 A	1/1998	Bryan
5,599,151 A	2/1997	Daum et al.	5,713,128 A	2/1998	Schrenk et al.
5,599,344 A	2/1997	Paterson	5,713,505 A	2/1998	Huitema
5,599,350 A	2/1997	Schulze et al.	5,713,895 A	2/1998	Lontine et al.
5,601,224 A	2/1997	Bishop et al.	5,715,987 A	2/1998	Kelley et al.
5,603,443 A	2/1997	Clark et al.	5,715,988 A	2/1998	Palmer
5,605,272 A	2/1997	Witt et al.	5,716,366 A	2/1998	Yates
5,605,273 A	2/1997	Hamblin et al.	5,718,359 A	2/1998	Palmer et al.
5,607,094 A	3/1997	Clark et al.	5,718,360 A	2/1998	Green et al.
5,607,095 A	3/1997	Smith et al.	5,718,548 A	2/1998	Cotellessa
5,607,450 A	3/1997	Zvenyatsky et al.	5,720,744 A	2/1998	Eggleston et al.
5,609,285 A	3/1997	Grant et al.	D393,067 S	3/1998	Geary et al.
5,611,709 A	3/1997	McAnulty	5,725,536 A	3/1998	Oberlin et al.
5,613,966 A	3/1997	Makower et al.	5,725,554 A	3/1998	Simon et al.
5,618,294 A	4/1997	Aust et al.	5,728,121 A	3/1998	Bimbo et al.
5,618,303 A	4/1997	Marlow et al.	5,730,758 A	3/1998	Allgeyer
5,620,289 A	4/1997	Curry	5,732,871 A	3/1998	Clark et al.
5,624,452 A	4/1997	Yates	5,732,872 A	3/1998	Bolduc et al.
5,626,587 A	5/1997	Bishop et al.	5,735,445 A	4/1998	Vidal et al.
5,628,446 A	5/1997	Geiste et al.	5,735,848 A	4/1998	Yates et al.
5,628,743 A	5/1997	Cimino	5,735,874 A	4/1998	Measamer et al.
5,630,539 A	5/1997	Plyley et al.	5,738,474 A	4/1998	Blewett
5,630,540 A	5/1997	Blewett	5,738,648 A	4/1998	Lands et al.
5,630,782 A	5/1997	Adair	5,743,456 A	4/1998	Jones et al.
5,632,432 A	5/1997	Schulze et al.	5,747,953 A	5/1998	Philipp
5,632,433 A	5/1997	Grant et al.	5,749,889 A	5/1998	Bacich et al.
5,634,584 A	6/1997	Okorocho et al.	5,749,893 A	5/1998	Vidal et al.
5,636,779 A	6/1997	Palmer	5,752,644 A	5/1998	Bolanos et al.
5,636,780 A	6/1997	Green et al.	5,752,965 A	5/1998	Francis et al.
5,639,008 A	6/1997	Gallagher et al.	5,755,717 A	5/1998	Yates et al.
5,643,291 A	7/1997	Pier et al.	5,758,814 A	6/1998	Gallagher et al.
5,645,209 A	7/1997	Green et al.	5,762,256 A	6/1998	Mastri et al.
5,647,526 A	7/1997	Green et al.	5,766,188 A	6/1998	Igaki
5,647,869 A	7/1997	Goble et al.	5,766,205 A	6/1998	Zvenyatsky et al.
5,649,937 A	7/1997	Bito et al.	5,769,892 A	6/1998	Kingwell
5,651,491 A	7/1997	Heaton et al.	5,772,578 A	6/1998	Heimberger et al.
5,653,373 A	8/1997	Green et al.	5,772,659 A	6/1998	Becker et al.
5,653,374 A	8/1997	Young et al.	5,776,130 A	7/1998	Buyse et al.
5,653,677 A	8/1997	Okada et al.	5,779,130 A	7/1998	Alesi et al.
5,653,721 A	8/1997	Knodel et al.	5,779,131 A	7/1998	Knodel et al.
5,655,698 A	8/1997	Yoon	5,779,132 A	7/1998	Knodel et al.
5,657,921 A	8/1997	Young et al.	5,782,396 A	7/1998	Mastri et al.
5,658,281 A	8/1997	Heard	5,782,397 A	7/1998	Koukline
5,658,300 A	8/1997	Bito et al.	5,782,859 A	7/1998	Nicholas et al.
5,662,258 A	9/1997	Knodel et al.	5,784,934 A	7/1998	Izumisawa
5,662,260 A	9/1997	Yoon	5,785,232 A	7/1998	Vidal et al.

# US 8,186,555 B2

Page 5

5,787,897 A	8/1998	Kieturakis	6,033,378 A	3/2000	Lundquist et al.
5,792,135 A	8/1998	Madhani et al.	6,033,399 A	3/2000	Gines
5,794,834 A	8/1998	Hamblin et al.	6,033,427 A	3/2000	Lee
5,796,188 A	8/1998	Bays	6,039,733 A	3/2000	Buyse et al.
5,797,536 A	8/1998	Smith et al.	6,039,734 A	3/2000	Goble
5,797,537 A	8/1998	Oberlin et al.	6,045,560 A	4/2000	McKean et al.
5,797,538 A	8/1998	Heaton et al.	6,050,472 A	4/2000	Shibata
5,797,906 A	8/1998	Rhum et al.	6,053,390 A	4/2000	Green et al.
5,797,959 A	8/1998	Castro et al.	6,056,746 A	5/2000	Goble et al.
5,799,857 A	9/1998	Robertson et al.	6,063,097 A	5/2000	Oi et al.
5,807,393 A	9/1998	Williamson, IV et al.	6,068,627 A	5/2000	Orszulak et al.
5,809,441 A	9/1998	McKee	6,071,233 A	6/2000	Ishikawa et al.
5,810,855 A	9/1998	Rayburn et al.	6,074,386 A	6/2000	Goble et al.
5,813,813 A	9/1998	Daum et al.	6,077,286 A	6/2000	Cuschieri et al.
5,814,057 A	9/1998	Oi et al.	6,079,606 A	6/2000	Milliman et al.
5,817,084 A	10/1998	Jensen	6,083,234 A	7/2000	Nicholas et al.
5,817,091 A	10/1998	Nardella et al.	6,083,242 A	7/2000	Cook
5,817,093 A	10/1998	Williamson, IV et al.	6,086,600 A	7/2000	Kortenbach
5,817,109 A	10/1998	McGarry et al.	6,090,106 A	7/2000	Goble et al.
5,820,009 A	10/1998	Melling et al.	6,093,186 A	7/2000	Goble
5,823,066 A	10/1998	Huitema et al.	6,099,537 A	8/2000	Sugai et al.
5,826,776 A	10/1998	Schulze et al.	6,099,551 A	8/2000	Gabbay
5,827,271 A	10/1998	Buyse et al.	6,109,500 A	8/2000	Alli et al.
5,829,662 A	11/1998	Allen et al.	6,117,158 A	9/2000	Measamer et al.
5,833,690 A	11/1998	Yates et al.	6,119,913 A	9/2000	Adams et al.
5,833,695 A	11/1998	Yoon	6,123,241 A	9/2000	Walter et al.
5,833,696 A	11/1998	Whitfield et al.	H1904 H	10/2000	Yates et al.
5,836,503 A	11/1998	Ehrenfels et al.	6,126,058 A	10/2000	Adams et al.
5,839,639 A	11/1998	Sauer et al.	6,126,670 A	10/2000	Walker et al.
5,843,132 A	12/1998	Ilvento	6,131,789 A	10/2000	Schulze et al.
5,846,254 A	12/1998	Schulze et al.	6,132,368 A	10/2000	Cooper
5,849,011 A	12/1998	Jones et al.	6,139,546 A	10/2000	Koenig et al.
5,855,311 A	1/1999	Hamblin et al.	6,155,473 A	12/2000	Tompkins et al.
5,860,975 A	1/1999	Goble et al.	6,156,056 A	12/2000	Kearns et al.
5,865,361 A	2/1999	Milliman et al.	6,159,146 A	12/2000	El Gazayerli
5,868,760 A	2/1999	McGuckin, Jr.	6,159,200 A	12/2000	Verdura et al.
5,871,135 A	2/1999	Williamson, IV et al.	6,162,208 A	12/2000	Hipps
5,876,401 A	3/1999	Schulze et al.	6,165,175 A	12/2000	Wampler et al.
5,878,193 A	3/1999	Wang et al.	6,168,605 B1	1/2001	Measamer et al.
5,878,937 A	3/1999	Green et al.	6,171,316 B1	1/2001	Kovac et al.
5,878,938 A	3/1999	Bittner et al.	6,171,330 B1	1/2001	Benchetrit
5,891,160 A	4/1999	Williamson, IV et al.	6,174,308 B1	1/2001	Goble et al.
5,893,506 A	4/1999	Powell	6,179,776 B1	1/2001	Adams et al.
5,894,979 A	4/1999	Powell	6,181,105 B1	1/2001	Cutolo et al.
5,897,562 A	4/1999	Bolanos et al.	6,193,129 B1	2/2001	Bittner et al.
5,899,914 A	5/1999	Zirps et al.	6,197,042 B1	3/2001	Ginn et al.
5,901,895 A	5/1999	Heaton et al.	6,202,914 B1	3/2001	Geiste et al.
5,902,312 A	5/1999	Frater et al.	6,214,028 B1	4/2001	Yoon et al.
5,904,693 A	5/1999	Dicesare et al.	6,220,368 B1	4/2001	Ark et al.
5,906,625 A	5/1999	Bito et al.	6,223,835 B1	5/2001	Habedank et al.
5,908,402 A	6/1999	Blythe	6,228,081 B1	5/2001	Goble
5,908,427 A	6/1999	McKean et al.	6,228,084 B1	5/2001	Kirwan, Jr.
5,911,353 A	6/1999	Bolanos et al.	6,231,565 B1	5/2001	Tovey et al.
5,918,791 A	7/1999	Sorrentino et al.	6,234,178 B1	5/2001	Goble et al.
5,919,198 A	7/1999	Graves, Jr. et al.	6,241,139 B1	6/2001	Milliman et al.
5,928,256 A	7/1999	Riza	6,241,723 B1	6/2001	Heim et al.
5,931,847 A	8/1999	Bittner et al.	6,249,076 B1	6/2001	Madden et al.
5,938,667 A	8/1999	Peyser et al.	6,250,532 B1	6/2001	Green et al.
5,941,442 A	8/1999	Geiste et al.	6,258,107 B1	7/2001	Balázs et al.
5,944,172 A	8/1999	Hannula	6,261,286 B1	7/2001	Goble et al.
5,944,715 A	8/1999	Goble et al.	6,264,086 B1	7/2001	McGuckin, Jr.
5,948,030 A	9/1999	Miller et al.	6,264,087 B1	7/2001	Whitman
5,951,552 A	9/1999	Long et al.	6,270,508 B1	8/2001	Klieman et al.
5,951,574 A	9/1999	Stefanchik et al.	6,273,897 B1	8/2001	Dallessandro et al.
5,954,259 A	9/1999	Viola et al.	6,277,114 B1	8/2001	Bullivant et al.
5,964,774 A	10/1999	McKean et al.	6,293,942 B1	9/2001	Goble et al.
5,988,479 A	11/1999	Palmer	6,296,640 B1	10/2001	Wampler et al.
6,003,517 A	12/1999	Sheffield et al.	6,302,311 B1	10/2001	Adams et al.
6,004,319 A	12/1999	Goble et al.	6,306,134 B1	10/2001	Goble et al.
6,010,054 A	1/2000	Johnson et al.	6,315,184 B1	11/2001	Whitman
6,012,494 A	1/2000	Balazs	6,320,123 B1	11/2001	Reimers
6,013,076 A	1/2000	Goble et al.	6,324,339 B1	11/2001	Hudson et al.
6,015,406 A	1/2000	Goble et al.	6,325,799 B1	12/2001	Goble
6,017,356 A	1/2000	Frederick et al.	6,325,810 B1	12/2001	Hamilton et al.
6,022,352 A	2/2000	Vandewalle	6,330,965 B1	12/2001	Milliman et al.
6,024,741 A	2/2000	Williamson, IV et al.	6,331,761 B1	12/2001	Kumar et al.
6,024,748 A	2/2000	Manzo et al.	6,336,926 B1	1/2002	Goble
6,027,501 A	2/2000	Goble et al.	6,346,077 B1	2/2002	Taylor et al.
6,032,849 A	3/2000	Mastri et al.	6,352,503 B1	3/2002	Matsui et al.

# US 8,186,555 B2

Page 6

6,358,224 B1	3/2002	Tims et al.	6,685,727 B2	2/2004	Fisher et al.
6,364,877 B1	4/2002	Goble et al.	6,695,199 B2	2/2004	Whitman
6,364,888 B1	4/2002	Niemeyer et al.	6,698,643 B2	3/2004	Whitman
6,387,113 B1	5/2002	Hawkins et al.	6,704,210 B1	3/2004	Myers
6,387,114 B2	5/2002	Adams	6,716,223 B2	4/2004	Leopold et al.
6,398,781 B1	6/2002	Goble et al.	6,716,232 B1	4/2004	Vidal et al.
6,398,797 B2	6/2002	Bombard et al.	6,716,233 B1	4/2004	Whitman
6,406,440 B1	6/2002	Stefanchik	6,723,087 B2	4/2004	O'Neill et al.
6,409,724 B1	6/2002	Penny et al.	6,723,091 B2	4/2004	Goble et al.
H2037 H	7/2002	Yates et al.	6,726,697 B2	4/2004	Nicholas et al.
6,416,486 B1	7/2002	Wampler	6,740,030 B2	5/2004	Martone et al.
6,416,509 B1	7/2002	Goble et al.	6,747,121 B2	6/2004	Gogolewski
RE37,814 E	8/2002	Allgeyer	6,749,560 B1	6/2004	Konstorum et al.
6,436,097 B1	8/2002	Nardella	6,752,768 B2	6/2004	Burdorff et al.
6,436,107 B1	8/2002	Wang et al.	6,755,338 B2	6/2004	Hahnen et al.
6,436,122 B1	8/2002	Frank et al.	6,758,846 B2	7/2004	Goble et al.
6,440,146 B2	8/2002	Nicholas et al.	6,761,685 B2	7/2004	Adams et al.
6,443,973 B1	9/2002	Whitman	6,767,352 B2	7/2004	Field et al.
6,468,275 B1	10/2002	Wampler et al.	6,767,356 B2	7/2004	Kanner et al.
6,471,106 B1	10/2002	Reining	6,769,594 B2	8/2004	Orban, III
6,482,200 B2	11/2002	Shippert	6,773,438 B1	8/2004	Knodel et al.
6,485,490 B2	11/2002	Wampler et al.	6,780,151 B2	8/2004	Grabover et al.
6,488,196 B1	12/2002	Fenton, Jr.	6,780,180 B1	8/2004	Goble et al.
6,488,197 B1	12/2002	Whitman	6,783,524 B2	8/2004	Anderson et al.
6,491,201 B1	12/2002	Whitman	6,786,382 B1	9/2004	Hoffman
6,491,690 B1	12/2002	Goble et al.	6,786,864 B2	9/2004	Matsuura et al.
6,492,785 B1	12/2002	Kasten et al.	6,786,896 B1	9/2004	Madani et al.
6,494,896 B1	12/2002	D'Alessio et al.	6,790,173 B2	9/2004	Saadat et al.
6,503,257 B2	1/2003	Grant et al.	6,793,652 B1	9/2004	Whitman et al.
6,503,259 B2	1/2003	Huxel et al.	6,805,273 B2	10/2004	Bilotti et al.
6,505,768 B2	1/2003	Whitman	6,806,808 B1	10/2004	Watters et al.
6,510,854 B2	1/2003	Goble	6,808,525 B2	10/2004	Latterell et al.
6,511,468 B1	1/2003	Cragg et al.	6,814,741 B2	11/2004	Bowman et al.
6,517,535 B2	2/2003	Edwards	6,817,508 B1	11/2004	Racenet et al.
6,517,565 B1	2/2003	Whitman et al.	6,817,509 B2	11/2004	Geiste et al.
6,522,101 B2	2/2003	Malackowski	6,817,974 B2	11/2004	Cooper et al.
6,543,456 B1	4/2003	Freeman	6,821,273 B2	11/2004	Mollenauer
6,547,786 B1	4/2003	Goble	6,827,725 B2	12/2004	Batchelor et al.
6,550,546 B2	4/2003	Thurler et al.	6,828,902 B2	12/2004	Casden
6,551,333 B2	4/2003	Kuhns et al.	6,830,174 B2	12/2004	Hillstead et al.
6,554,861 B2	4/2003	Knox et al.	6,832,998 B2	12/2004	Goble
6,558,379 B1	5/2003	Batchelor et al.	6,834,001 B2	12/2004	Myono
6,565,560 B1	5/2003	Goble et al.	6,835,199 B2	12/2004	McGuckin, Jr. et al.
6,569,085 B2	5/2003	Kortenbach et al.	6,843,789 B2	1/2005	Goble
6,569,171 B2	5/2003	DeGuillebon et al.	6,846,307 B2	1/2005	Whitman et al.
6,578,751 B2	6/2003	Hartwick	6,846,308 B2	1/2005	Whitman et al.
6,582,427 B1	6/2003	Goble et al.	6,846,309 B2	1/2005	Whitman et al.
6,588,643 B2	7/2003	Bolduc et al.	6,849,071 B2	2/2005	Whitman et al.
6,592,597 B2	7/2003	Grant et al.	RE38,708 E	3/2005	Bolanos et al.
6,596,432 B2	7/2003	Kawakami et al.	6,872,214 B2	3/2005	Sonnenschein et al.
D478,665 S	8/2003	Isaacs et al.	6,874,669 B2	4/2005	Adams et al.
D478,986 S	8/2003	Johnston et al.	6,877,647 B2	4/2005	Green et al.
6,601,749 B2	8/2003	Sullivan et al.	6,878,106 B1	4/2005	Herrmann
6,602,252 B2	8/2003	Mollenauer	6,893,435 B2	5/2005	Goble
6,605,078 B2	8/2003	Adams	6,905,057 B2	6/2005	Swayze et al.
6,605,669 B2	8/2003	Awokola et al.	6,905,497 B2	6/2005	Truckai et al.
6,616,686 B2	9/2003	Coleman et al.	6,913,608 B2	7/2005	Liddicoat et al.
6,619,529 B2	9/2003	Green et al.	6,913,613 B2	7/2005	Schwarz et al.
6,620,166 B1	9/2003	Wenstrom, Jr. et al.	6,923,803 B2	8/2005	Goble
6,629,630 B2	10/2003	Adams	6,929,641 B2	8/2005	Goble et al.
6,629,974 B2	10/2003	Penny et al.	6,931,830 B2	8/2005	Liao
6,629,988 B2	10/2003	Weadock	6,939,358 B2	9/2005	Palacios et al.
6,636,412 B2	10/2003	Smith	6,942,662 B2	9/2005	Goble et al.
6,638,108 B2	10/2003	Tachi	6,945,444 B2	9/2005	Gresham et al.
6,638,285 B2	10/2003	Gabbay	6,953,138 B1	10/2005	Dworak et al.
6,644,532 B2	11/2003	Green et al.	6,953,139 B2	10/2005	Milliman et al.
6,648,816 B2	11/2003	Irion et al.	6,959,852 B2	11/2005	Shelton, IV et al.
D484,243 S	12/2003	Ryan et al.	6,960,163 B2	11/2005	Ewers et al.
D484,595 S	12/2003	Ryan et al.	6,960,220 B2	11/2005	Marino et al.
D484,596 S	12/2003	Ryan et al.	6,964,363 B2	11/2005	Wales et al.
6,656,193 B2	12/2003	Grant et al.	6,966,907 B2	11/2005	Goble
6,666,875 B1	12/2003	Sakurai et al.	6,966,909 B2	11/2005	Marshall et al.
6,669,073 B2	12/2003	Milliman et al.	6,972,199 B2	12/2005	Leboutitz et al.
D484,977 S	1/2004	Ryan et al.	6,974,462 B2	12/2005	Sater
6,676,660 B2	1/2004	Wampler et al.	6,978,921 B2	12/2005	Shelton, IV et al.
6,679,410 B2	1/2004	Würsch et al.	6,978,922 B2	12/2005	Bilotti et al.
6,681,978 B2	1/2004	Geiste et al.	6,981,628 B2	1/2006	Wales
6,681,979 B2	1/2004	Whitman	6,981,941 B2	1/2006	Whitman et al.
6,682,528 B2	1/2004	Frazier et al.	6,981,978 B2	1/2006	Gannoe

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6,984,203 B2	1/2006	Tartaglia et al.	7,208,005 B2	4/2007	Frecker et al.
6,984,231 B2	1/2006	Goble et al.	7,211,081 B2	5/2007	Goble
6,988,649 B2	1/2006	Shelton, IV et al.	7,211,084 B2	5/2007	Goble et al.
6,988,650 B2	1/2006	Schwemberger et al.	7,214,224 B2	5/2007	Goble
6,990,796 B2	1/2006	Schnipke et al.	7,220,260 B2	5/2007	Fleming et al.
6,997,931 B2	2/2006	Sauer et al.	7,220,272 B2	5/2007	Weadock
7,000,818 B2	2/2006	Shelton, IV et al.	7,225,964 B2	6/2007	Mastri et al.
7,000,819 B2	2/2006	Swayze et al.	7,234,624 B2	6/2007	Gresham et al.
7,001,380 B2	2/2006	Goble	7,235,089 B1	6/2007	McGuckin, Jr.
7,001,408 B2	2/2006	Knodel et al.	7,235,302 B2	6/2007	Jing et al.
7,008,435 B2	3/2006	Cummins	7,237,708 B1	7/2007	Guy et al.
7,018,390 B2	3/2006	Turovskiy et al.	7,241,288 B2	7/2007	Braun
7,025,743 B2	4/2006	Mann et al.	7,246,734 B2	7/2007	Shelton, IV
7,029,435 B2	4/2006	Nakao	7,247,161 B2	7/2007	Johnston et al.
7,032,798 B2	4/2006	Whitman et al.	7,252,660 B2	8/2007	Kunz
7,032,799 B2	4/2006	Viola et al.	7,255,696 B2	8/2007	Goble et al.
7,033,356 B2	4/2006	Latterell et al.	7,258,262 B2	8/2007	Mastri et al.
7,037,344 B2	5/2006	Kagan et al.	7,260,431 B2	8/2007	Libbus et al.
7,044,352 B2	5/2006	Shelton, IV et al.	7,265,374 B2	9/2007	Lee et al.
7,044,353 B2	5/2006	Mastri et al.	7,267,679 B2	9/2007	McGuckin, Jr. et al.
7,048,687 B1	5/2006	Reuss et al.	7,278,562 B2	10/2007	Mastri et al.
7,052,494 B2	5/2006	Goble et al.	7,278,563 B1	10/2007	Green
7,055,730 B2	6/2006	Ehrenfels et al.	7,278,994 B2	10/2007	Goble
7,055,731 B2	6/2006	Shelton, IV et al.	7,282,048 B2	10/2007	Goble et al.
7,056,284 B2	6/2006	Martone et al.	7,295,907 B2	11/2007	Lu et al.
7,056,330 B2	6/2006	Gayton	7,296,724 B2	11/2007	Green et al.
7,059,508 B2	6/2006	Shelton, IV et al.	7,297,149 B2	11/2007	Vitali et al.
7,063,712 B2	6/2006	Vargas et al.	7,303,106 B2	12/2007	Milliman et al.
7,066,944 B2	6/2006	Laufer et al.	7,303,107 B2	12/2007	Milliman et al.
7,070,083 B2	7/2006	Jankowski	7,303,556 B2	12/2007	Metzger
7,070,559 B2	7/2006	Adams et al.	7,324,572 B2	1/2008	Chang
7,071,287 B2	7/2006	Rhine et al.	7,328,829 B2	2/2008	Arad et al.
7,075,770 B1	7/2006	Smith	7,330,004 B2	2/2008	DeJonge et al.
7,077,856 B2	7/2006	Whitman	7,334,717 B2	2/2008	Rethy et al.
7,080,769 B2	7/2006	Vresh et al.	7,336,184 B2	2/2008	Smith et al.
7,081,114 B2	7/2006	Rashidi	7,338,513 B2	3/2008	Lee et al.
7,083,073 B2	8/2006	Yoshie et al.	7,348,763 B1	3/2008	Reinhart et al.
7,083,075 B2	8/2006	Swayze et al.	7,351,258 B2	4/2008	Ricotta et al.
7,083,571 B2	8/2006	Wang et al.	7,364,060 B2	4/2008	Milliman
7,087,071 B2	8/2006	Nicholas et al.	7,377,928 B2	5/2008	Zubik et al.
7,090,637 B2	8/2006	Danitz et al.	7,388,217 B2	6/2008	Buschbeck et al.
7,090,684 B2	8/2006	McGuckin, Jr. et al.	7,397,364 B2	7/2008	Govari
7,094,202 B2	8/2006	Nobis et al.	7,398,907 B2	7/2008	Racenet et al.
7,098,794 B2	8/2006	Lindsay et al.	7,398,908 B2	7/2008	Holsten et al.
7,104,741 B2	9/2006	Krohn	7,404,508 B2	7/2008	Smith et al.
7,108,695 B2	9/2006	Witt et al.	7,404,509 B2	7/2008	Ortiz et al.
7,108,701 B2	9/2006	Evens et al.	7,418,078 B2	8/2008	Blanz et al.
7,108,709 B2	9/2006	Cummins	7,419,080 B2	9/2008	Smith et al.
7,112,214 B2	9/2006	Peterson et al.	7,422,136 B1	9/2008	Marczyk
RE39,358 E	10/2006	Goble	7,424,965 B2	9/2008	Racenet et al.
7,114,642 B2	10/2006	Whitman	7,431,188 B1	10/2008	Marczyk
7,118,582 B1	10/2006	Wang et al.	7,431,694 B2	10/2008	Stefanchik et al.
7,121,446 B2	10/2006	Arad et al.	7,438,209 B1	10/2008	Hess et al.
7,122,028 B2	10/2006	Looper et al.	7,439,354 B2	10/2008	Lenges et al.
7,128,253 B2	10/2006	Mastri et al.	7,441,685 B1	10/2008	Boudreaux
7,128,254 B2	10/2006	Shelton, IV et al.	7,461,767 B2	12/2008	Viola et al.
7,128,748 B2	10/2006	Mooradian et al.	7,464,847 B2	12/2008	Viola et al.
7,131,445 B2	11/2006	Amoah	7,472,814 B2	1/2009	Mastri et al.
7,133,601 B2	11/2006	Phillips et al.	7,473,253 B2	1/2009	Dycus et al.
7,140,527 B2	11/2006	Ehrenfels et al.	7,481,349 B2	1/2009	Holsten et al.
7,143,925 B2	12/2006	Shelton, IV et al.	7,481,824 B2	1/2009	Boudreaux et al.
7,143,926 B2	12/2006	Shelton, IV et al.	7,485,133 B2	2/2009	Cannon et al.
7,147,139 B2	12/2006	Schwemberger et al.	7,490,749 B2	2/2009	Schall et al.
7,147,637 B2	12/2006	Goble	7,494,039 B2	2/2009	Racenet et al.
7,147,650 B2	12/2006	Lee	7,494,499 B2	2/2009	Nagase et al.
7,150,748 B2	12/2006	Ebbutt et al.	7,506,790 B2	3/2009	Shelton, IV
7,153,300 B2	12/2006	Goble	7,510,107 B2	3/2009	Timm et al.
7,156,863 B2	1/2007	Sonnenschein et al.	7,524,320 B2	4/2009	Tierney et al.
7,159,750 B2	1/2007	Racenet et al.	7,530,985 B2	5/2009	Takemoto et al.
7,161,036 B2	1/2007	Oikawa et al.	7,546,940 B2	6/2009	Milliman et al.
7,172,104 B2	2/2007	Scirica et al.	7,547,312 B2	6/2009	Bauman et al.
7,179,223 B2	2/2007	Motoki et al.	7,549,564 B2	6/2009	Boudreaux
7,179,267 B2	2/2007	Nolan et al.	7,552,854 B2	6/2009	Wixey et al.
7,182,239 B1	2/2007	Myers	7,556,186 B2	7/2009	Milliman
7,195,627 B2	3/2007	Amoah et al.	7,563,862 B2	7/2009	Sieg et al.
7,204,835 B2	4/2007	Latterell et al.	7,566,300 B2	7/2009	Devierre et al.
7,207,233 B2	4/2007	Wadge	7,568,604 B2	8/2009	Ehrenfels et al.
7,207,471 B2	4/2007	Heinrich et al.	7,568,619 B2	8/2009	Todd et al.
7,207,472 B2	4/2007	Wukusick et al.	7,575,144 B2	8/2009	Ortiz et al.

# US 8,186,555 B2

Page 8

7,588,175 B2	9/2009	Timm et al.	8,066,167 B2	11/2011	Measamer et al.
7,588,176 B2	9/2009	Timm et al.	D650,074 S	12/2011	Hunt et al.
7,597,229 B2	10/2009	Boudreaux et al.	8,083,120 B2	12/2011	Shelton, IV et al.
7,600,663 B2	10/2009	Green	2002/0022836 A1	2/2002	Goble et al.
7,604,150 B2	10/2009	Boudreaux	2002/0029036 A1	3/2002	Goble et al.
7,604,151 B2	10/2009	Hess et al.	2002/0117534 A1	8/2002	Green et al.
7,611,038 B2	11/2009	Racenet et al.	2002/0134811 A1	9/2002	Napier et al.
7,615,003 B2	11/2009	Stefanchik et al.	2002/0165541 A1	11/2002	Whitman
7,631,793 B2	12/2009	Rethy et al.	2003/0093103 A1	5/2003	Malackowski et al.
7,641,092 B2	1/2010	Kruszynski et al.	2003/0105478 A1	6/2003	Whitman et al.
7,641,093 B2	1/2010	Doll et al.	2003/0130677 A1	7/2003	Whitman et al.
7,651,498 B2	1/2010	Shifrin et al.	2003/0139741 A1	7/2003	Goble et al.
7,658,311 B2	2/2010	Boudreaux	2003/0153908 A1	8/2003	Goble et al.
7,665,646 B2	2/2010	Prommersberger	2003/0195387 A1	10/2003	Kortenbach et al.
7,669,747 B2	3/2010	Weisenburgh, II et al.	2003/0216732 A1	11/2003	Truckai et al.
7,673,782 B2	3/2010	Hess et al.	2003/0216778 A1	11/2003	Weadock
7,674,255 B2	3/2010	Braun	2003/0220660 A1	11/2003	Kortenbach et al.
7,682,307 B2	3/2010	Danitz et al.	2004/0002726 A1	1/2004	Nunez et al.
7,686,826 B2	3/2010	Lee et al.	2004/0006340 A1	1/2004	Latterell et al.
7,691,098 B2	4/2010	Wallace et al.	2004/0006372 A1	1/2004	Racenet et al.
7,699,204 B2	4/2010	Viola	2004/0028502 A1	2/2004	Cummins
7,717,312 B2	5/2010	Beetel	2004/0030333 A1	2/2004	Goble
7,721,930 B2	5/2010	McKenna et al.	2004/0034357 A1	2/2004	Beane et al.
7,722,610 B2	5/2010	Viola et al.	2004/0034369 A1	2/2004	Sauer et al.
7,726,537 B2	6/2010	Olson et al.	2004/0044364 A1	3/2004	DeVries et al.
7,726,538 B2	6/2010	Holsten et al.	2004/0068161 A1	4/2004	Couvillon, Jr.
7,731,072 B2	6/2010	Timm et al.	2004/0068307 A1	4/2004	Goble
7,735,703 B2	6/2010	Morgan et al.	2004/0078037 A1	4/2004	Batchelor et al.
7,743,960 B2	6/2010	Whitman et al.	2004/0093024 A1	5/2004	Lousararian et al.
7,744,627 B2	6/2010	Orban, III et al.	2004/0094597 A1	5/2004	Whitman et al.
7,753,245 B2	7/2010	Boudreaux et al.	2004/0097987 A1	5/2004	Pugsley et al.
7,766,209 B2	8/2010	Baxter, III et al.	2004/0101822 A1	5/2004	Wiesner et al.
7,771,396 B2	8/2010	Stefanchik et al.	2004/0108357 A1	6/2004	Milliman et al.
7,780,685 B2	8/2010	Hunt et al.	2004/0111081 A1	6/2004	Whitman et al.
7,793,812 B2	9/2010	Moore et al.	2004/0115022 A1	6/2004	Albertson et al.
7,798,386 B2	9/2010	Schall et al.	2004/0116952 A1	6/2004	Sakurai et al.
7,806,891 B2	10/2010	Nowlin et al.	2004/0122471 A1	6/2004	Toby et al.
7,810,692 B2	10/2010	Hall et al.	2004/0147909 A1	7/2004	Johnston et al.
7,810,693 B2	10/2010	Broehl et al.	2004/0164123 A1	8/2004	Racenet et al.
7,815,565 B2	10/2010	Stefanchik et al.	2004/0167572 A1	8/2004	Roth et al.
7,819,296 B2	10/2010	Hueil et al.	2004/0173659 A1	9/2004	Green et al.
7,819,297 B2	10/2010	Doll et al.	2004/0181219 A1	9/2004	Goble et al.
7,819,298 B2	10/2010	Hall et al.	2004/0186470 A1	9/2004	Goble et al.
7,819,299 B2	10/2010	Shelton, IV et al.	2004/0222268 A1	11/2004	Bilotti et al.
7,824,401 B2	11/2010	Manzo et al.	2004/0232199 A1	11/2004	Shelton, IV et al.
7,828,794 B2	11/2010	Sartor	2004/0232201 A1	11/2004	Wenchell et al.
7,828,808 B2	11/2010	Hinman et al.	2004/0243151 A1	12/2004	Demmy et al.
7,832,408 B2	11/2010	Shelton, IV et al.	2004/0243163 A1	12/2004	Casiano et al.
7,832,611 B2	11/2010	Boyden et al.	2004/0243176 A1	12/2004	Hahnen et al.
7,832,612 B2	11/2010	Baxter, III et al.	2004/0254608 A1	12/2004	Huitema et al.
7,836,400 B2	11/2010	May et al.	2004/0267310 A1	12/2004	Racenet et al.
7,837,080 B2	11/2010	Schwemmerger	2005/0006434 A1	1/2005	Wales et al.
7,845,533 B2	12/2010	Marczyk et al.	2005/0021026 A1	1/2005	Baily
7,845,534 B2	12/2010	Viola et al.	2005/0021078 A1 *	1/2005	Vleugels et al. .... 606/205
7,846,149 B2	12/2010	Jankowski	2005/0023324 A1	2/2005	Doll et al.
7,857,185 B2	12/2010	Swayze et al.	2005/0032511 A1	2/2005	Malone et al.
7,857,186 B2	12/2010	Baxter, III et al.	2005/0033357 A1	2/2005	Braun
7,861,906 B2	1/2011	Doll et al.	2005/0054946 A1	3/2005	Krzyzanowski
7,866,527 B2	1/2011	Hall et al.	2005/0059997 A1	3/2005	Bauman et al.
7,870,989 B2	1/2011	Viola et al.	2005/0070925 A1	3/2005	Shelton, IV et al.
7,887,530 B2	2/2011	Zemlok et al.	2005/0070929 A1	3/2005	Dalessandro et al.
7,900,191 B1	3/2011	Baker et al.	2005/0070958 A1	3/2005	Swayze et al.
7,905,380 B2	3/2011	Shelton, IV et al.	2005/0072827 A1	4/2005	Mollenauer
7,905,381 B2	3/2011	Baxter, III et al.	2005/0080454 A1	4/2005	Drews et al.
7,909,221 B2	3/2011	Viola et al.	2005/0085693 A1	4/2005	Belson et al.
7,913,891 B2	3/2011	Doll et al.	2005/0103819 A1	5/2005	Racenet et al.
7,918,377 B2	4/2011	Measamer et al.	2005/0107814 A1	5/2005	Johnston et al.
7,922,061 B2	4/2011	Shelton, IV et al.	2005/0107824 A1	5/2005	Hillstead et al.
7,922,063 B2	4/2011	Zemlok et al.	2005/0113820 A1	5/2005	Goble et al.
7,934,630 B2	5/2011	Shelton, IV et al.	2005/0119525 A1	6/2005	Takemoto
7,950,560 B2	5/2011	Zemlok et al.	2005/0119669 A1	6/2005	Demmy
7,954,684 B2	6/2011	Boudreaux	2005/0124855 A1	6/2005	Jaffe et al.
7,954,686 B2	6/2011	Baxter, III et al.	2005/0131173 A1	6/2005	McDaniel et al.
7,959,051 B2	6/2011	Smith et al.	2005/0131211 A1	6/2005	Bayley et al.
7,980,443 B2	7/2011	Scheib et al.	2005/0131390 A1	6/2005	Heinrich et al.
8,002,795 B2	8/2011	Beetel	2005/0131436 A1	6/2005	Johnston et al.
8,011,551 B2	9/2011	Marczyk et al.	2005/0131437 A1	6/2005	Johnston et al.
8,020,743 B2	9/2011	Shelton, IV	2005/0131457 A1	6/2005	Douglas et al.
8,056,787 B2	11/2011	Boudreaux et al.	2005/0137454 A1	6/2005	Saadat et al.



# US 8,186,555 B2

Page 9

2005/0137455 A1	6/2005	Ewers et al.	2006/0278680 A1	12/2006	Viola et al.
2005/0143759 A1	6/2005	Kelly	2006/0278681 A1	12/2006	Viola et al.
2005/0145671 A1	7/2005	Viola	2006/0289602 A1	12/2006	Wales et al.
2005/0154258 A1	7/2005	Tartaglia et al.	2006/0291981 A1	12/2006	Viola et al.
2005/0165415 A1	7/2005	Wales	2007/0023476 A1	2/2007	Whitman et al.
2005/0165419 A1	7/2005	Sauer et al.	2007/0023477 A1	2/2007	Whitman et al.
2005/0165435 A1	7/2005	Johnston et al.	2007/0027468 A1	2/2007	Wales et al.
2005/0169974 A1	8/2005	Tenerz et al.	2007/0027469 A1	2/2007	Smith et al.
2005/0173490 A1	8/2005	Shelton et al.	2007/0034668 A1	2/2007	Holsten et al.
2005/0177181 A1	8/2005	Kagan et al.	2007/0045379 A1	3/2007	Shelton
2005/0182298 A1	8/2005	Ikeda et al.	2007/0055219 A1	3/2007	Whitman et al.
2005/0184121 A1	8/2005	Heinrich	2007/0070574 A1	3/2007	Nerheim et al.
2005/0187545 A1	8/2005	Hooven et al.	2007/0073340 A1	3/2007	Shelton, IV et al.
2005/0187572 A1	8/2005	Johnston et al.	2007/0073341 A1	3/2007	Smith et al.
2005/0187576 A1	8/2005	Whitman et al.	2007/0075114 A1	4/2007	Shelton, IV et al.
2005/0189397 A1	9/2005	Jankowski	2007/0078484 A1	4/2007	Talarico et al.
2005/0192628 A1	9/2005	Viola	2007/0083234 A1	4/2007	Shelton, IV et al.
2005/0203550 A1	9/2005	Laufer et al.	2007/0084897 A1	4/2007	Shelton, IV et al.
2005/0216055 A1	9/2005	Scirica et al.	2007/0102452 A1	5/2007	Shelton, IV et al.
2005/0228224 A1	10/2005	Okada et al.	2007/0102453 A1	5/2007	Morgan et al.
2005/0230453 A1	10/2005	Viola	2007/0102472 A1	5/2007	Shelton, IV
2005/0240222 A1	10/2005	Shipp	2007/0102473 A1	5/2007	Shelton, IV et al.
2005/0245965 A1	11/2005	Orban, III et al.	2007/0102474 A1	5/2007	Shelton, IV et al.
2005/0251128 A1	11/2005	Amoah	2007/0102475 A1	5/2007	Ortiz et al.
2005/0256522 A1	11/2005	Francischelli et al.	2007/0102476 A1	5/2007	Shelton, IV et al.
2005/0261676 A1	11/2005	Hall et al.	2007/0106317 A1	5/2007	Shelton, IV et al.
2005/0261677 A1	11/2005	Hall et al.	2007/0114261 A1	5/2007	Ortiz et al.
2005/0263562 A1	12/2005	Shelton, IV et al.	2007/0135803 A1	6/2007	Belson
2005/0263563 A1	12/2005	Racenet et al.	2007/0158358 A1	7/2007	Mason, II et al.
2005/0274768 A1	12/2005	Cummins et al.	2007/0173806 A1	7/2007	Orszulak et al.
2006/0011699 A1	1/2006	Olson et al.	2007/0173813 A1	7/2007	Odom
2006/0015009 A1	1/2006	Jaffe et al.	2007/0175958 A1	8/2007	Shelton, IV et al.
2006/0020247 A1	1/2006	Kagan et al.	2007/0175959 A1	8/2007	Shelton, IV et al.
2006/0025811 A1	2/2006	Shelton, IV	2007/0181632 A1	8/2007	Milliman
2006/0025812 A1	2/2006	Shelton, IV	2007/0213750 A1	9/2007	Weadock
2006/0025813 A1	2/2006	Shelton et al.	2007/0221700 A1	9/2007	Ortiz et al.
2006/0025816 A1	2/2006	Shelton	2007/0221701 A1	9/2007	Ortiz et al.
2006/0047275 A1	3/2006	Goble	2007/0225562 A1	9/2007	Spivey et al.
2006/0047307 A1	3/2006	Ortiz et al.	2007/0233053 A1	10/2007	Shelton, IV et al.
2006/0047308 A1	3/2006	Ortiz et al.	2007/0246505 A1	10/2007	Pace-Florida et al.
2006/0049229 A1	3/2006	Milliman et al.	2007/0260278 A1	11/2007	Wheeler et al.
2006/0052825 A1	3/2006	Ransick et al.	2007/0262116 A1	11/2007	Hueil et al.
2006/0060630 A1	3/2006	Shelton, IV et al.	2007/0270784 A1	11/2007	Smith et al.
2006/0079735 A1	4/2006	Martone et al.	2007/0288044 A1	12/2007	Jinno et al.
2006/0085031 A1	4/2006	Bettuchi	2007/0295780 A1	12/2007	Shelton et al.
2006/0085033 A1	4/2006	Criscuolo et al.	2008/0015598 A1	1/2008	Prommersberger
2006/0086032 A1	4/2006	Valencic et al.	2008/0029570 A1	2/2008	Shelton et al.
2006/0087442 A1	4/2006	Smith et al.	2008/0029571 A1	2/2008	Shelton et al.
2006/0100643 A1	5/2006	Laufer et al.	2008/0029572 A1	2/2008	Shelton et al.
2006/0108393 A1	5/2006	Heinrich et al.	2008/0029573 A1	2/2008	Shelton et al.
2006/0111710 A1	5/2006	Goble et al.	2008/0029574 A1	2/2008	Shelton et al.
2006/0111711 A1	5/2006	Goble	2008/0029575 A1	2/2008	Shelton et al.
2006/0122636 A1	6/2006	Bailley et al.	2008/0029576 A1	2/2008	Shelton et al.
2006/0142772 A1	6/2006	Ralph et al.	2008/0029577 A1	2/2008	Shelton et al.
2006/0149163 A1	7/2006	Hibner et al.	2008/0030170 A1	2/2008	Dacquay et al.
2006/0151567 A1	7/2006	Roy	2008/0035701 A1	2/2008	Racenet et al.
2006/0161185 A1	7/2006	Saadat et al.	2008/0041916 A1	2/2008	Milliman et al.
2006/0173470 A1	8/2006	Oray et al.	2008/0041917 A1	2/2008	Racenet et al.
2006/0180634 A1	8/2006	Shelton, IV et al.	2008/0078800 A1	4/2008	Hess et al.
2006/0183246 A1	8/2006	Wiesner et al.	2008/0078801 A1	4/2008	Shelton et al.
2006/0190028 A1	8/2006	Wales et al.	2008/0078802 A1	4/2008	Hess et al.
2006/0190029 A1	8/2006	Wales	2008/0078803 A1	4/2008	Shelton et al.
2006/0190031 A1	8/2006	Wales et al.	2008/0078804 A1	4/2008	Shelton et al.
2006/0200123 A1	9/2006	Ryan	2008/0078805 A1	4/2008	Omaitis et al.
2006/0212069 A1	9/2006	Shelton, IV	2008/0078806 A1	4/2008	Omaitis et al.
2006/0217729 A1	9/2006	Eskridge et al.	2008/0078807 A1	4/2008	Hess et al.
2006/0226196 A1	10/2006	Hueil et al.	2008/0078808 A1	4/2008	Hess et al.
2006/0229665 A1	10/2006	Wales et al.	2008/0082114 A1	4/2008	McKenna et al.
2006/0235469 A1	10/2006	Viola	2008/0082115 A1	4/2008	Morgan et al.
2006/0241655 A1	10/2006	Viola	2008/0082124 A1	4/2008	Hess et al.
2006/0241692 A1	10/2006	McGuckin, Jr. et al.	2008/0082125 A1	4/2008	Murray et al.
2006/0244460 A1	11/2006	Weaver	2008/0082126 A1	4/2008	Murray et al.
2006/0245971 A1	11/2006	Burns et al.	2008/0083813 A1	4/2008	Zemlok et al.
2006/0258904 A1	11/2006	Stefanchik et al.	2008/0114385 A1	5/2008	Byrum et al.
2006/0259073 A1	11/2006	Miyamoto et al.	2008/0129253 A1	6/2008	Shiue et al.
2006/0264927 A1	11/2006	Ryan	2008/0140115 A1	6/2008	Stopek
2006/0264929 A1	11/2006	Goble et al.	2008/0164296 A1	7/2008	Shelton et al.
2006/0271042 A1	11/2006	Latterell et al.	2008/0167522 A1	7/2008	Giordano et al.
2006/0271102 A1	11/2006	Bosshard et al.	2008/0167644 A1	7/2008	Shelton et al.

# US 8,186,555 B2

Page 10

2008/0167670 A1	7/2008	Shelton et al.	2010/0193566 A1	8/2010	Scheib et al.
2008/0167671 A1	7/2008	Giordano et al.	2010/0193567 A1	8/2010	Scheib et al.
2008/0167672 A1	7/2008	Giordano et al.	2010/0193568 A1	8/2010	Scheib et al.
2008/0167736 A1	7/2008	Swayze et al.	2010/0193569 A1	8/2010	Yates et al.
2008/0169327 A1	7/2008	Shelton et al.	2010/0198220 A1	8/2010	Boudreaux et al.
2008/0169328 A1	7/2008	Shelton	2010/0200637 A1	8/2010	Beetel
2008/0169329 A1	7/2008	Shelton et al.	2010/0213241 A1	8/2010	Bedi et al.
2008/0169330 A1	7/2008	Shelton et al.	2010/0222901 A1	9/2010	Swayze et al.
2008/0169331 A1	7/2008	Shelton et al.	2010/0224669 A1	9/2010	Shelton, IV et al.
2008/0169332 A1	7/2008	Shelton et al.	2010/0243709 A1	9/2010	Hess et al.
2008/0169333 A1	7/2008	Shelton et al.	2010/0264193 A1	10/2010	Huang et al.
2008/0197167 A1	8/2008	Viola et al.	2010/0264194 A1	10/2010	Huang et al.
2008/0228029 A1	9/2008	Mikkaichi et al.	2010/0276471 A1	11/2010	Whitman
2008/0251568 A1	10/2008	Zemlok et al.	2010/0294827 A1	11/2010	Boyden et al.
2008/0255413 A1	10/2008	Zemlok et al.	2010/0294829 A1	11/2010	Giordano et al.
2008/0262654 A1	10/2008	Omori et al.	2010/0301095 A1	12/2010	Shelton, IV et al.
2008/0283570 A1	11/2008	Boyden et al.	2010/0301096 A1	12/2010	Moore et al.
2008/0290134 A1	11/2008	Bettuchi et al.	2010/0305552 A1	12/2010	Shelton, IV et al.
2008/0296346 A1	12/2008	Shelton, IV et al.	2010/0308100 A1	12/2010	Boudreaux
2008/0300580 A1	12/2008	Shelton, IV et al.	2010/0312261 A1	12/2010	Suzuki et al.
2008/0308602 A1	12/2008	Timm et al.	2011/0006099 A1	1/2011	Hall et al.
2008/0308603 A1	12/2008	Shelton, IV et al.	2011/0006101 A1	1/2011	Hall et al.
2008/0308608 A1	12/2008	Prommersberger	2011/0006103 A1	1/2011	Laurent et al.
2008/0314960 A1	12/2008	Marczyk et al.	2011/0011914 A1	1/2011	Baxter, III et al.
2009/0001121 A1	1/2009	Hess et al.	2011/0011915 A1	1/2011	Shelton, IV
2009/0001122 A1	1/2009	Prommersberger et al.	2011/0017801 A1	1/2011	Zemlok et al.
2009/0001124 A1	1/2009	Hess et al.	2011/0022032 A1	1/2011	Zemlok et al.
2009/0001130 A1	1/2009	Hess et al.	2011/0024477 A1	2/2011	Hall et al.
2009/0005807 A1	1/2009	Hess et al.	2011/0024478 A1	2/2011	Shelton, IV
2009/0005808 A1	1/2009	Hess et al.	2011/0024479 A1	2/2011	Swensgard et al.
2009/0005809 A1	1/2009	Hess et al.	2011/0036887 A1	2/2011	Zemlok et al.
2009/0012556 A1	1/2009	Boudreaux et al.	2011/0042441 A1	2/2011	Shelton, IV et al.
2009/0020958 A1	1/2009	Soul	2011/0060363 A1	3/2011	Hess et al.
2009/0054908 A1	2/2009	Zand et al.	2011/0062212 A1	3/2011	Shelton, IV et al.
2009/0057369 A1	3/2009	Smith et al.	2011/0068145 A1	3/2011	Bedi et al.
2009/0076534 A1	3/2009	Shelton, IV et al.	2011/0068148 A1	3/2011	Hall et al.
2009/0090763 A1	4/2009	Zemlok et al.	2011/0084112 A1	4/2011	Kostrzewski
2009/0108048 A1	4/2009	Zemlok et al.	2011/0084113 A1	4/2011	Bedi et al.
2009/0114701 A1	5/2009	Zemlok et al.	2011/0084115 A1	4/2011	Bedi et al.
2009/0149871 A9	6/2009	Kagan et al.	2011/0087276 A1	4/2011	Bedi et al.
2009/0157067 A1	6/2009	Kane et al.	2011/0101065 A1	5/2011	Milliman
2009/0206125 A1	8/2009	Huitema et al.	2011/0114697 A1	5/2011	Baxter, III et al.
2009/0206126 A1	8/2009	Huitema et al.	2011/0114698 A1	5/2011	Baxter, III et al.
2009/0206131 A1	8/2009	Weisenburgh, II et al.	2011/0114699 A1	5/2011	Baxter, III et al.
2009/0206132 A1	8/2009	Hueil et al.	2011/0114700 A1	5/2011	Baxter, III et al.
2009/0206133 A1	8/2009	Morgan et al.	2011/0118761 A1	5/2011	Baxter, III et al.
2009/0206137 A1	8/2009	Hall et al.	2011/0121051 A1	5/2011	Shelton, IV et al.
2009/0206139 A1	8/2009	Hall et al.	2011/0121052 A1	5/2011	Shelton, IV et al.
2009/0206141 A1	8/2009	Huitema et al.	2011/0125176 A1	5/2011	Yates et al.
2009/0206142 A1	8/2009	Huitema et al.	2011/0125177 A1	5/2011	Yates et al.
2009/0206143 A1	8/2009	Huitema et al.	2011/0132962 A1	6/2011	Hall et al.
2009/0209946 A1	8/2009	Swayze et al.	2011/0132963 A1	6/2011	Giordano et al.
2009/0209979 A1	8/2009	Yates et al.	2011/0132964 A1	6/2011	Weisenburgh, II et al.
2009/0209990 A1	8/2009	Yates et al.	2011/0132965 A1	6/2011	Moore et al.
2009/0218384 A1	9/2009	Aranyi	2011/0139852 A1	6/2011	Zingman
2009/0242610 A1	10/2009	Shelton, IV et al.	2011/0144430 A1	6/2011	Spivey et al.
2009/0255974 A1	10/2009	Viola	2011/0147433 A1	6/2011	Shelton, IV et al.
2009/0255975 A1	10/2009	Zemlok et al.	2011/0147434 A1	6/2011	Hueil et al.
2009/0255976 A1	10/2009	Marczyk et al.	2011/0155780 A1	6/2011	Boudreaux
2009/0255977 A1	10/2009	Zemlok	2011/0155781 A1	6/2011	Swensgard et al.
2009/0255978 A1	10/2009	Viola et al.	2011/0155785 A1	6/2011	Laurent et al.
2009/0292283 A1	11/2009	Odom	2011/0155787 A1	6/2011	Baxter, III et al.
2009/0308907 A1	12/2009	Nalagatla et al.	2011/0163147 A1	7/2011	Laurent et al.
2010/0001036 A1	1/2010	Marczyk et al.	2011/0174860 A1	7/2011	Shelton, IV et al.
2010/0023024 A1	1/2010	Zeiner et al.	2011/0174863 A1	7/2011	Shelton, IV et al.
2010/0032470 A1	2/2010	Hess et al.	2011/0192882 A1	8/2011	Hess et al.
2010/0049084 A1	2/2010	Nock et al.	2011/0226837 A1	9/2011	Baxter, III et al.
2010/0069942 A1	3/2010	Shelton, IV	2011/0233258 A1	9/2011	Boudreaux
2010/0076474 A1	3/2010	Yates et al.	2011/0253766 A1	10/2011	Baxter, III et al.
2010/0076475 A1	3/2010	Yates et al.	2011/0288573 A1	11/2011	Yates et al.
2010/0089970 A1	4/2010	Smith et al.	2011/0290851 A1	12/2011	Shelton, IV
2010/0089972 A1	4/2010	Marczyk	2011/0290853 A1	12/2011	Shelton, IV et al.
2010/0108741 A1	5/2010	Hessler et al.	2011/0290854 A1	12/2011	Timm et al.
2010/0127042 A1	5/2010	Shelton, IV	2011/0290855 A1	12/2011	Moore et al.
2010/0133317 A1	6/2010	Shelton, IV et al.	2011/0290856 A1	12/2011	Shelton, IV et al.
2010/0133318 A1	6/2010	Boudreaux	2011/0290857 A1	12/2011	Shelton, IV et al.
2010/0163598 A1	7/2010	Belzer	2011/0295242 A1	12/2011	Spivey et al.
2010/0179382 A1	7/2010	Shelton, IV et al.			
2010/0181364 A1	7/2010	Shelton, IV et al.			

2011/0295269 A1 12/2011 Swensgard et al.  
 2011/0295270 A1 12/2011 Giordano et al.  
 2011/0295295 A1 12/2011 Shelton, IV et al.

## FOREIGN PATENT DOCUMENTS

CA 2514274 A1 1/2006  
 CN 1868411 A 11/2006  
 CN 1915180 A 2/2007  
 DE 273689 C 5/1914  
 DE 1775926 A 1/1972  
 DE 3036217 A1 4/1982  
 DE 3210466 A1 9/1983  
 DE 9412228 U 9/1994  
 DE 19509116 A1 9/1996  
 DE 19851291 A1 1/2000  
 DE 19924311 A1 11/2000  
 DE 69328576 T2 1/2001  
 DE 10052679 A1 5/2001  
 DE 20112837 U1 10/2001  
 DE 20121753 U1 4/2003  
 DE 202007003114 U1 6/2007  
 EP 0122046 A1 10/1984  
 EP 0070230 B1 10/1985  
 EP 0387980 B1 10/1985  
 EP 0033548 B1 5/1986  
 EP 0276104 A2 7/1988  
 EP 0248844 B1 1/1993  
 EP 0545029 A1 6/1993  
 EP 0277959 B1 10/1993  
 EP 0233940 B1 11/1993  
 EP 0261230 B1 11/1993  
 EP 0639349 A2 2/1994  
 EP 0324636 B1 3/1994  
 EP 0593920 A1 4/1994  
 EP 0523174 B1 6/1994  
 EP 0310431 B1 11/1994  
 EP 0375302 B1 11/1994  
 EP 0376562 81 11/1994  
 EP 0630612 A1 12/1994  
 EP 0634144 A1 1/1995  
 EP 0646356 A2 4/1995  
 EP 0646357 A1 4/1995  
 EP 0653189 A2 5/1995  
 EP 0669104 A1 8/1995  
 EP 0511470 B1 10/1995  
 EP 0679367 A2 11/1995  
 EP 0685204 A1 12/1995  
 EP 0364216 B1 1/1996  
 EP 0699418 A1 3/1996  
 EP 0702937 A1 3/1996  
 EP 0705571 A1 4/1996  
 EP 0711611 A2 5/1996  
 EP 0484677 B2 6/1996  
 EP 0541987 B1 7/1996  
 EP 0667119 B1 7/1996  
 EP 0708618 B1 3/1997  
 EP 0770355 A1 5/1997  
 EP 0503662 B1 6/1997  
 EP 0447121 B1 7/1997  
 EP 0625077 B1 7/1997  
 EP 0633749 B1 8/1997  
 EP 0710090 B1 8/1997  
 EP 0578425 B1 9/1997  
 EP 0625335 B1 11/1997  
 EP 0552423 B1 1/1998  
 EP 0592244 B1 1/1998  
 EP 0648476 B1 1/1998  
 EP 0649290 B1 3/1998  
 EP 0598618 B1 9/1998  
 EP 0676173 B1 9/1998  
 EP 0678007 81 9/1998  
 EP 0603472 B1 11/1998  
 EP 0605351 B1 11/1998  
 EP 0878169 A1 11/1998  
 EP 0879742 A1 11/1998  
 EP 0695144 B1 12/1998  
 EP 0722296 B1 12/1998  
 EP 0760230 B1 2/1999  
 EP 0623316 B1 3/1999

EP 0650701 B1 3/1999  
 EP 0537572 B1 6/1999  
 EP 0923907 A1 6/1999  
 EP 0843906 B1 3/2000  
 EP 0552050 B1 5/2000  
 EP 0833592 B1 5/2000  
 EP 0830094 B1 9/2000  
 EP 1034747 A1 9/2000  
 EP 1034748 A1 9/2000  
 EP 0694290 B1 11/2000  
 EP 1050278 A1 11/2000  
 EP 1053719 A1 11/2000  
 EP 1053720 A1 11/2000  
 EP 1055399 A1 11/2000  
 EP 1055400 A1 11/2000  
 EP 1080694 A1 3/2001  
 EP 1095627 A1 5/2001  
 EP 1256318 B1 5/2001  
 EP 0806914 B1 9/2001  
 EP 0768840 B1 12/2001  
 EP 0908152 B1 1/2002  
 EP 0872213 B1 5/2002  
 EP 0862386 B1 6/2002  
 EP 0949886 B1 9/2002  
 EP 1238634 A2 9/2002  
 EP 0858295 B1 12/2002  
 EP 0656188 B1 1/2003  
 EP 1284120 A1 2/2003  
 EP 1287788 A1 3/2003  
 EP 0717966 B1 4/2003  
 EP 0869742 B1 5/2003  
 EP 0829235 B1 6/2003  
 EP 0887046 B1 7/2003  
 EP 0852480 B1 8/2003  
 EP 0891154 B1 9/2003  
 EP 0873089 B1 10/2003  
 EP 0856326 B1 11/2003  
 EP 1374788 A1 1/2004  
 EP 0741996 B1 2/2004  
 EP 0814712 B1 2/2004  
 EP 1402837 A1 3/2004  
 EP 0705570 B1 4/2004  
 EP 0959784 B1 4/2004  
 EP 1407719 A2 4/2004  
 EP 1086713 B1 5/2004  
 EP 0996378 B1 6/2004  
 EP 1426012 A1 6/2004  
 EP 0833593 B2 7/2004  
 EP 1442694 A1 8/2004  
 EP 0888749 B1 9/2004  
 EP 0959786 B1 9/2004  
 EP 1459695 A1 9/2004  
 EP 1473819 A1 11/2004  
 EP 1477119 A1 11/2004  
 EP 1479345 A1 11/2004  
 EP 1479347 A1 11/2004  
 EP 1479348 A1 11/2004  
 EP 0754437 B2 12/2004  
 EP 1025807 B1 12/2004  
 EP 1001710 B1 1/2005  
 EP 1520521 A1 4/2005  
 EP 1520523 A1 4/2005  
 EP 1520525 A1 4/2005  
 EP 1523942 A2 4/2005  
 EP 1550408 A1 7/2005  
 EP 1557129 A1 7/2005  
 EP 1064883 B1 8/2005  
 EP 1067876 B1 8/2005  
 EP 0870473 B1 9/2005  
 EP 1157666 B1 9/2005  
 EP 0880338 B1 10/2005  
 EP 1158917 B1 11/2005  
 EP 1344498 B1 11/2005  
 EP 1330989 B1 12/2005  
 EP 0771176 B2 1/2006  
 EP 1621138 A2 2/2006  
 EP 1621139 A2 2/2006  
 EP 1621141 A2 2/2006  
 EP 1621145 A2 2/2006

# US 8,186,555 B2

Page 12

EP	1621151	A2	2/2006	JP	8229050	A	9/1996
EP	1034746	B1	3/2006	JP	2000033071	A	2/2000
EP	1632191	A2	3/2006	JP	2000171730	A	6/2000
EP	1065981	B1	5/2006	JP	2000287987	A	10/2000
EP	1082944	B1	5/2006	JP	2000325303	A	11/2000
EP	1652481	A2	5/2006	JP	2001286477	A	10/2001
EP	1253866	B1	7/2006	JP	2002143078	A	5/2002
EP	1032318	B1	8/2006	JP	2002369820	A	12/2002
EP	1045672	B1	8/2006	JP	2005505322	T	2/2005
EP	1617768	B1	8/2006	JP	2005103293	A	4/2005
EP	1693015	A2	8/2006	JP	2005131163	A	5/2005
EP	1400214	B1	9/2006	JP	2005131164	A	5/2005
EP	1129665	B1	11/2006	JP	2005131173	A	5/2005
EP	1400206	B1	11/2006	JP	2005131211	A	5/2005
EP	1721568	A1	11/2006	JP	2005131212	A	5/2005
EP	1256317	B1	12/2006	JP	2005137423	A	6/2005
EP	1728473	A1	12/2006	JP	2005152416	A	6/2005
EP	1728475	A2	12/2006	JP	2006-281405	A	10/2006
EP	1479346	B1	1/2007	RU	2008830	C1	3/1994
EP	1484024	B1	1/2007	RU	2187249	C2	8/2002
EP	1754445	A2	2/2007	RU	2225170	C2	3/2004
EP	1759812	A1	3/2007	SU	189517	A	1/1967
EP	1767163	A1	3/2007	SU	328636	A	9/1972
EP	1769756	A1	4/2007	SU	886900	A1	12/1981
EP	1769758	A1	4/2007	SU	1009439	A	4/1983
EP	1581128	B1	5/2007	SU	1333319	A2	8/1987
EP	1785097	A2	5/2007	SU	1377053	A1	2/1988
EP	1790293	A2	5/2007	SU	1561964	A1	5/1990
EP	1800610	A1	6/2007	SU	1722476	A1	3/1992
EP	1300117	B1	8/2007	WO	WO 91/15157	A1	10/1991
EP	1813199	A1	8/2007	WO	WO 92/20295	A1	11/1992
EP	1813201	A1	8/2007	WO	WO 92/21300	A1	12/1992
EP	1813203	A2	8/2007	WO	WO 93/13718	A1	7/1993
EP	1813207	A1	8/2007	WO	WO 93/14690	A1	8/1993
EP	1813209	A1	8/2007	WO	WO 93/15648	A1	8/1993
EP	1487359	B1	10/2007	WO	WO 93/15850	A1	8/1993
EP	1599146	B1	10/2007	WO	WO 93/19681	A1	10/1993
EP	1839596	A1	10/2007	WO	WO 94/00060	A1	1/1994
EP	1402821	B1	12/2007	WO	WO 94/11057	A1	5/1994
EP	1872727	A1	1/2008	WO	WO 94/12108	A1	6/1994
EP	1897502	A1	3/2008	WO	WO 94/18893	A1	9/1994
EP	1330201	B1	6/2008	WO	WO 94/22378	A1	10/1994
EP	1702568	B1	7/2008	WO	WO 94/23659	A1	10/1994
EP	1943976	A2	7/2008	WO	WO 95/02369	A1	1/1995
EP	1593337	B1	8/2008	WO	WO 95/03743	A1	2/1995
EP	1970014	A1	9/2008	WO	WO 95/06817	A1	3/1995
EP	1980213	A2	10/2008	WO	WO 95/09576	A1	4/1995
EP	1759645	B1	11/2008	WO	WO 95/09577	A1	4/1995
EP	1693008	B1	12/2008	WO	WO 95/14436	A1	6/1995
EP	1759640	B1	12/2008	WO	WO 95/17855	A1	7/1995
EP	2000102	A2	12/2008	WO	WO 95/18383	A1	7/1995
EP	1736104	B1	3/2009	WO	WO 95/18572	A1	7/1995
EP	1749486	B1	3/2009	WO	WO 95/19739	A1	7/1995
EP	1721576	B1	4/2009	WO	WO 95/20360	A1	8/1995
EP	1733686	B1	4/2009	WO	WO 95/23557	A1	9/1995
EP	1745748	B1	8/2009	WO	WO 95/24865	A1	9/1995
EP	2090256	A2	8/2009	WO	WO 95/25471	A3	9/1995
EP	1813208	B1	11/2009	WO	WO 95/26562	A1	10/1995
EP	1607050	B1	12/2009	WO	WO 95/29639	A1	11/1995
EP	1566150	B1	4/2010	WO	WO 96/04858	A1	2/1996
EP	1813206	B1	4/2010	WO	WO 96/19151	A1	6/1996
EP	1769754	B1	6/2010	WO	WO 96/19152	A1	6/1996
EP	1535565	B1	10/2010	WO	WO 96/20652	A1	7/1996
EP	1702570	B1	10/2010	WO	WO 96/21119	A1	7/1996
EP	1785098	B1	10/2010	WO	WO 96/22055	A1	7/1996
FR	999646	A	2/1952	WO	WO 96/23448	A1	8/1996
FR	1112936	A	3/1956	WO	WO 96/24301	A1	8/1996
FR	2765794	A	1/1999	WO	WO 96/27337	A1	9/1996
GB	1210522	A	10/1970	WO	WO 96/31155	A1	10/1996
GB	1217159	A	12/1970	WO	WO 96/35464	A1	11/1996
GB	1339394	A	12/1973	WO	WO 96/39085	A1	12/1996
GB	2109241	A	6/1983	WO	WO 96/39086	A1	12/1996
GB	2272159	A	5/1994	WO	WO 96/39087	A1	12/1996
GB	2284242	A	5/1995	WO	WO 96/39088	A1	12/1996
GB	2336214	A	10/1999	WO	WO 96/39089	A1	12/1996
GB	2425903	A	11/2006	WO	WO 97/00646	A1	1/1997
JP	6007357	A	1/1994	WO	WO 97/00647	A1	1/1997
JP	7051273	A	2/1995	WO	WO 97/06582	A1	2/1997
JP	8033641	A	2/1996	WO	WO 97/10763	A1	3/1997

# US 8,186,555 B2

Page 13

WO WO 97/10764 A1 3/1997  
 WO WO 97/11648 A2 4/1997  
 WO WO 97/11649 A1 4/1997  
 WO WO 97/15237 A1 5/1997  
 WO WO 97/24073 A1 7/1997  
 WO WO 97/24993 A1 7/1997  
 WO WO 97/30644 A1 8/1997  
 WO WO 97/34533 A1 9/1997  
 WO WO 97/37598 A1 10/1997  
 WO WO 97/39688 A2 10/1997  
 WO WO 98/17180 A1 4/1998  
 WO WO 98/27880 A1 7/1998  
 WO WO 98/30153 A1 7/1998  
 WO WO 98/47436 A1 10/1998  
 WO WO 99/03407 A1 1/1999  
 WO WO 99/03408 A1 1/1999  
 WO WO 99/03409 A1 1/1999  
 WO WO 99/12483 A1 3/1999  
 WO WO 99/12487 A1 3/1999  
 WO WO 99/12488 A1 3/1999  
 WO WO 99/15086 A1 4/1999  
 WO WO 99/15091 A1 4/1999  
 WO WO 99/23933 A2 5/1999  
 WO WO 99/23959 A1 5/1999  
 WO WO 99/25261 A1 5/1999  
 WO WO 99/29244 A1 6/1999  
 WO WO 99/34744 A1 7/1999  
 WO WO 99/45849 A1 9/1999  
 WO WO 99/48430 A1 9/1999  
 WO WO 99/51158 A1 10/1999  
 WO WO 00/24322 A1 5/2000  
 WO WO 00/24330 A1 5/2000  
 WO WO 00/41638 A1 7/2000  
 WO WO 00/48506 A1 8/2000  
 WO WO 00/53112 A2 9/2000  
 WO WO 00/54653 A1 9/2000  
 WO WO 00/57796 A1 10/2000  
 WO WO 00/64365 A1 11/2000  
 WO WO 00/72762 A1 12/2000  
 WO WO 00/72765 A1 12/2000  
 WO WO 01/03587 A1 1/2001  
 WO WO 01/05702 A1 1/2001  
 WO WO 01/10482 A1 2/2001  
 WO WO 01/35845 A1 5/2001  
 WO WO 01/54594 A1 8/2001  
 WO WO 01/58371 A1 8/2001  
 WO WO 01/62158 A2 8/2001  
 WO WO 01/62161 A1 8/2001  
 WO WO 01/62162 A1 8/2001  
 WO WO 01/62164 A2 8/2001  
 WO WO 01/62169 A2 8/2001  
 WO WO 01/78605 A2 10/2001  
 WO WO 01/91646 A1 12/2001  
 WO WO 02/07608 A2 1/2002  
 WO WO 02/07618 A1 1/2002  
 WO WO 02/17799 A1 3/2002  
 WO WO 02/19920 A1 3/2002  
 WO WO 02/19932 A1 3/2002  
 WO WO 02/30297 A2 4/2002  
 WO WO 02/32322 A2 4/2002  
 WO WO 02/36028 A1 5/2002  
 WO WO 02/43571 A2 6/2002  
 WO WO 02/058568 A1 8/2002  
 WO WO 02/060328 A1 8/2002  
 WO WO 02/067785 A2 9/2002  
 WO WO 02/098302 A1 12/2002  
 WO WO 03/000138 A2 1/2003  
 WO WO 03/001329 A2 1/2003  
 WO WO 03/013363 A1 2/2003  
 WO WO 03/015604 A2 2/2003  
 WO WO 03/020106 A2 3/2003  
 WO WO 03/020139 A2 3/2003  
 WO WO 03/024339 A1 3/2003  
 WO WO 03/079909 A3 3/2003  
 WO WO 03/030743 A2 4/2003  
 WO WO 03/047436 A3 6/2003  
 WO WO 03/055402 A1 7/2003  
 WO WO 03/057048 A1 7/2003  
 WO WO 03/057058 A1 7/2003

WO WO 03/063694 A1 8/2003  
 WO WO 03/077769 A1 9/2003  
 WO WO 03/079911 A1 10/2003  
 WO WO 03/082126 A1 10/2003  
 WO WO 03/088845 A2 10/2003  
 WO WO 03/090630 A2 11/2003  
 WO WO 03/094743 A1 11/2003  
 WO WO 03/094745 A1 11/2003  
 WO WO 03/094746 A1 11/2003  
 WO WO 03/094747 A1 11/2003  
 WO WO 03/105698 A2 12/2003  
 WO WO 03/105702 A2 12/2003  
 WO WO 2004/006980 A2 1/2004  
 WO WO 2004/019769 A1 3/2004  
 WO WO 2004/021868 A2 3/2004  
 WO WO 2004/028585 A2 4/2004  
 WO WO 2004/032754 A2 4/2004  
 WO WO 2004/032760 A2 4/2004  
 WO WO 2004/032763 A2 4/2004  
 WO WO 2004/034875 A2 4/2004  
 WO WO 2004/047626 A1 6/2004  
 WO WO 2004/047653 A2 6/2004  
 WO WO 2004/052426 A2 6/2004  
 WO WO 2004/056276 A1 7/2004  
 WO WO 2004/056277 A1 7/2004  
 WO WO 2004/062516 A1 7/2004  
 WO WO 2004/078050 A2 9/2004  
 WO WO 2004/078051 A2 9/2004  
 WO WO 2004/086987 A1 10/2004  
 WO WO 2004/096015 A2 11/2004  
 WO WO 2004/096057 A2 11/2004  
 WO WO 2004/103157 A2 12/2004  
 WO WO 2004/105593 A1 12/2004  
 WO WO 2004/105621 A1 12/2004  
 WO WO 2004/112618 A2 12/2004  
 WO WO 2004/112652 A2 12/2004  
 WO WO 2005/027983 A2 3/2005  
 WO WO 2005/037329 A2 4/2005  
 WO WO 2005/044078 A2 5/2005  
 WO WO 2005/055846 A1 6/2005  
 WO WO 2005/072634 A2 8/2005  
 WO WO 2005/078892 A1 8/2005  
 WO WO 2005/096954 A2 10/2005  
 WO WO 2005/112806 A2 12/2005  
 WO WO 2005/112808 A1 12/2005  
 WO WO 2005/115251 A2 12/2005  
 WO WO 2005/117735 A1 12/2005  
 WO WO 2005/122936 A1 12/2005  
 WO WO 2006/027014 A1 3/2006  
 WO WO 2006/044490 A2 4/2006  
 WO WO 2006/044581 A2 4/2006  
 WO WO 2006/044810 A2 4/2006  
 WO WO 2006/051252 A1 5/2006  
 WO WO 2006/059067 A1 6/2006  
 WO WO 2006/083748 A1 8/2006  
 WO WO 2006/092563 A1 9/2006  
 WO WO 2006/092565 A1 9/2006  
 WO WO 2006/115958 A1 11/2006  
 WO WO 2006/125940 A1 11/2006  
 WO WO 2006/132992 A1 12/2006  
 WO WO 2007/002180 A2 1/2007  
 WO WO 2007/016290 A2 2/2007  
 WO WO 2007/018898 A2 2/2007  
 WO WO 2007/098220 A2 8/2007  
 WO WO 2007/121579 A1 11/2007  
 WO WO 2007/137304 A2 11/2007  
 WO WO 2007/139734 A2 12/2007  
 WO WO 2007/142625 A2 12/2007  
 WO WO 2008/021969 A2 2/2008  
 WO WO 2008/039270 A1 4/2008  
 WO WO 2008/045383 A2 4/2008  
 WO WO 2008/109125 A1 9/2008  
 WO WO 2010/063795 A1 6/2010

## OTHER PUBLICATIONS

Office Action issued on Jun. 18, 2007 in U.S. Appl. No. 11/343,545.  
 Office Action issued on Jun. 25, 2007 in U.S. Appl. No. 11/343,546.  
 European Search Report, Application No. 07250383.2, dated Jun. 19, 2007 (9 pages).

Disclosed Anonymously, "Motor-Driven Surgical Stapler Improvements," Research Disclosure Database No. 526041, Published: Feb. 2008.

C.C. Thompson et al., "Peroral Endoscopic Reduction of Dilated Gastrojejunal Anastomosis After Roux-en-Y Gastric Bypass: A Possible New Option for Patients with Weight Regain," *Surg Endosc* (2006) vol. 20, pp. 1744-1748.

Singapore Examination Report for Application No. 200700738-8, dated Jan. 20, 2009 (9 pages).

B.R. Coolman, DVM, MS et al., "Comparison of Skin Staples With Sutures for Anastomosis of the Small Intestine in Dogs," Abstract; <http://www.blackwell-synergy.com/doi/abs/10.1053/jvet.2000.7539?cookieSet=1&journalCode=vsu> which redirects to <http://www3.interscience.wiley.com/journal/119040681/abstract?CRETRY=1&SRETRY=0>; [online] accessed: Sep. 22, 2008 (2 pages).

The Soderm Aseptic Battery Transfer Kit, Soderm Systems, 2000, 3 pages.

"Biomedical Coatings," Fort Wayne Metals, Research Products Corporation, obtained online at [www.fwmetals.com](http://www.fwmetals.com) on Jun. 21, 2010 (1 page).

Van Meer et al., "A Disposable Plastic Compact Wrist for Smart Minimally Invasive Surgical Tools," LAAS/CNRS (Aug. 2005).

Breedveld et al., "A New, Easily Miniaturized Sterrable Endoscope," *IEEE Engineering in Medicine and Biology Magazine* (Nov./Dec. 2005).

D. Tuite, Ed., "Get the Lowdown on Ultracapacitors," Nov. 15, 2007; [online]URL: <http://electronicdesign.com/Articles/Print.cfm?ArticleID=17465>, accessed Jan. 15, 2008 (5 pages).

Datasheet for Panasonic TK Relays Ultra Low Profile 2 A Polarized Relay, Copyright Matsushita Electric Works, Ltd. (Known of at least as early as Aug. 17, 2010), 5 pages.

U.S. Appl. No. 12/032,024, filed Feb. 15, 2008.

U.S. Appl. No. 12/031,580, filed Feb. 14, 2008.

U.S. Appl. No. 12/031,368, filed Feb. 14, 2008.

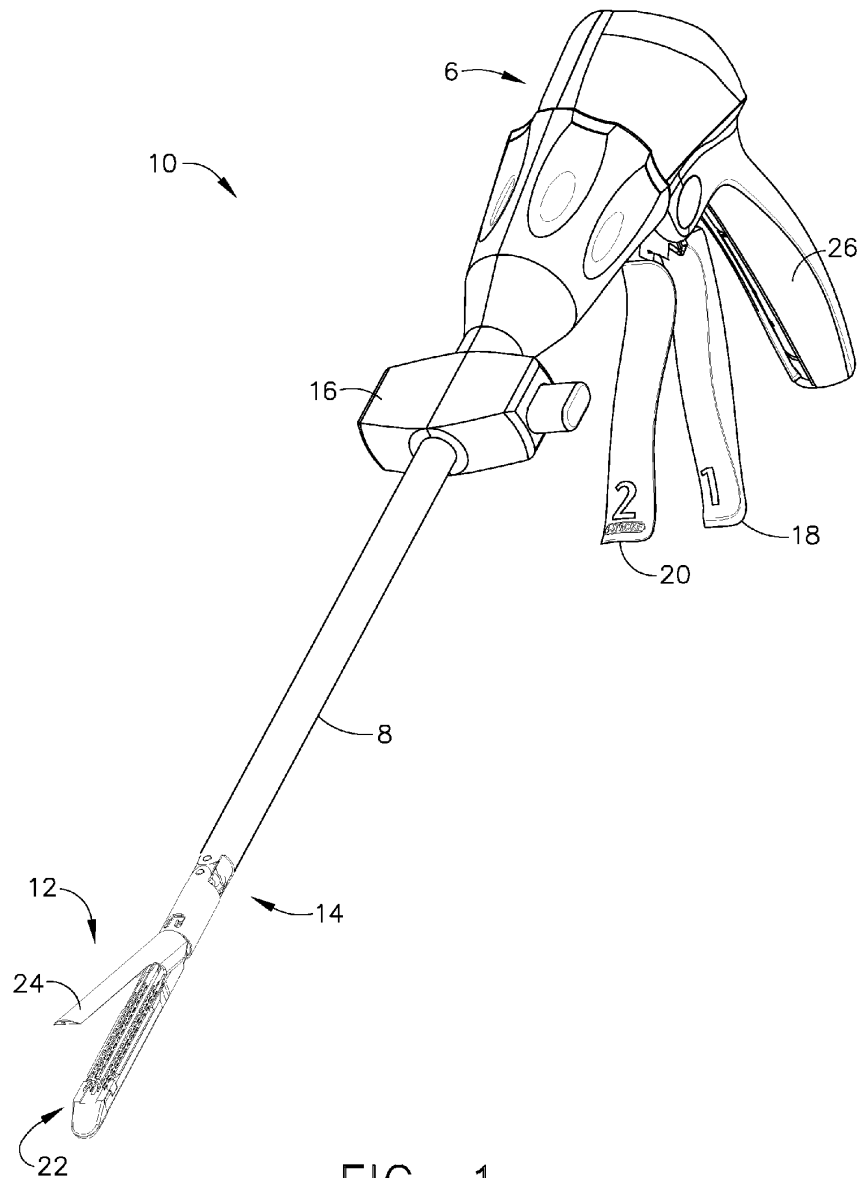
U.S. Appl. No. 12/031,542, filed Feb. 14, 2008.

U.S. Appl. No. 12/031,556, filed Feb. 14, 2008.

U.S. Appl. No. 12/031,573, filed Feb. 14, 2008.

U.S. Appl. No. 13/118,241, filed May 27, 2011.

\* cited by examiner



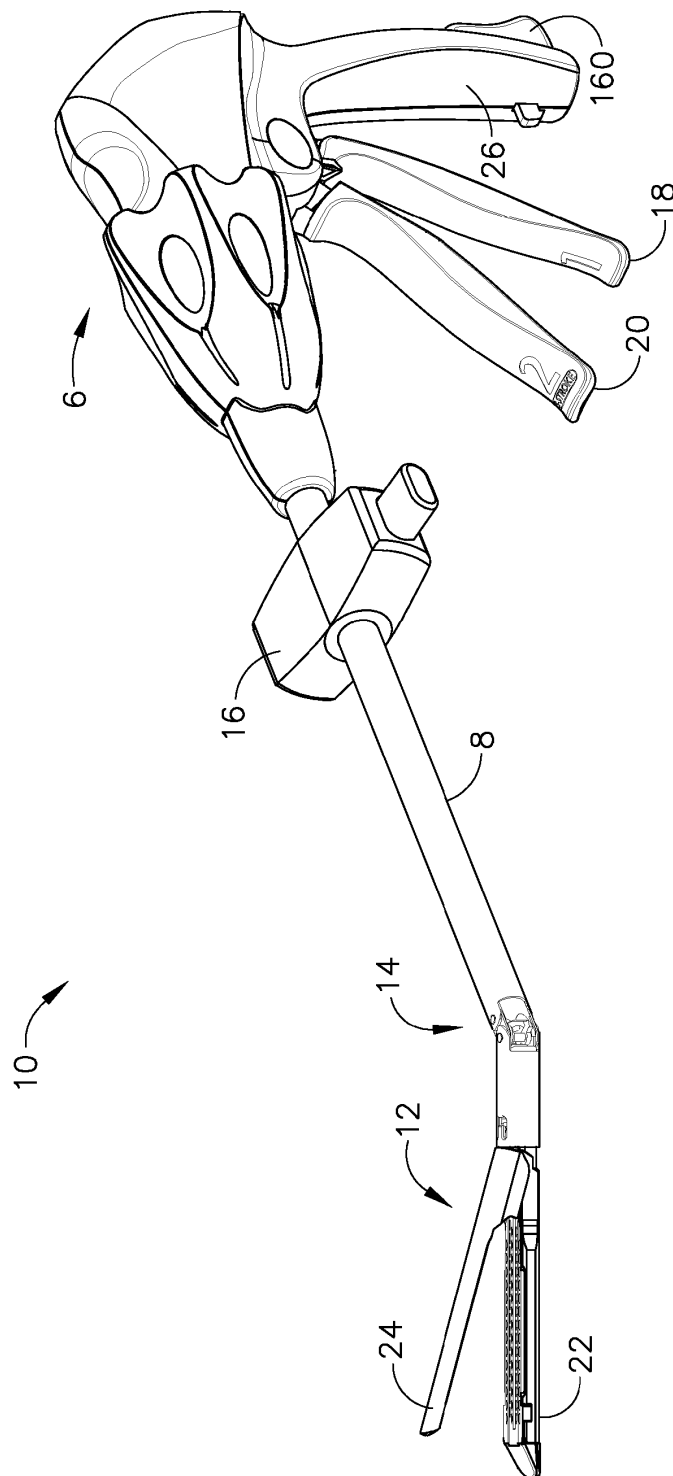


FIG. 2



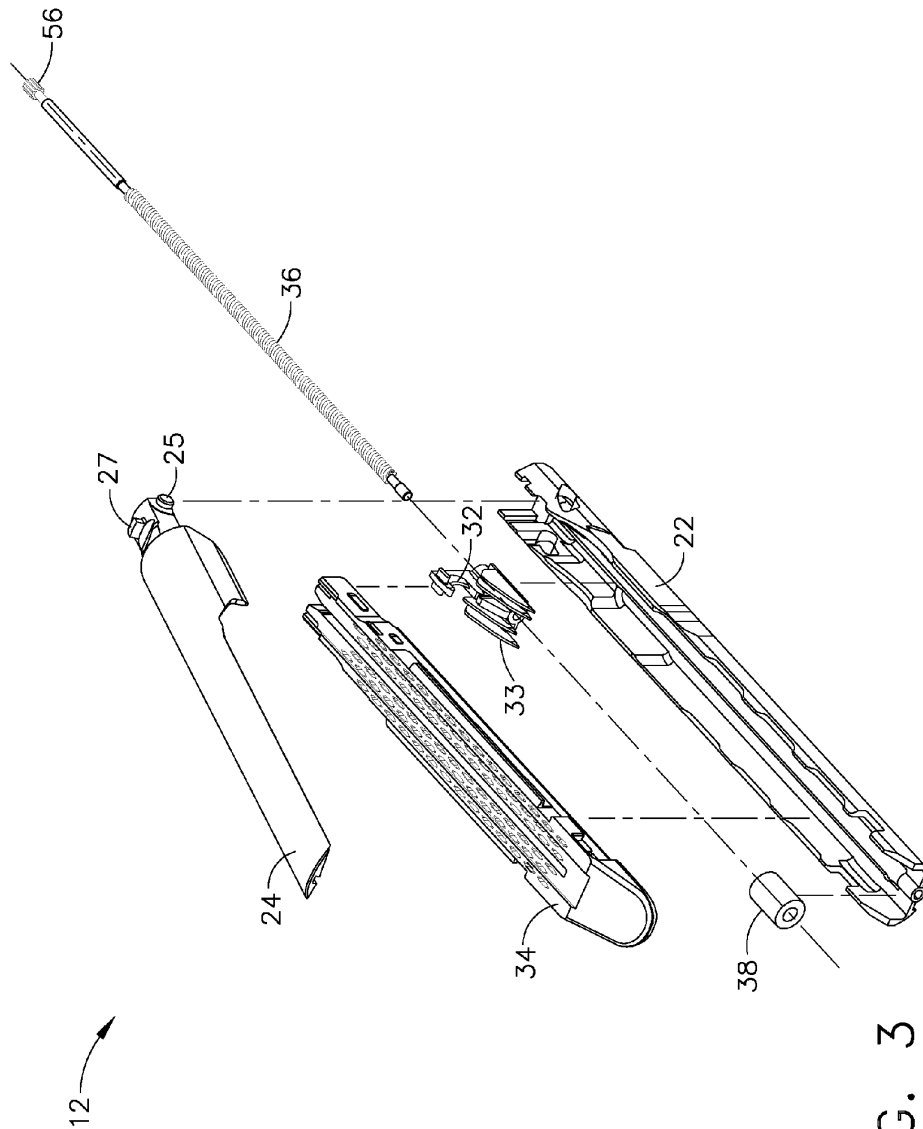
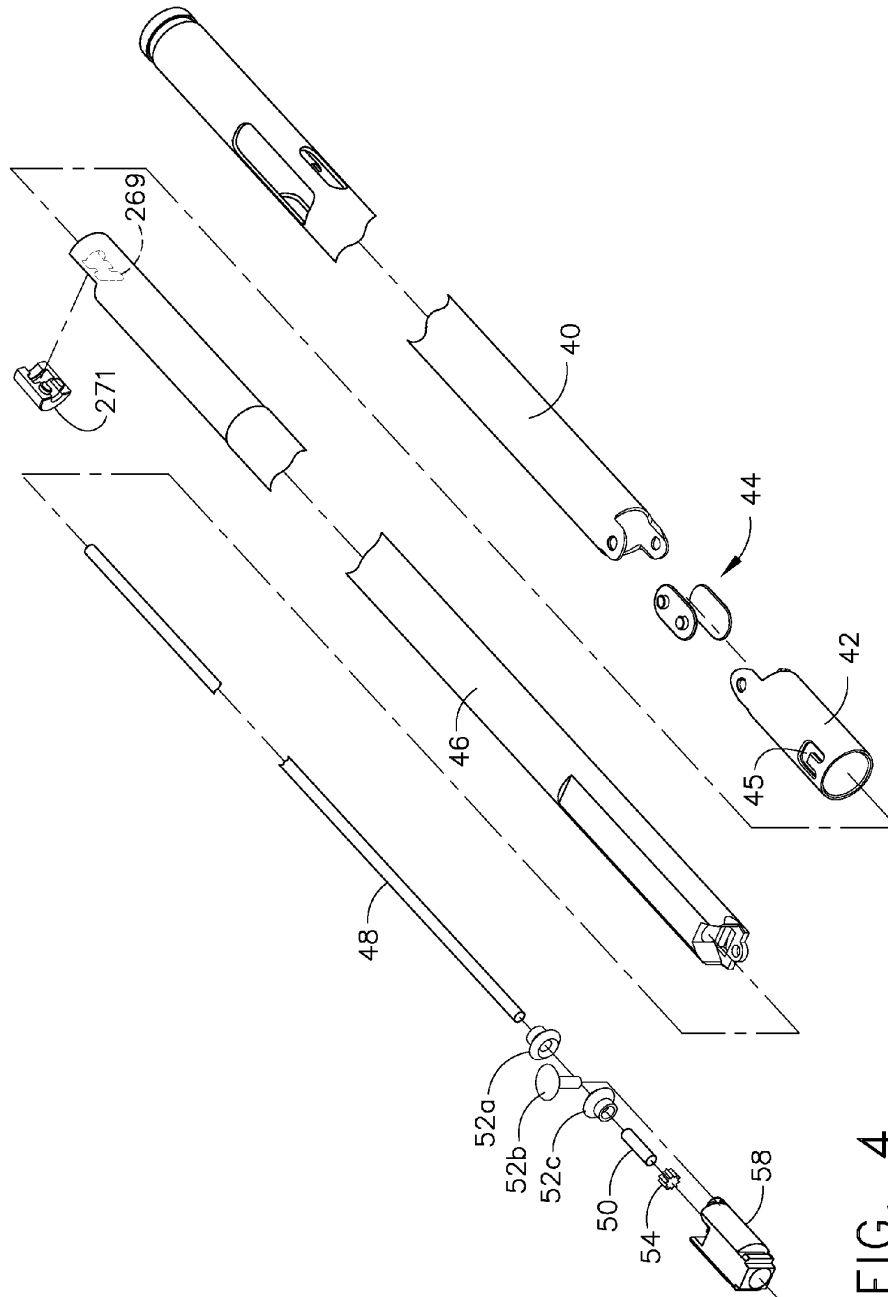
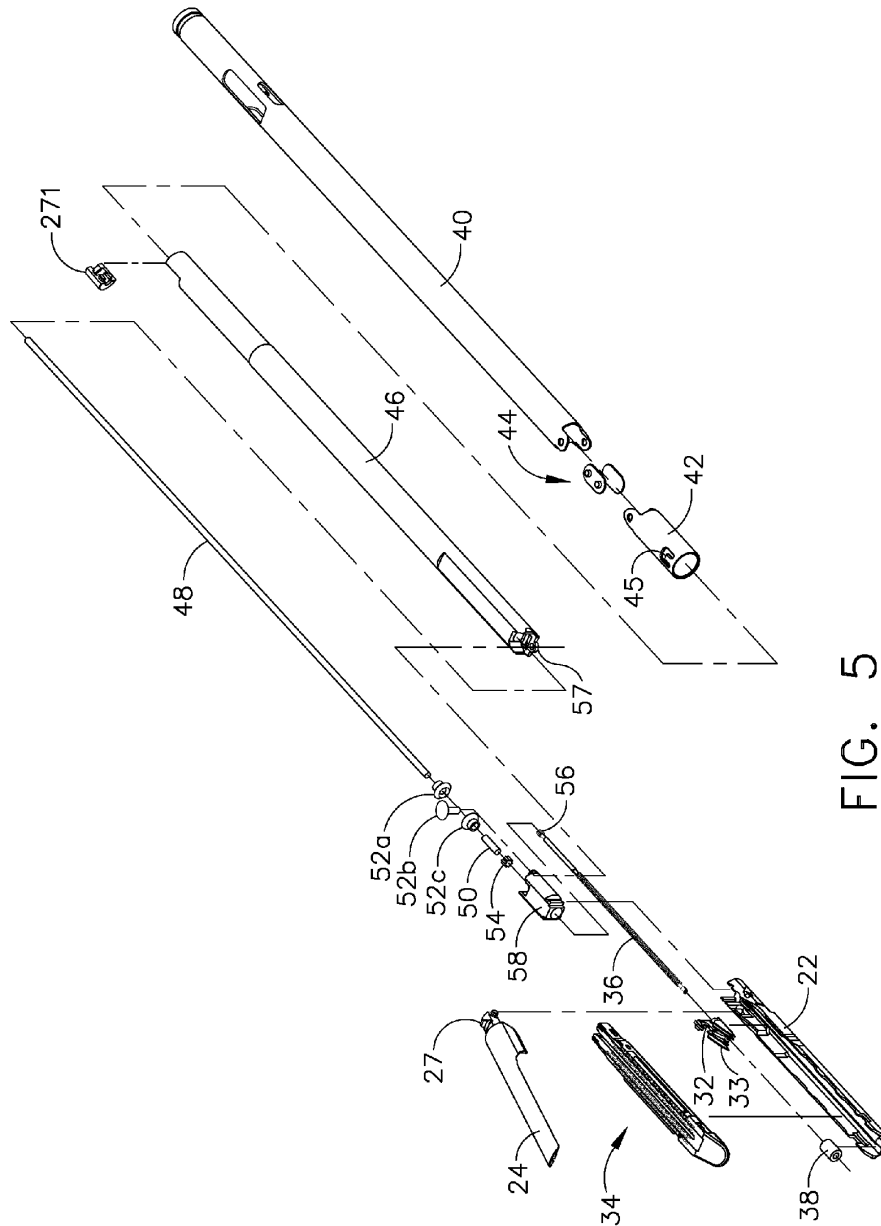


FIG. 3





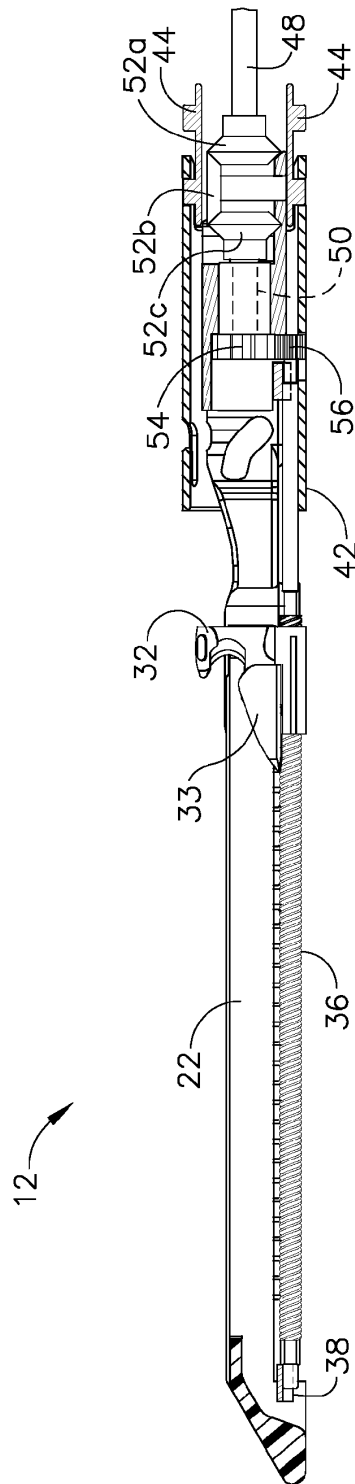


FIG. 6

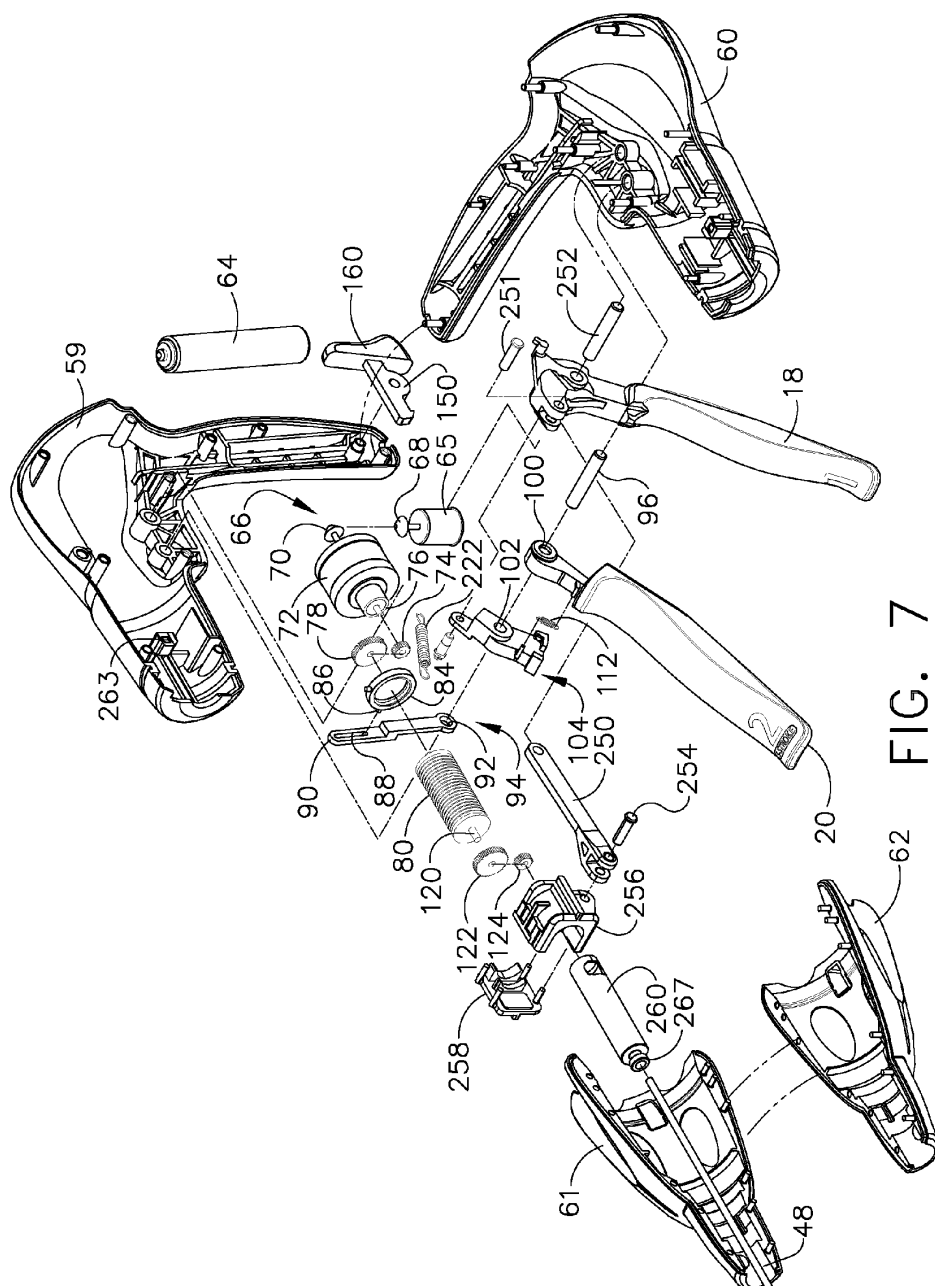


FIG. 7

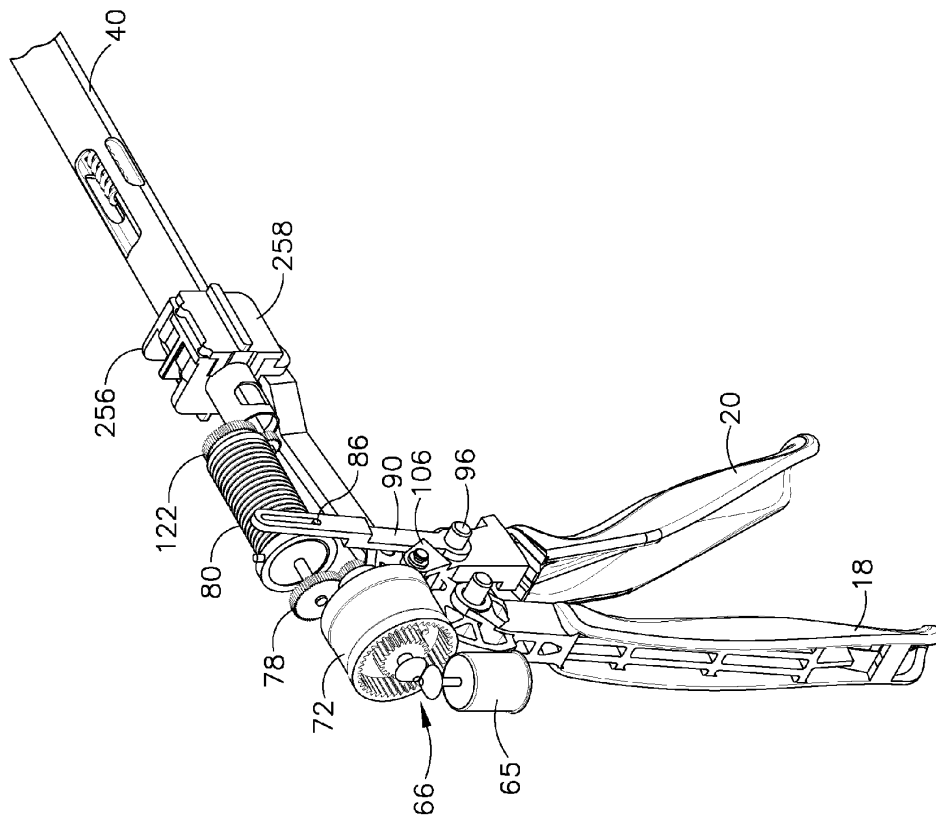


FIG. 8

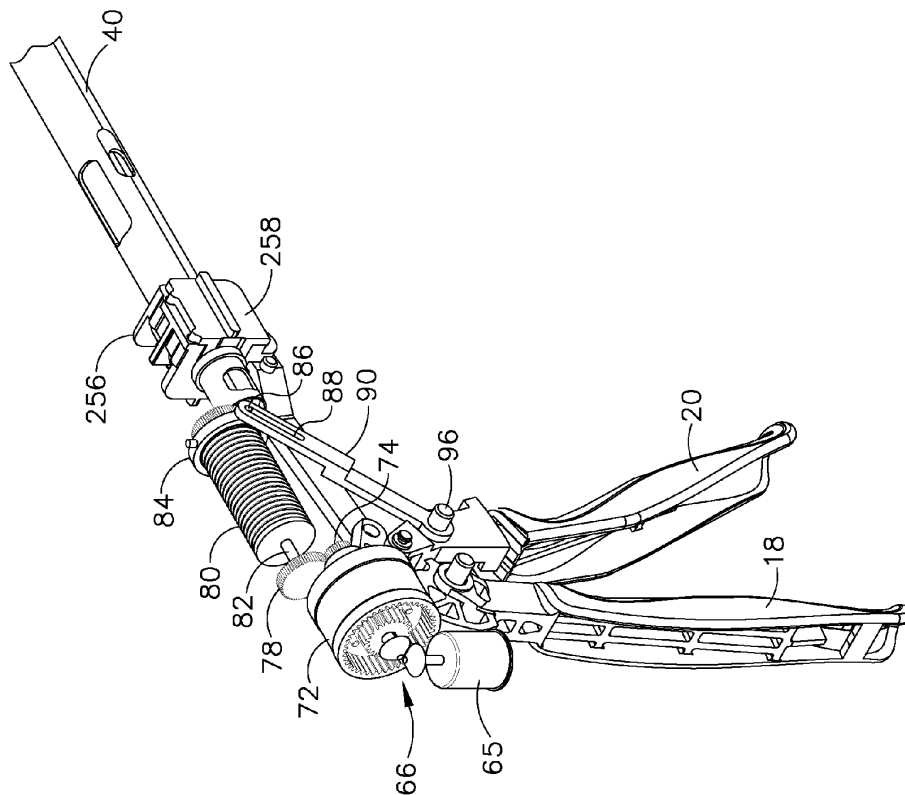


FIG. 9

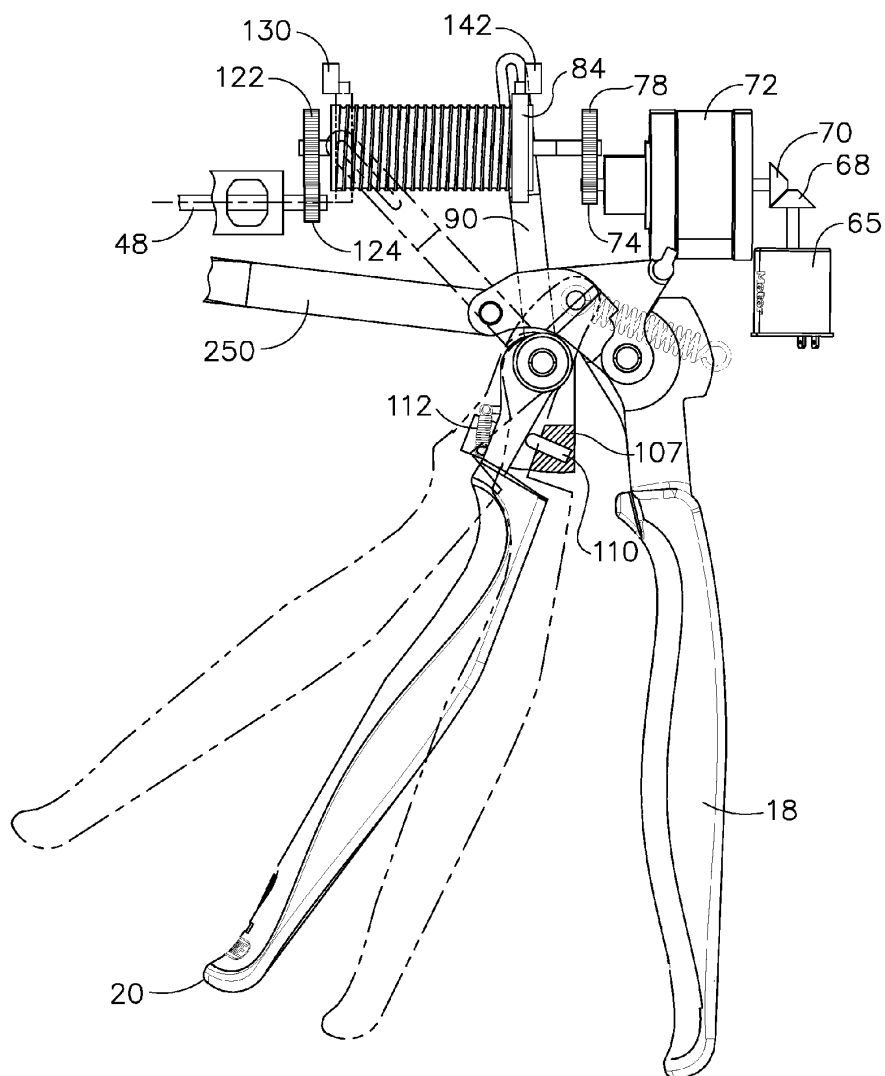


FIG. 10



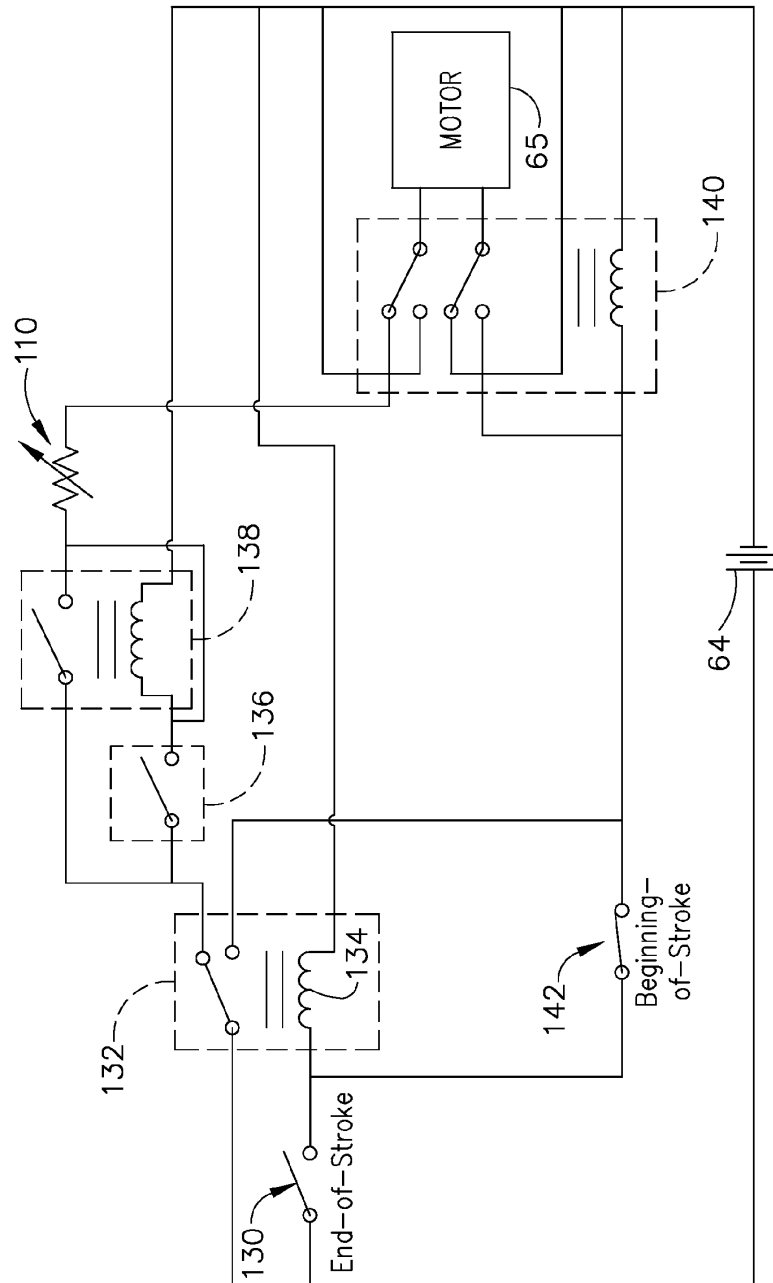


FIG. 11

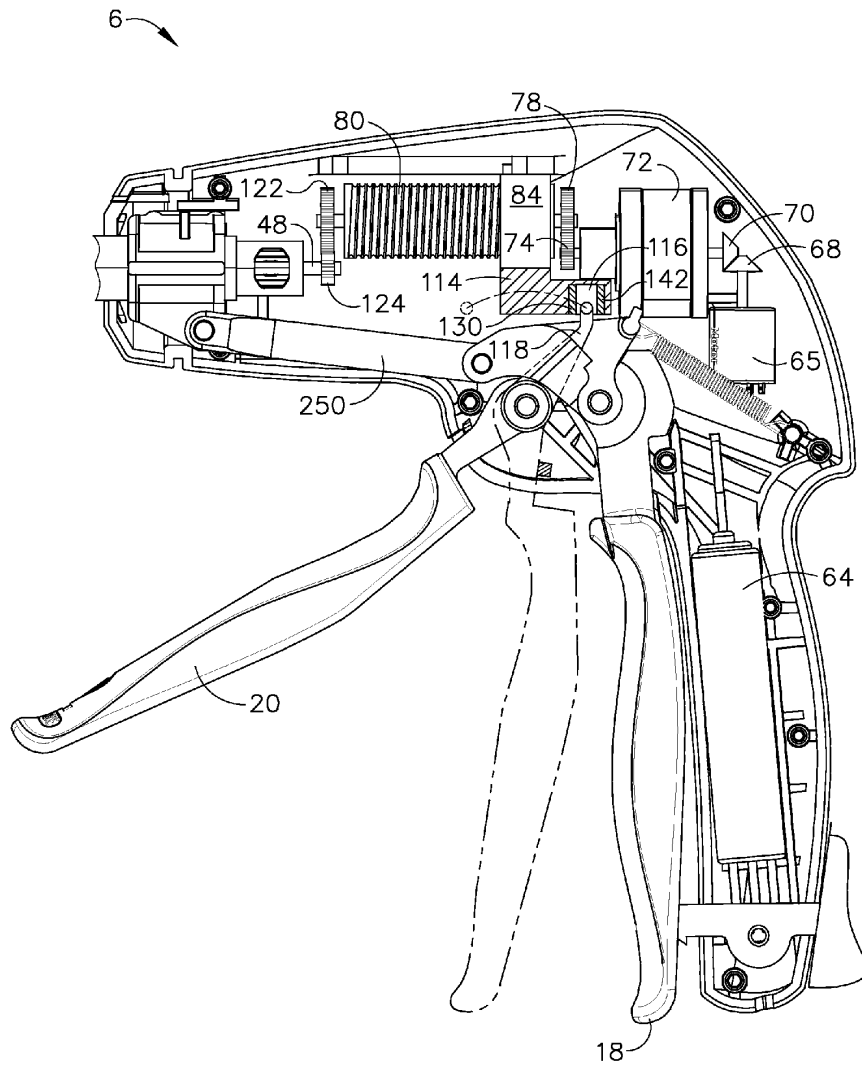


FIG. 12

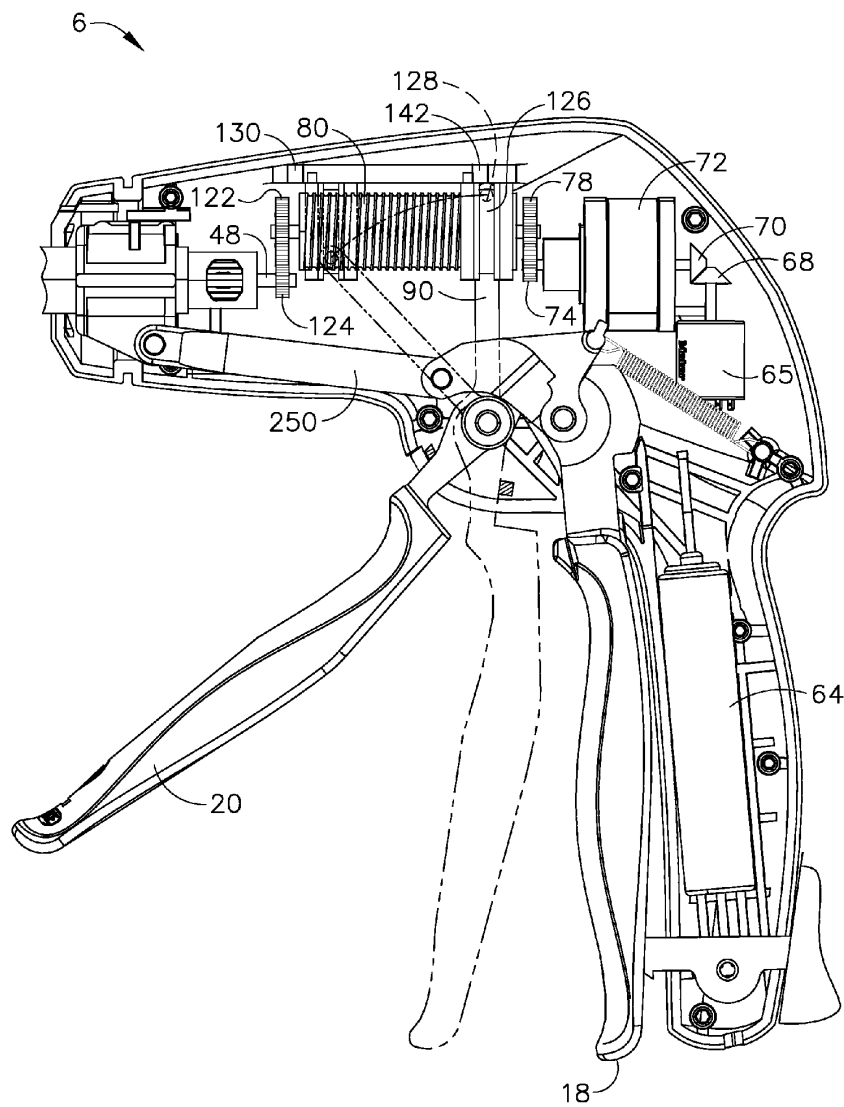
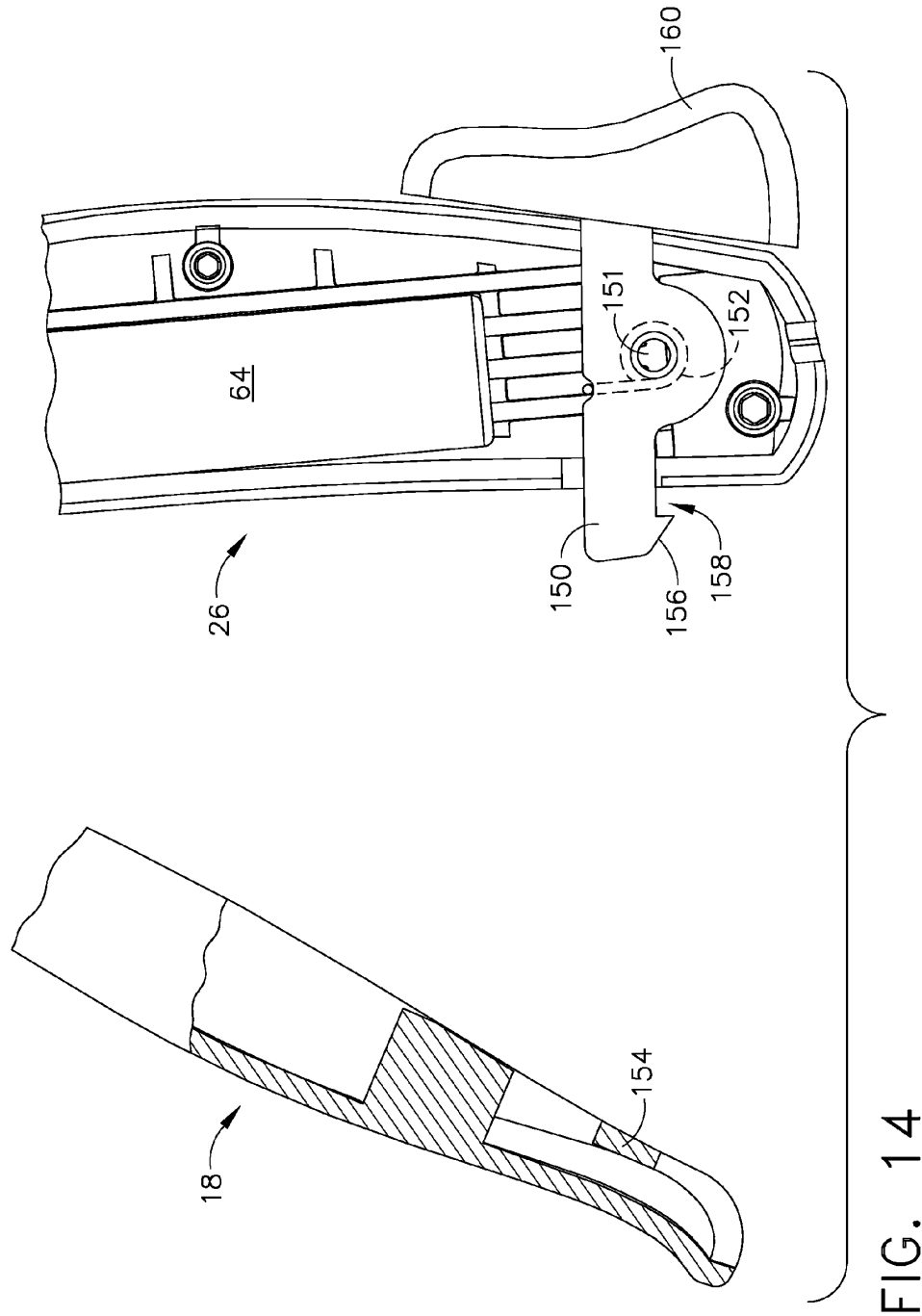


FIG. 13



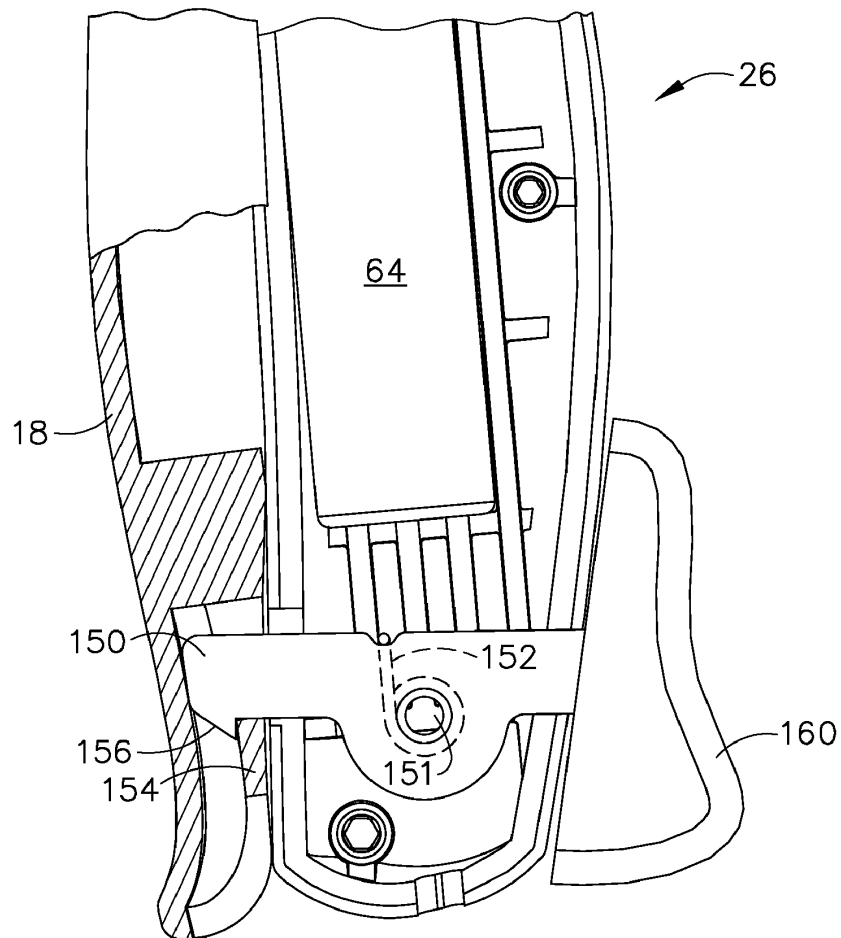


FIG. 15



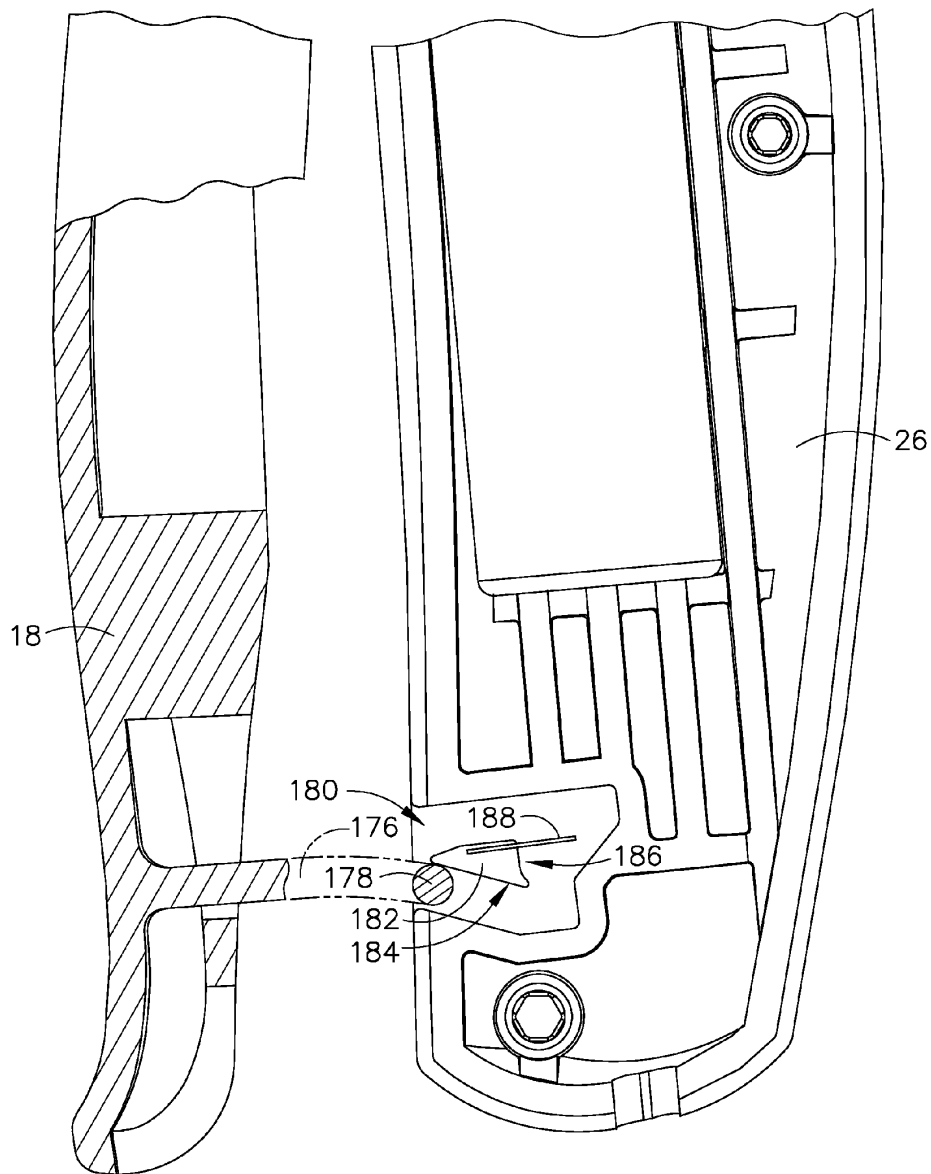


FIG. 17

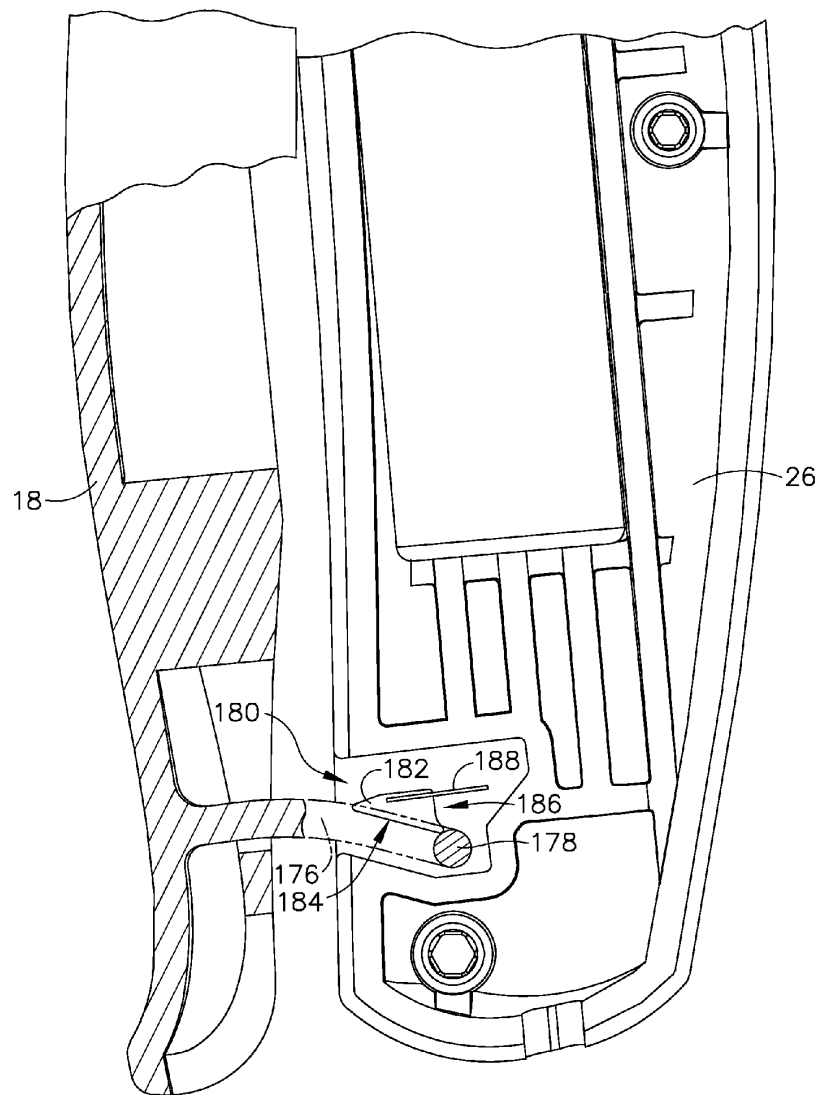


FIG. 18



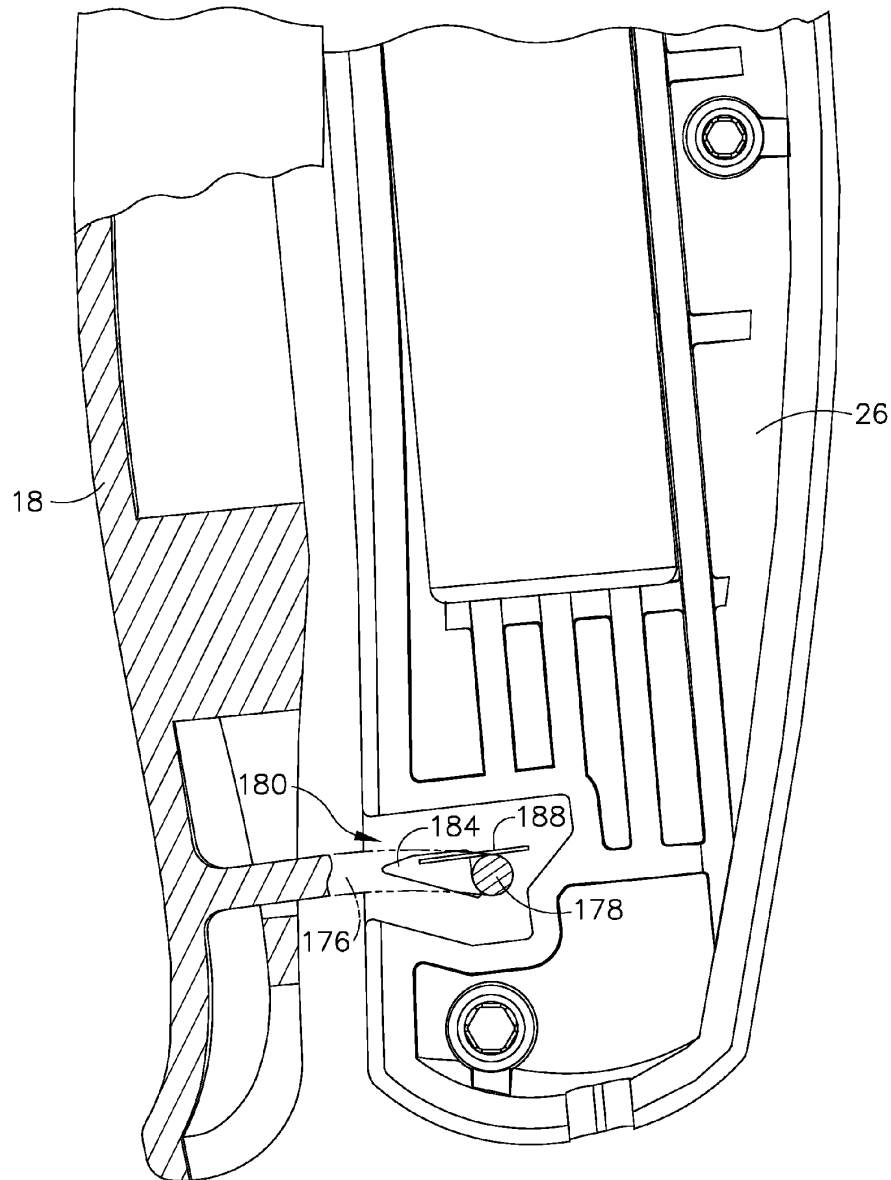


FIG. 19

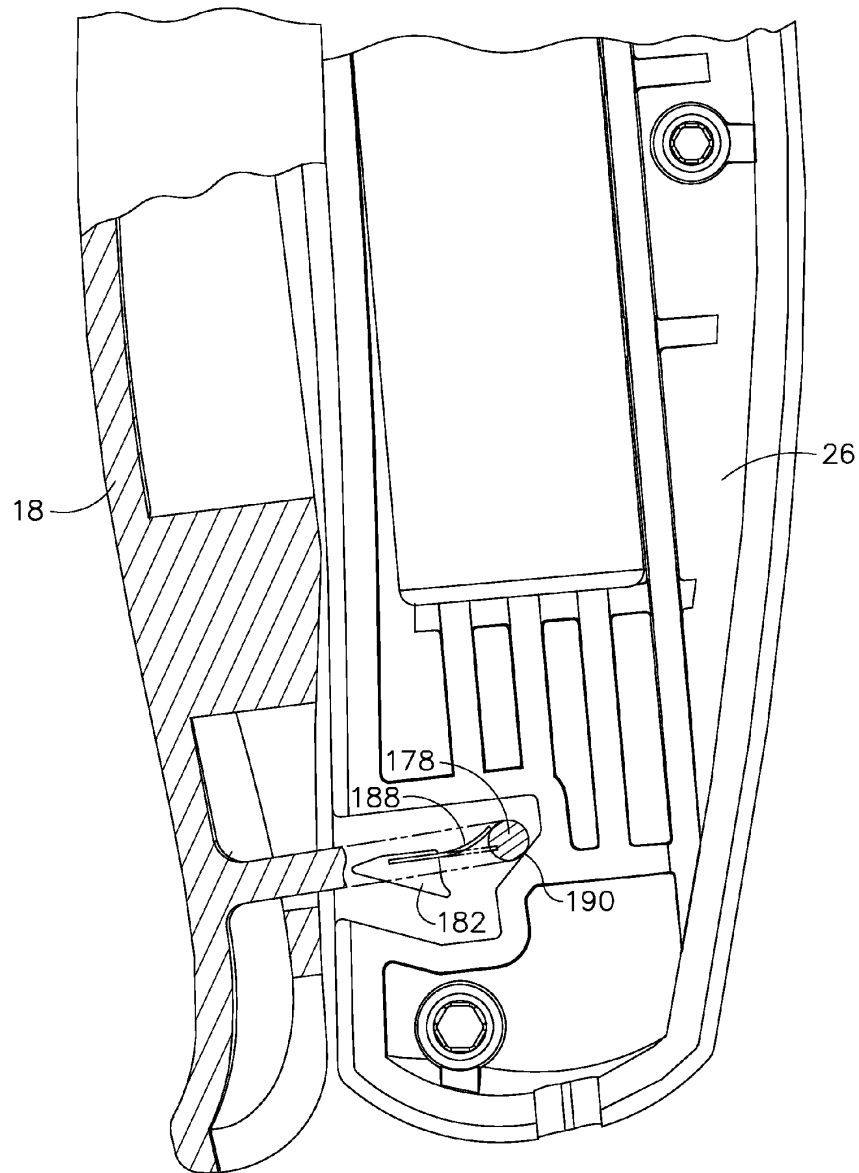


FIG. 20

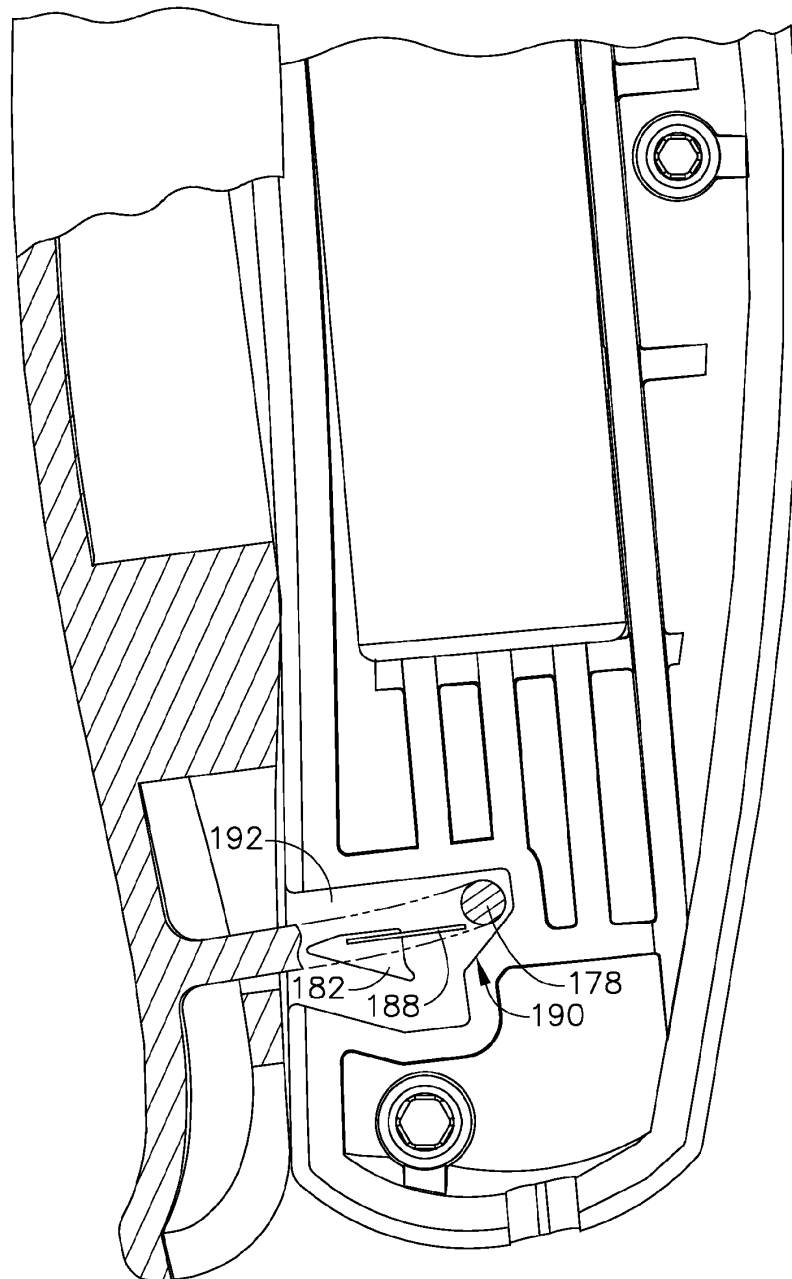


FIG. 21

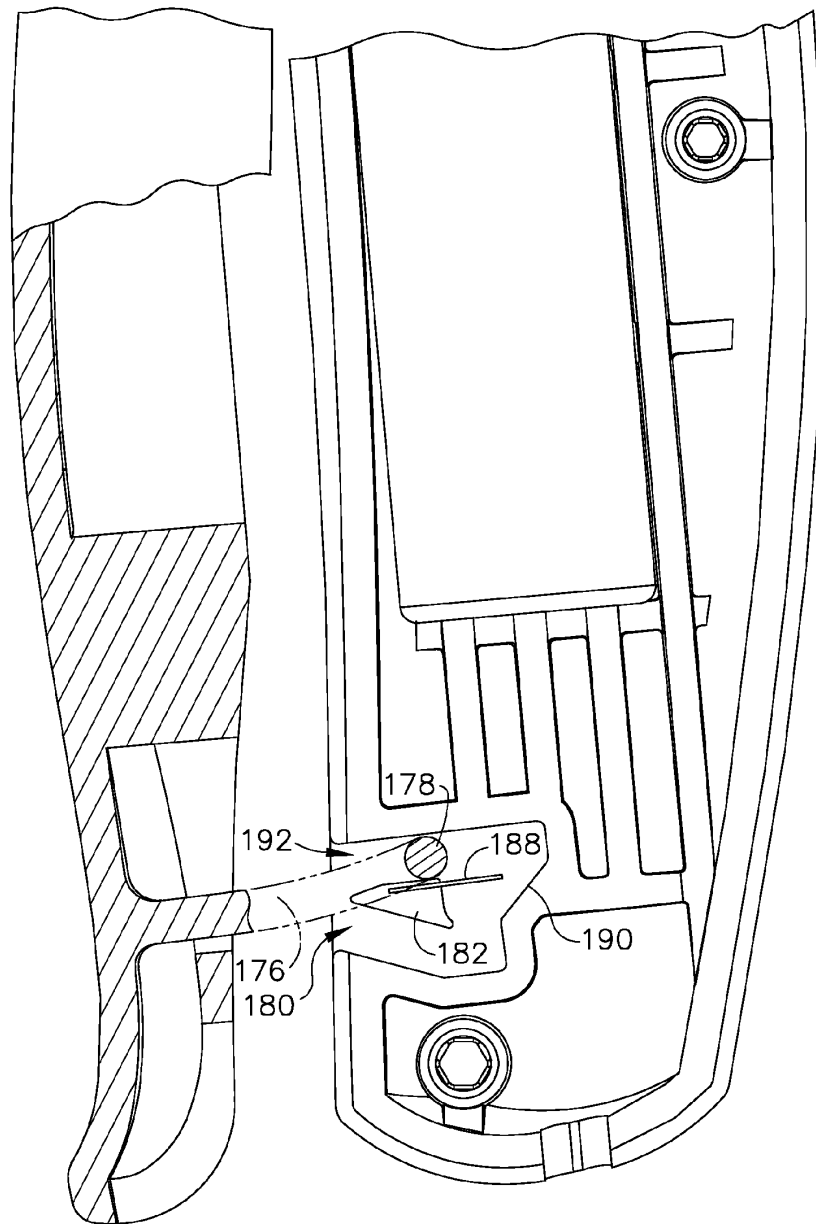


FIG. 22

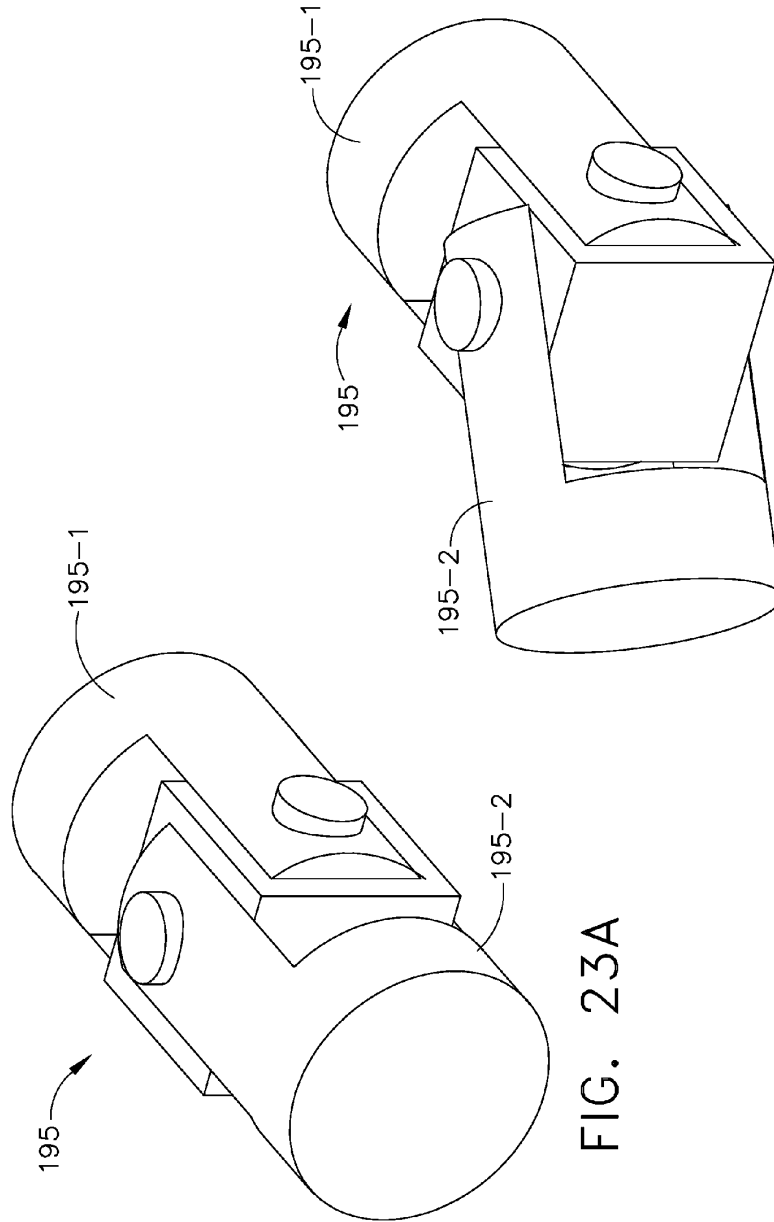


FIG. 23A

FIG. 23B

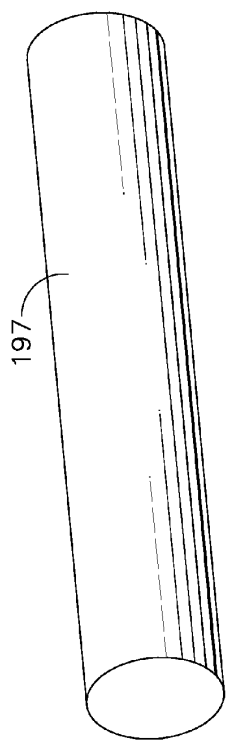


FIG. 24A

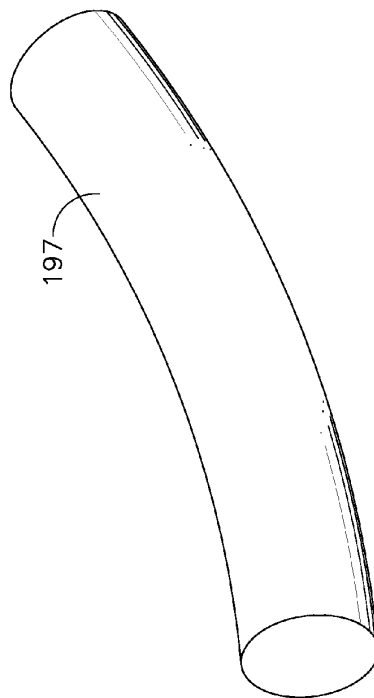


FIG. 24B

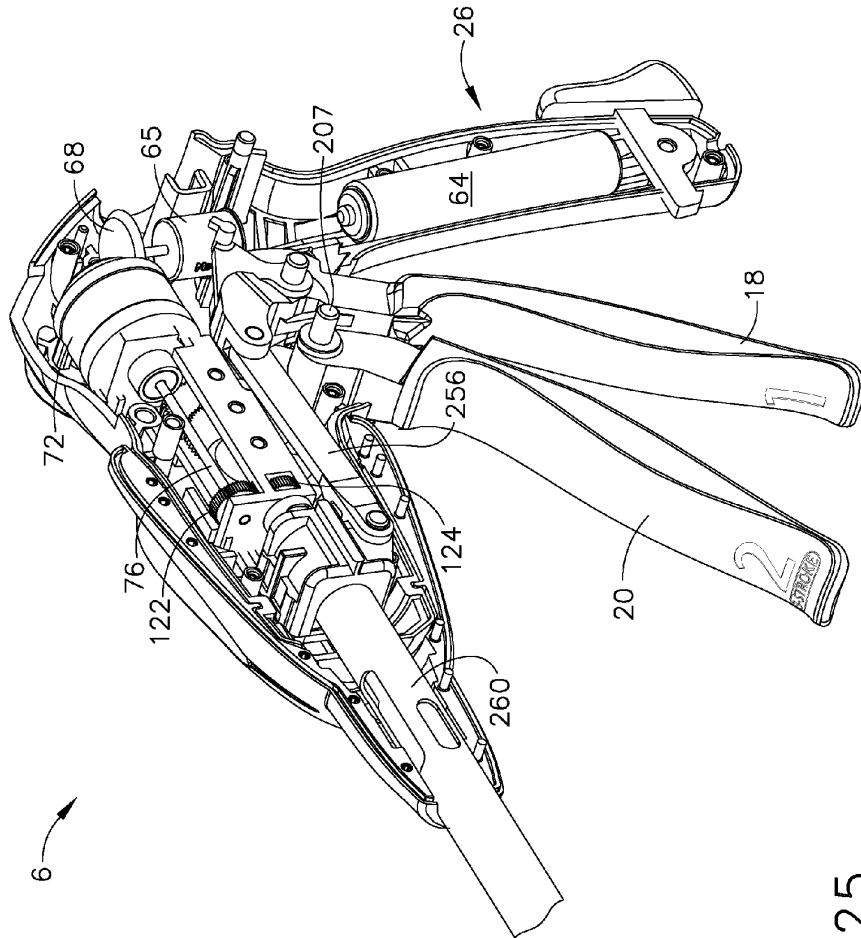


FIG. 25

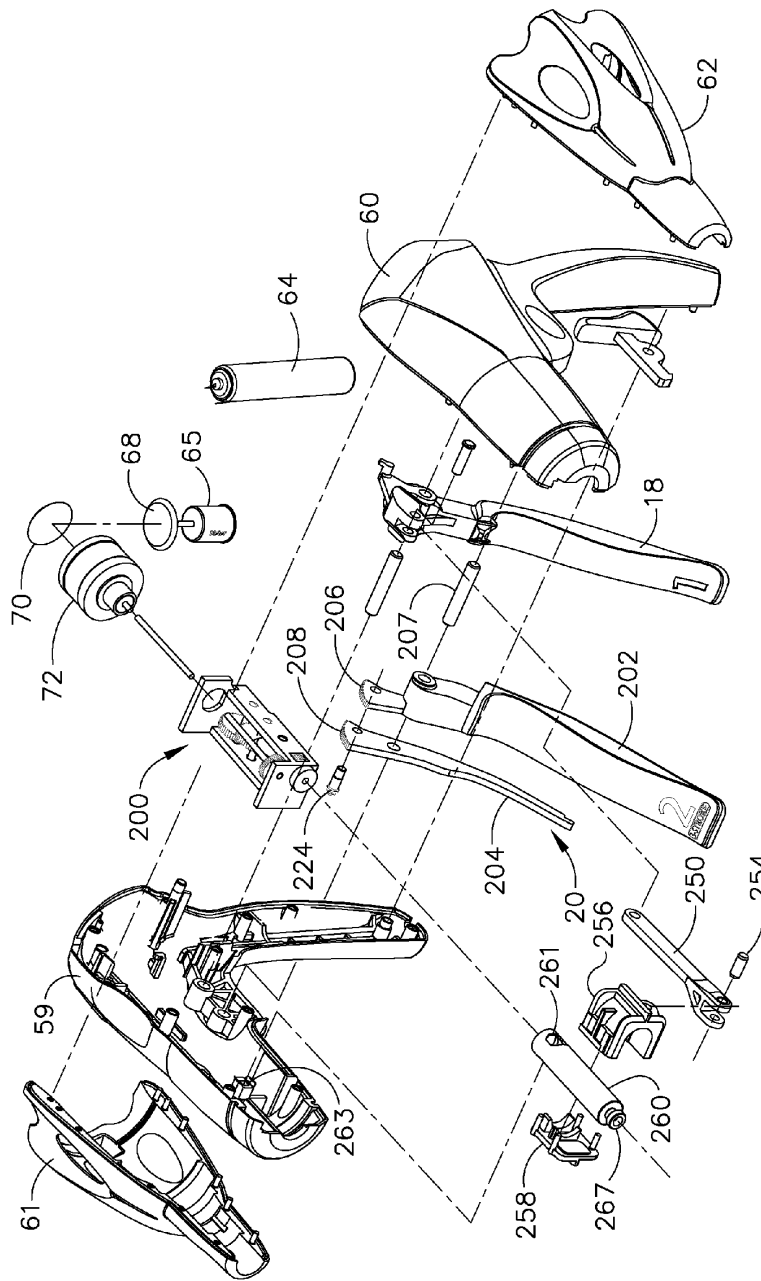


FIG. 26



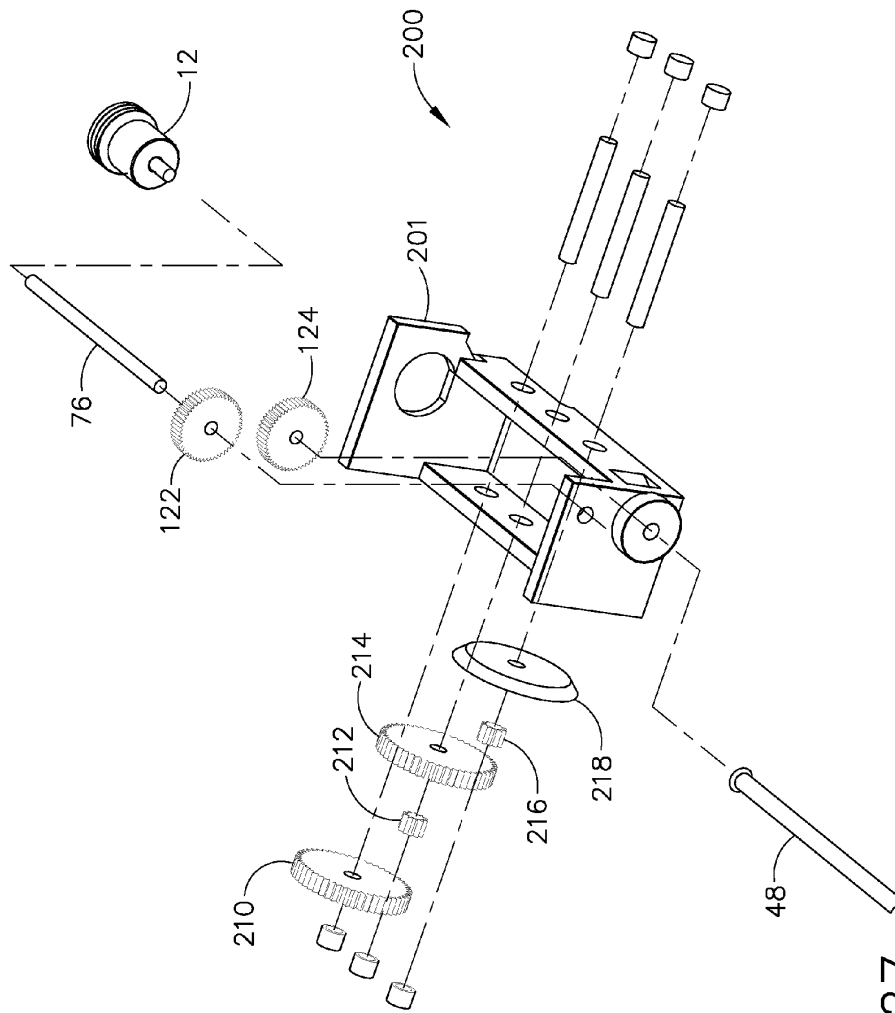


FIG. 27

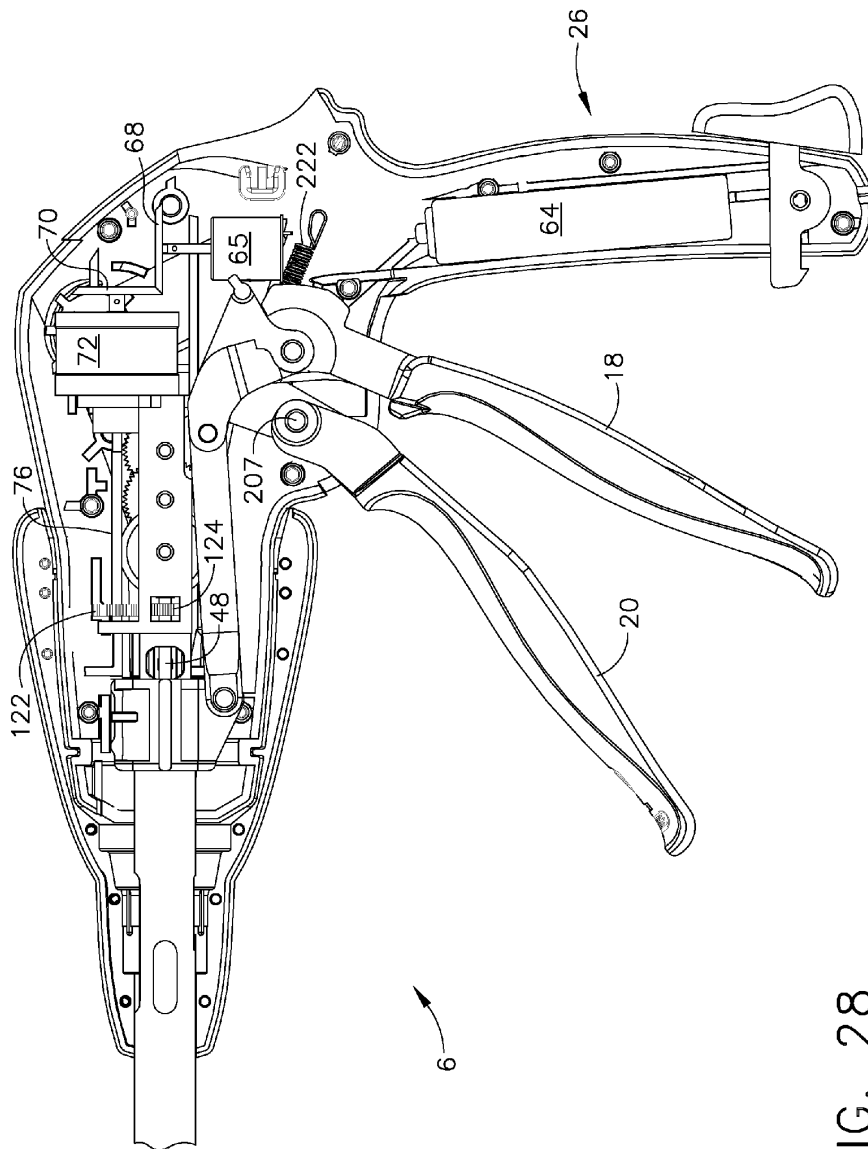


FIG. 28

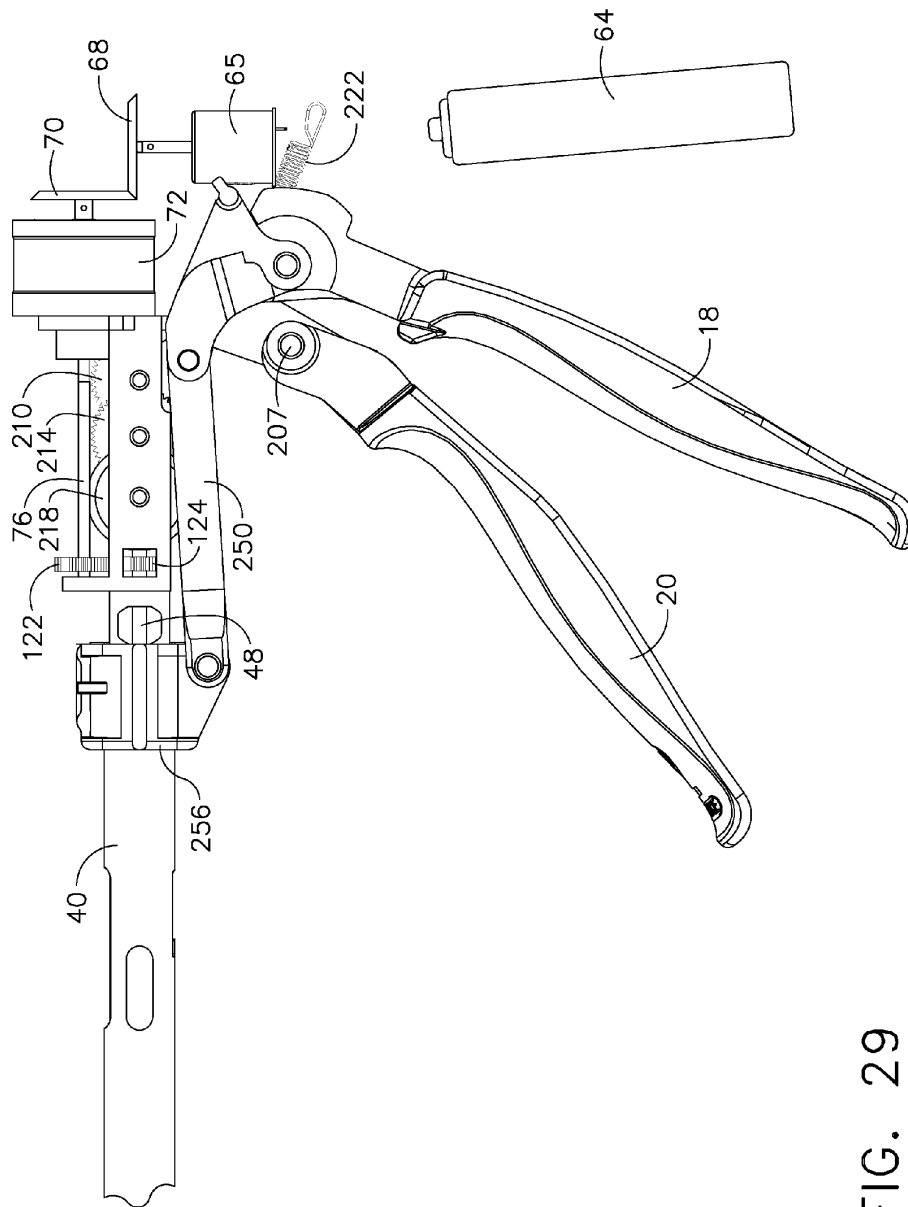


FIG. 29

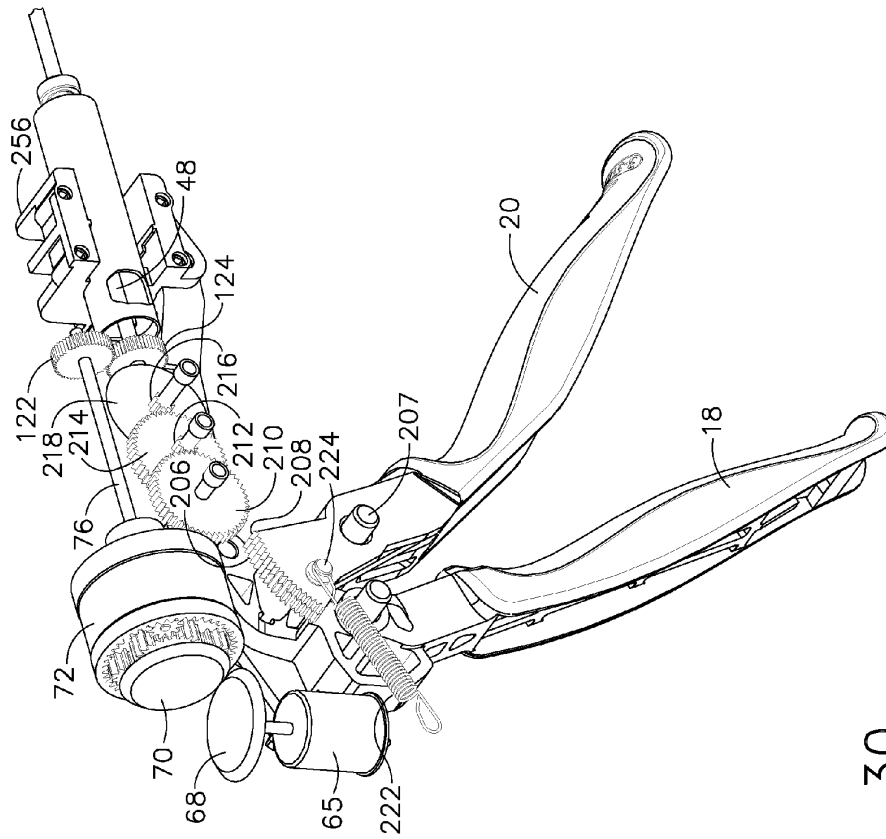


FIG. 30

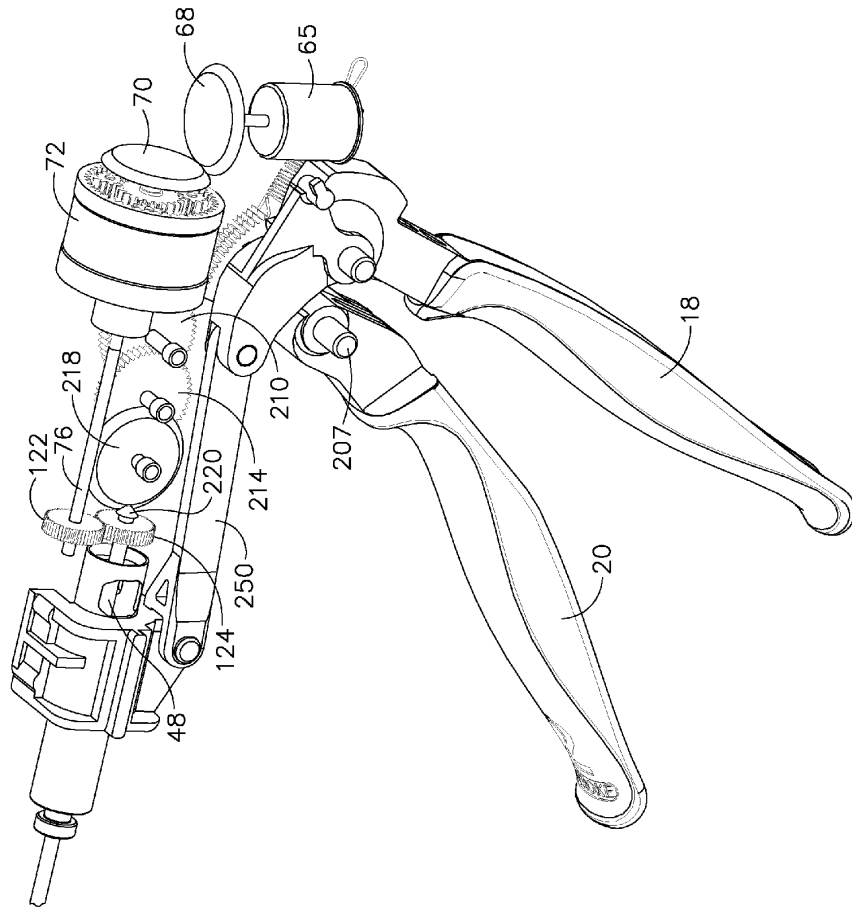


FIG. 31

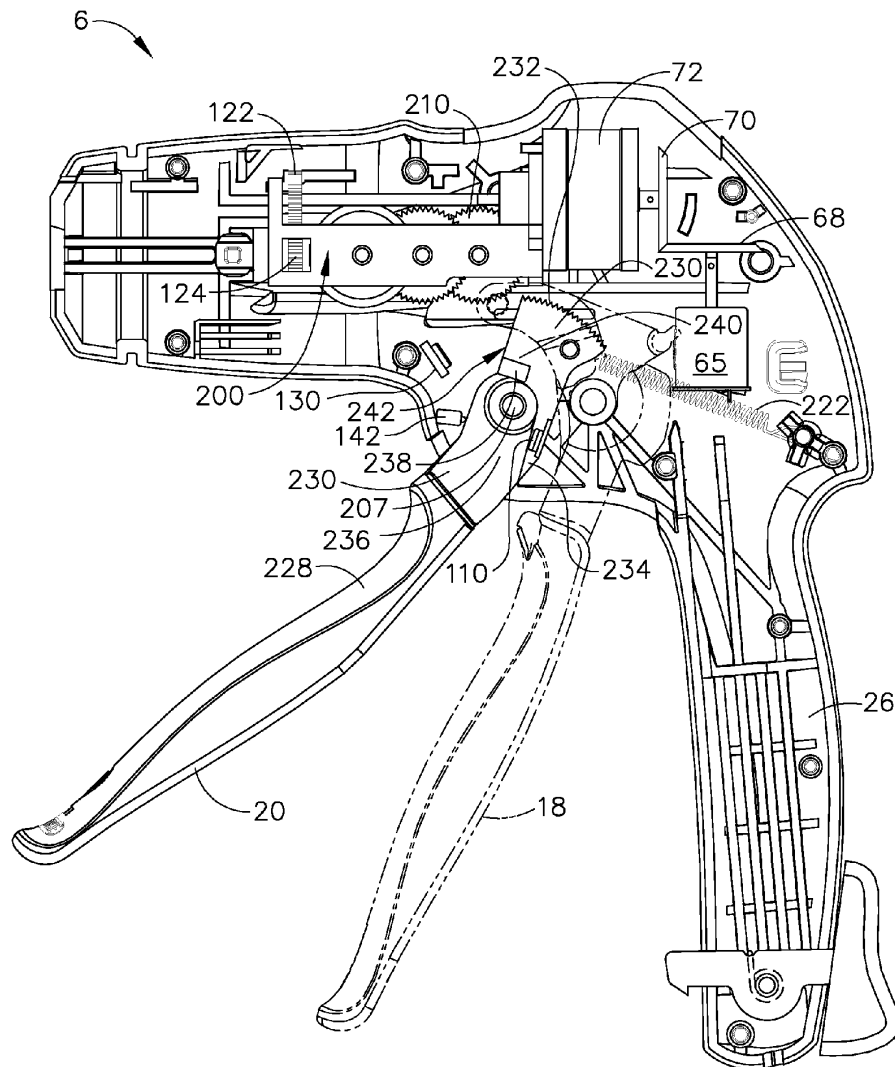


FIG. 32

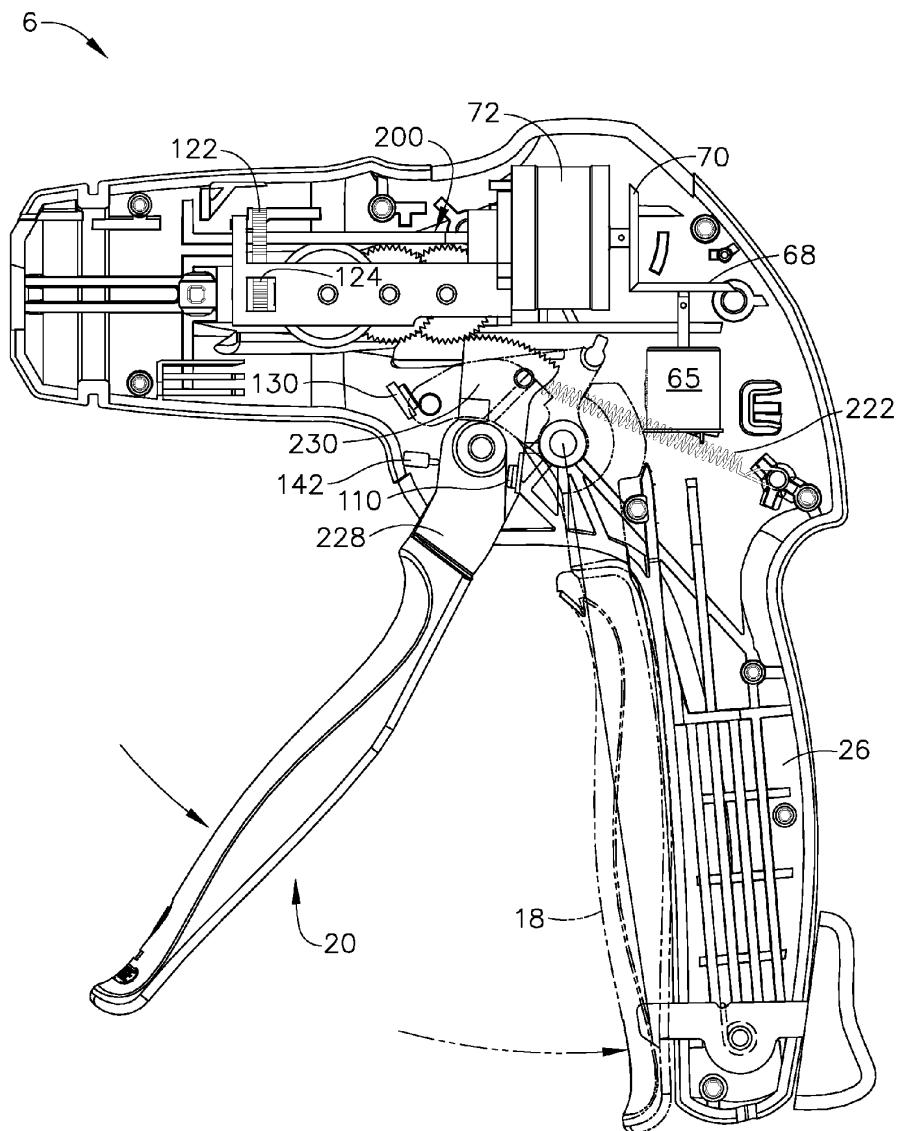


FIG. 33

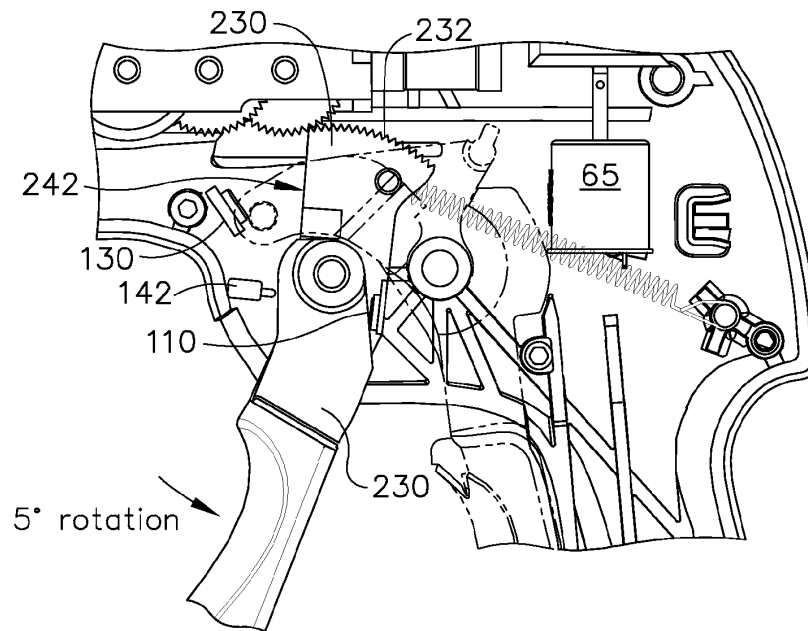


FIG. 34

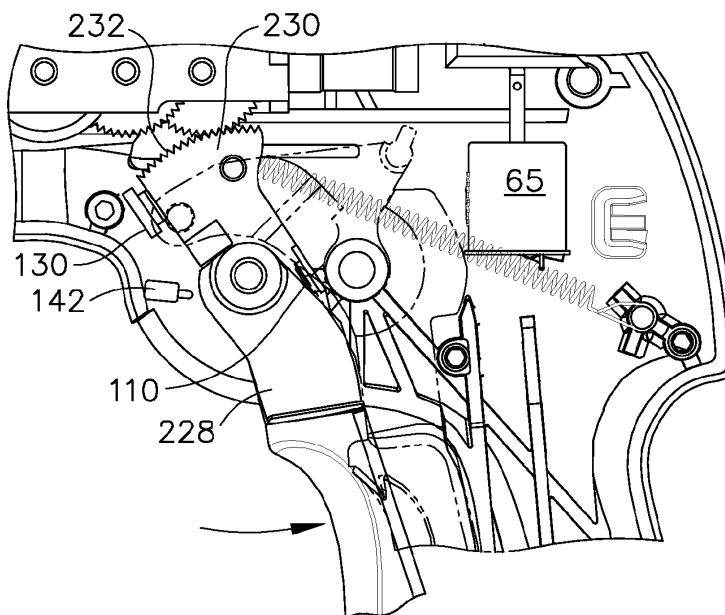


FIG. 35



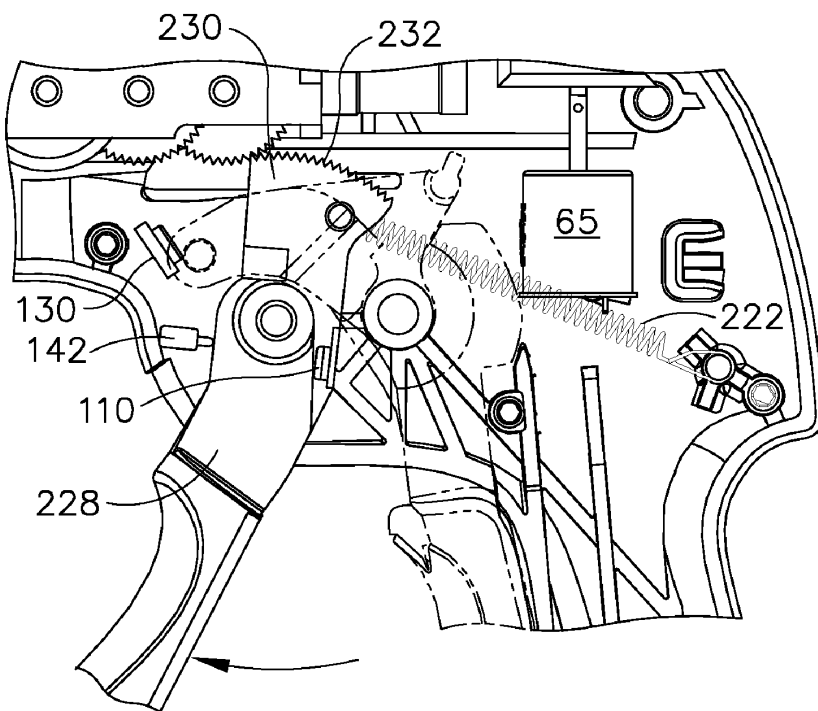


FIG. 36

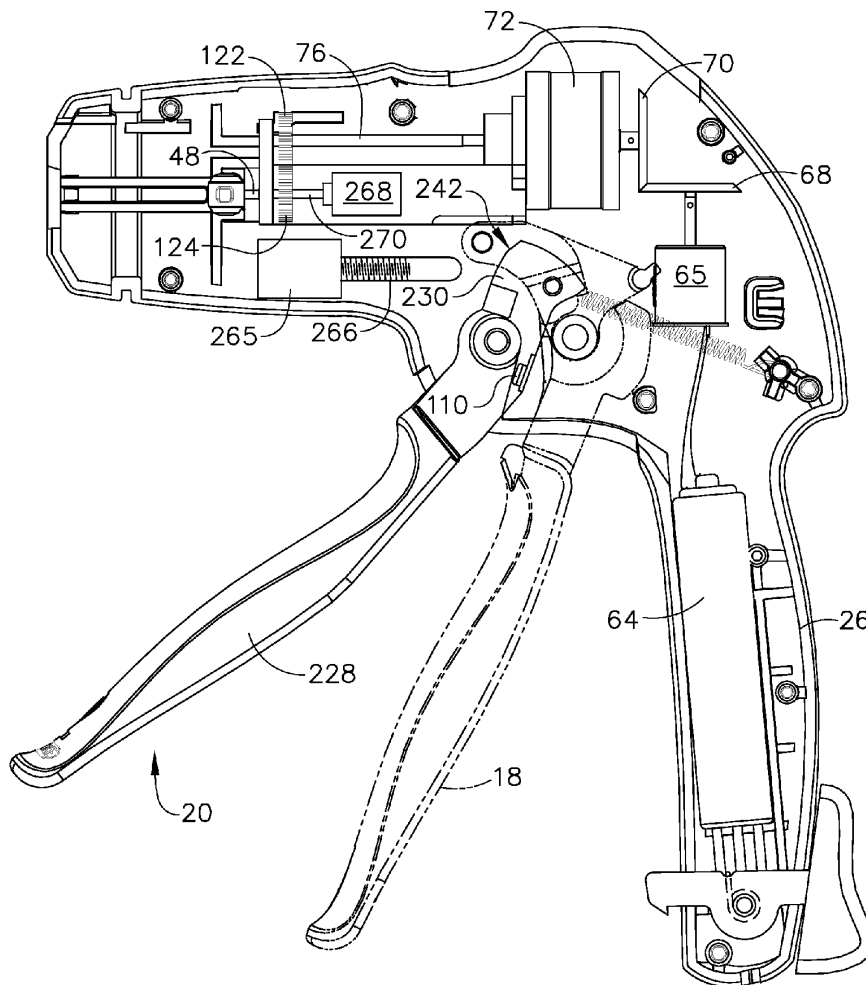


FIG. 37

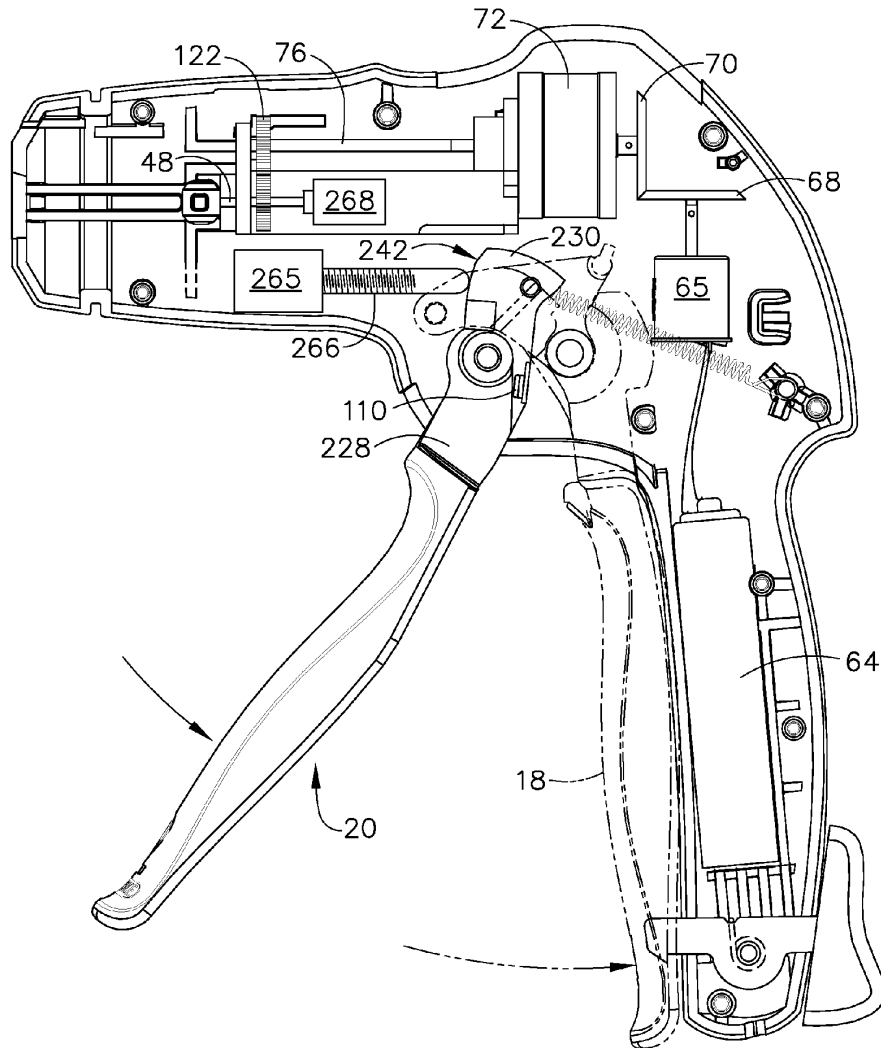


FIG. 38

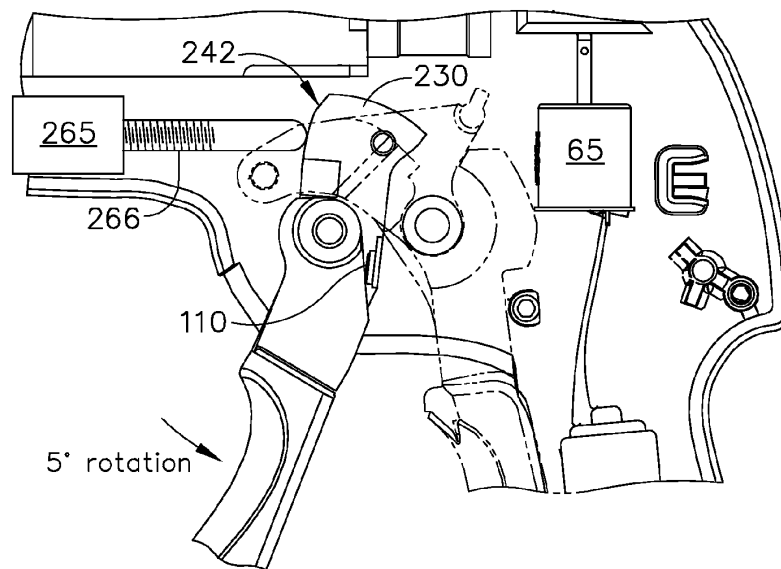


FIG. 39

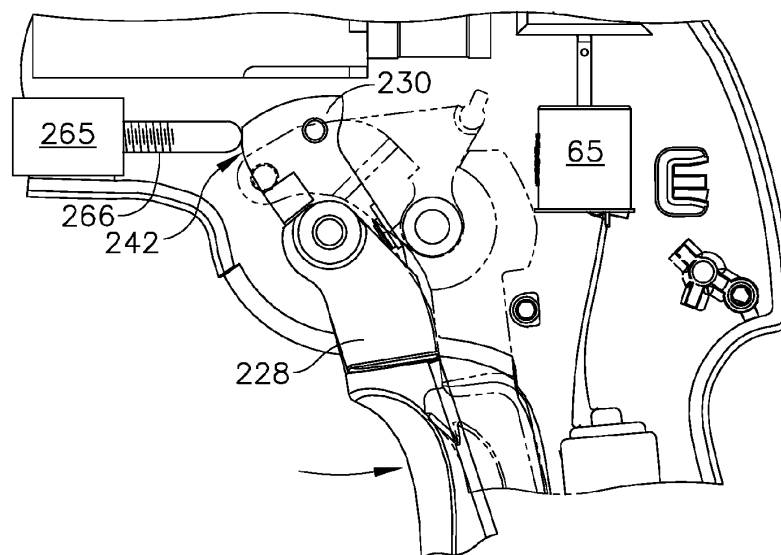


FIG. 40

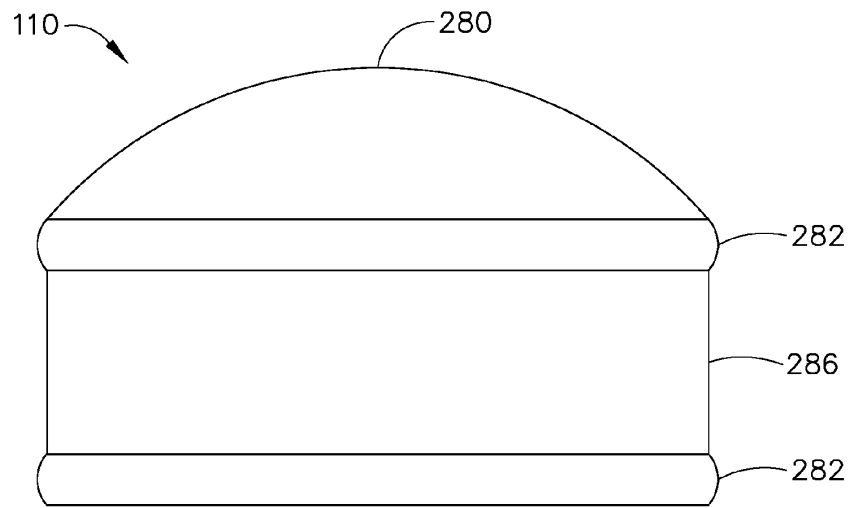


FIG. 41

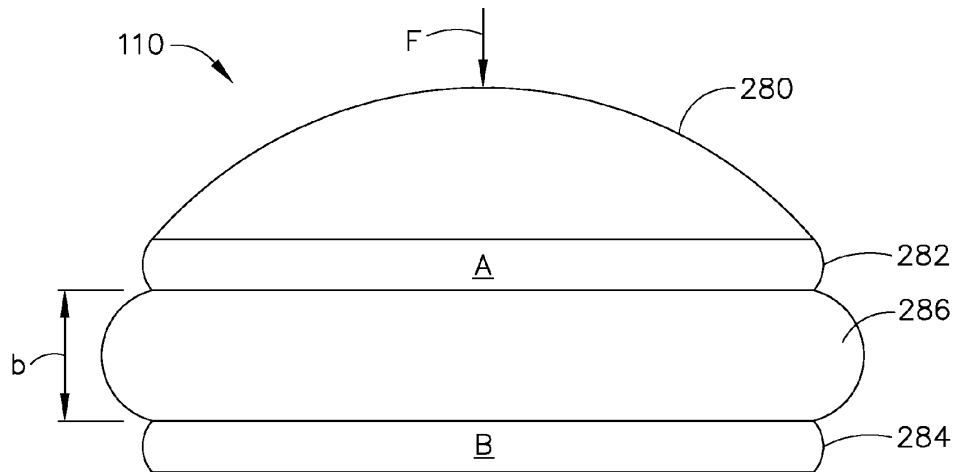


FIG. 42

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# **MOTOR-DRIVEN SURGICAL CUTTING AND FASTENING INSTRUMENT WITH MECHANICAL CLOSURE SYSTEM**

## **CROSS-REFERENCE TO RELATED APPLICATIONS**

The present application is related to the following concurrently-filed U.S. patent applications, which are incorporated herein by reference:

MOTOR-DRIVEN SURGICAL CUTTING AND FASTENING INSTRUMENT WITH USER FEEDBACK SYSTEM; Inventors: Frederick E. Shelton, IV, John Ouwerkerk and Jerome R. Morgan, Ser. No. 11/343,498

MOTOR-DRIVEN SURGICAL CUTTING AND FASTENING INSTRUMENT WITH LOADING FORCE FEEDBACK; Inventors: Frederick E. Shelton, IV, John N. Ouwerkerk, Jerome R. Morgan, and Jeffrey S. Swayze, Ser. No. 11/343,573

MOTOR-DRIVEN SURGICAL CUTTING AND FASTENING INSTRUMENT WITH TACTILE POSITION FEEDBACK; Inventors: Frederick E. Shelton, IV, John N. Ouwerkerk, Jerome R. Morgan, and Jeffrey S. Swayze, Ser. No. 11/344,035

MOTOR-DRIVEN SURGICAL CUTTING AND FASTENING INSTRUMENT WITH ADAPTIVE USER FEEDBACK; Inventors: Frederick E. Shelton, IV, John N. Ouwerkerk, and Jerome R. Morgan, Ser. No. 11/343,447

MOTOR-DRIVEN SURGICAL CUTTING AND FASTENING INSTRUMENT WITH ARTICULATABLE END EFFECTOR; Inventors: Frederick E. Shelton, IV and Christoph L. Gillum, Ser. No. 11/343,562

SURGICAL CUTTING AND FASTENING INSTRUMENT WITH CLOSURE TRIGGER LOCKING MECHANISM; Inventors: Frederick E. Shelton, IV and Kevin R. Doll, Ser. No. 11/343,321

GEARING SELECTOR FOR A POWERED SURGICAL CUTTING AND FASTENING STAPLING INSTRUMENT; Inventors: Frederick E. Shelton, IV, Jeffrey S. Swayze, Eugene L. Timperman, Ser. No. 11/343,563

SURGICAL INSTRUMENT HAVING RECORDING CAPABILITIES; Inventors: Frederick E. Shelton, IV, John N. Ouwerkerk, and Eugene L. Timperman, Ser. No. 11/343,803

SURGICAL INSTRUMENT HAVING A REMOVABLE BATTERY; Inventors: Frederick E. Shelton, IV, Kevin R. Doll, Jeffrey S. Swayze and Eugene Timperman, Ser. No. 11/344,020

ELECTRONIC LOCKOUTS AND SURGICAL INSTRUMENT INCLUDING SAME; Inventors: Jeffrey S. Swayze, Frederick E. Shelton, IV, Kevin R. Doll, Ser. No. 11/343,439

ENDOSCOPIC SURGICAL INSTRUMENT WITH A HANDLE THAT CAN ARTICULATE WITH RESPECT TO THE SHAFT; Inventors: Frederick E. Shelton, IV, Jeffrey S. Swayze, Mark S. Ortiz, and Leslie M. Fugikawa, Ser. No. 11/343,547

ELECTRO-MECHANICAL SURGICAL CUTTING AND FASTENING INSTRUMENT HAVING A ROTARY FIRING AND CLOSURE SYSTEM WITH PARALLEL CLOSURE AND ANVIL ALIGNMENT COMPONENTS; Inventors: Frederick E. Shelton, IV, Stephen J. Balek and Eugene L. Timperman, Ser. No. 11/344,021

DISPOSABLE STAPLE CARTRIDGE HAVING AN ANVIL WITH TISSUE LOCATOR FOR USE WITH A SURGICAL CUTTING AND FASTENING INSTRUMENT AND MODULAR END EFFECTOR SYSTEM THEREFOR; Inventors: Frederick E. Shelton, IV, Michael S. Crop-

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per, Joshua M. Broehl, Ryan S. Crisp, Jamison J. Float, Eugene L. Timperman, Ser. No. 11/343,546

SURGICAL INSTRUMENT HAVING A FEEDBACK SYSTEM; Inventors: Frederick E. Shelton, IV, Jerome R. Morgan, Kevin R. Doll, Jeffrey S. Swayze and Eugene Timperman, Ser. No. 11/343,545

## **BACKGROUND**

The present invention generally concerns surgical cutting and fastening instruments and, more particularly, motor-driven surgical cutting and fastening instruments.

Endoscopic surgical instruments are often preferred over traditional open surgical devices since a smaller incision tends to reduce the post-operative recovery time and complications. Consequently, significant development has gone into a range of endoscopic surgical instruments that are suitable for precise placement of a distal end effector at a desired surgical site through a cannula of a trocar. These distal end effectors engage the tissue in a number of ways to achieve a diagnostic or therapeutic effect (e.g., endocutter, grasper, cutter, staplers, clip applicator, access device, drug/gene therapy delivery device, and energy device using ultrasound, RF, laser, etc.).

Known surgical staplers include an end effector that simultaneously makes a longitudinal incision in tissue and applies lines of staples on opposing sides of the incision. The end effector includes a pair of cooperating jaw members that, if the instrument is intended for endoscopic or laparoscopic applications, are capable of passing through a cannula passageway. One of the jaw members receives a staple cartridge having at least two laterally spaced rows of staples. The other jaw member defines an anvil having staple-forming pockets aligned with the rows of staples in the cartridge. The instrument includes a plurality of reciprocating wedges which, when driven distally, pass through openings in the staple cartridge and engage drivers supporting the staples to effect the firing of the staples toward the anvil.

An example of a surgical stapler suitable for endoscopic applications is described in U.S. Pat. No. 5,465,895, which discloses an endocutter with distinct closing and firing actions. A clinician using this device is able to close the jaw members upon tissue to position the tissue prior to firing. Once the clinician has determined that the jaw members are properly gripping tissue, the clinician can then fire the surgical stapler with a single firing stroke, or multiple firing strokes, depending on the device. Firing the surgical stapler causes severing and stapling the tissue. The simultaneous severing and stapling avoids complications that may arise when performing such actions sequentially with different surgical tools that respectively only sever and staple.

One specific advantage of being able to close upon tissue before firing is that the clinician is able to verify via an endoscope that the desired location for the cut has been achieved, including a sufficient amount of tissue has been captured between opposing jaws. Otherwise, opposing jaws may be drawn too close together, especially pinching at their distal ends, and thus not effectively forming closed staples in the severed tissue. At the other extreme, an excessive amount of clamped tissue may cause binding and an incomplete firing.

Endoscopic staplers/cutters continue to increase in complexity and function with each generation. One of the main reasons for this is the quest for lower force-to-fire (FTF) to a level that all or a great majority of surgeons can handle. One known solution to lower FTF is use CO<sub>2</sub> or electrical motors. These devices have not fared much better than traditional

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hand-powered devices, but for a different reason. Surgeons typically prefer to experience proportionate force distribution to that being experienced by the end-effector in the forming the staple to assure them that the cutting/stapling cycle is complete, with the upper limit within the capabilities of most surgeons (usually around 15-30 lbs). They also typically want to maintain control of deploying the staple and being able to stop at anytime if the forces felt in the handle of the device feel too great or for some other clinical reason. These user-feedback effects are not suitably realizable in present motor-driven endocutters. As a result, there is a general lack of acceptance by physicians of motor-drive endocutters where the cutting/stapling operation is actuated by merely pressing a button.

## SUMMARY

In one general aspect, the present invention is directed to a motorized surgical cutting and fastening instrument that provides feedback to the user regarding the position, force and/or deployment of the end effector. The instrument, in various embodiments, also allows the operator to control the end effector, including being able to stop deployment if so desired. The instrument may include two triggers in its handle—a closure trigger and a firing trigger—with separate actuation motions. When an operator of the instrument retracts the closure trigger, tissue positioned in the end effector may be clamped by the end effector. Then, when the operator retracts the firing trigger, a motor may power, via a gear drive train, a rotational main drive shaft assembly, which causes a cutting instrument in the end effector to sever the clamped tissue.

In various embodiments, the instrument may comprise a power assist system with loading force feedback and control to reduce the firing force required to be exerted by the operator in order to complete the cutting operation. In such embodiments, the firing trigger may be geared into the gear drive train of the main drive shaft assembly. In that way, the operator may experience feedback regarding the force being applied to the cutting instrument. That is, the loading force on the firing trigger may be related to the loading force experienced by the cutting instrument. Also in such embodiments, because the firing trigger is geared into the gear drive train, force applied by the operator may be added to the force applied to the motor.

According to various embodiments, when the firing trigger is retracted an appropriate amount (e.g., five degrees), an on/off switch may be actuated, which sends a signal to the motor to rotate at a specified rate, thus commencing actuation of the drive shaft assembly and end effector. According to other embodiments, a proportional sensor may be used. The proportional sensor may send a signal to the motor to rotate at a rate proportional to the force applied to the firing trigger by the operator. In that way, the rotational position of the firing trigger is generally proportional to where the cutting instrument is in the end effector (e.g., fully deployed or fully retracted). Further, the operator could stop retracting the firing trigger at some point in the stroke to stop the motor, and thereby stop the cutting motion. In addition, sensors may be used to detect the beginning of the stroke of the end effector (e.g., fully retracted position) and the end of the stroke (e.g., fully deployed position), respectively. Consequently, the sensors may provide an adaptive control system for controlling end effector deployment that is outside of the closed loop system of the motor, gear drive train, and end effector.

In other embodiments, the firing trigger may not be directly geared into the gear drive train used to actuate the end effec-

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tor. In such embodiments, a second motor may be used to apply forces to the firing trigger to simulate the deployment of the cutting instrument in the end effector. The second motor may be controlled based on incremental rotations of the main drive shaft assembly, which may be measured by a rotary encoder. In such embodiment, the position of the rotational position of the firing trigger may be related to the position of the cutting instrument in the end effector. Additionally, an on/off switch or a proportional switch may be used to control the main motor (i.e., the motor that powers the main drive shaft).

In various implementations, the end effector may use a helical drive screw in the base of the end effector to drive the cutting instrument (e.g., knife). Also, the end effector may include a staple cartridge for stapling the severed tissue. According to other embodiments, other means for fastening (or sealing) the severed tissue may be used, including RF energy and adhesives.

Also, the instrument may include a mechanical closure system. The mechanical closure system may include an elongate channel having a clamping member, such as an anvil, pivotably connected to the channel to clamp tissue positioned in the end effector. The user may activate the clamping action of the end effector by retracting the closer trigger, which, through a mechanical closure system, causes the clamping action of the end effector. Once the clamping member is locked in place, the operator may activate the cutting operation by retracting the separate firing trigger. This may cause the cutting instrument to travel longitudinally along the channel in order to cut tissue clamped by the end effector.

In various implementations, the instrument may include a rotational main drive shaft assembly for actuating the end effector. Further, the main drive shaft may comprise an articulating joint such that the end effector may be articulated. The articulation joint may comprise, for example, a bevel gear assembly, a universal joint, or a flexible torsion cable capable of transmitting torsion force to the end effector.

Other aspects of the present invention are directed to various mechanisms for locking the closure trigger to a lower, pistol-grip portion of the handle. Such embodiments free up space in the handle directly above and behind the triggers for other components of the instrument, including components of the gear drive train and the mechanical closure system.

## DRAWINGS

Various embodiments of the present invention are described herein by way of example in conjunction with the following figures, wherein

FIGS. 1 and 2 are perspective views of a surgical cutting and fastening instrument according to various embodiments of the present invention;

FIGS. 3-5 are exploded views of an end effector and shaft of the instrument according to various embodiments of the present invention;

FIG. 6 is a side view of the end effector according to various embodiments of the present invention;

FIG. 7 is an exploded view of the handle of the instrument according to various embodiments of the present invention;

FIGS. 8 and 9 are partial perspective views of the handle according to various embodiments of the present invention;

FIG. 10 is a side view of the handle according to various embodiments of the present invention;

FIG. 11 is a schematic diagram of a circuit used in the instrument according to various embodiments of the present invention;

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FIGS. 12-13 are side views of the handle according to other embodiments of the present invention;

FIGS. 14-22 illustrate different mechanisms for locking the closure trigger according to various embodiments of the present invention;

FIGS. 23A-B show a universal joint ("u-joint") that may be employed at the articulation point of the instrument according to various embodiments of the present invention;

FIGS. 24A-B shows a torsion cable that may be employed at the articulation point of the instrument according to various embodiments of the present invention;

FIGS. 25-31 illustrate a surgical cutting and fastening instrument with power assist according to another embodiment of the present invention;

FIGS. 32-36 illustrate a surgical cutting and fastening instrument with power assist according to yet another embodiment of the present invention;

FIGS. 37-40 illustrate a surgical cutting and fastening instrument with tactile feedback to embodiments of the present invention; and

FIGS. 41-42 illustrate a proportional sensor that may be used according to various embodiments of the present invention.

#### DETAILED DESCRIPTION

FIGS. 1 and 2 depict a surgical cutting and fastening instrument 10 according to various embodiments of the present invention. The illustrated embodiment is an endoscopic instrument and, in general, the embodiments of the instrument 10 described herein are endoscopic surgical cutting and fastening instruments. It should be noted, however, that according to other embodiments of the present invention, the instrument may be a non-endoscopic surgical cutting and fastening instrument, such as a laparoscopic instrument.

The surgical instrument 10 depicted in FIGS. 1 and 2 comprises a handle 6, a shaft 8, and an articulating end effector 12 pivotally connected to the shaft 8 at an articulation pivot 14. An articulation control 16 may be provided adjacent to the handle 6 to effect rotation of the end effector 12 about the articulation pivot 14. In the illustrated embodiment, the end effector 12 is configured to act as an endocutter for clamping, severing and stapling tissue, although, in other embodiments, different types of end effectors may be used, such as end effectors for other types of surgical devices, such as graspers, cutters, staplers, clip applicators, access devices, drug/gene therapy devices, ultrasound, RF or laser devices, etc.

The handle 6 of the instrument 10 may include a closure trigger 18 and a firing trigger 20 for actuating the end effector 12. It will be appreciated that instruments having end effectors directed to different surgical tasks may have different numbers or types of triggers or other suitable controls for operating the end effector 12. The end effector 12 is shown separated from the handle 6 by a preferably elongate shaft 8. In one embodiment, a clinician or operator of the instrument 10 may articulate the end effector 12 relative to the shaft 8 by utilizing the articulation control 16, as described in more detail in pending U.S. patent application Ser. No. 11/329,020, filed Jan. 10, 2006, entitled "Surgical Instrument Having An Articulating End Effector," by Geoffrey C. Hueil et al., which is incorporated herein by reference.

The end effector 12 includes in this example, among other things, a staple channel 22 and a pivotally translatable clamping member, such as an anvil 24, which are maintained at a spacing that assures effective stapling and severing of tissue clamped in the end effector 12. The handle 6 includes a pistol grip 26 towards which a closure trigger 18 is pivotally drawn

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by the clinician to cause clamping or closing of the anvil 24 toward the staple channel 22 of the end effector 12 to thereby clamp tissue positioned between the anvil 24 and channel 22. The firing trigger 20 is farther outboard of the closure trigger 18. Once the closure trigger 18 is locked in the closure position as further described below, the firing trigger 20 may rotate slightly toward the pistol grip 26 so that it can be reached by the operator using one hand. Then the operator may pivotally draw the firing trigger 20 toward the pistol grip 26 to cause the stapling and severing of clamped tissue in the end effector 12. In other embodiments, different types of clamping members besides the anvil 24 could be used, such as, for example, an opposing jaw, etc.

It will be appreciated that the terms "proximal" and "distal" are used herein with reference to a clinician gripping the handle 6 of an instrument 10. Thus, the end effector 12 is distal with respect to the more proximal handle 6. It will be further appreciated that, for convenience and clarity, spatial terms such as "vertical" and "horizontal" are used herein with respect to the drawings. However, surgical instruments are used in many orientations and positions, and these terms are not intended to be limiting and absolute.

The closure trigger 18 may be actuated first. Once the clinician is satisfied with the positioning of the end effector 12, the clinician may draw back the closure trigger 18 to its fully closed, locked position proximate to the pistol grip 26. The firing trigger 20 may then be actuated. The firing trigger 20 returns to the open position (shown in FIGS. 1 and 2) when the clinician removes pressure, as described more fully below. A release button on the handle 6, when depressed may release the locked closure trigger 18. The release button may be implemented in various forms such as, for example, as a slide release button 160 shown in FIG. 14, and/or button 172 shown in FIG. 16.

FIG. 3 is an exploded view of the end effector 12 according to various embodiments. As shown in the illustrated embodiment, the end effector 12 may include, in addition to the previously-mentioned channel 22 and anvil 24, a cutting instrument 32, a sled 33, a staple cartridge 34 that is removably seated in the channel 22, and a helical screw shaft 36. The cutting instrument 32 may be, for example, a knife. The anvil 24 may be pivotally opened and closed at a pivot point 25 connected to the proximate end of the channel 22. The anvil 24 may also include a tab 27 at its proximate end that is inserted into a component of the mechanical closure system (described further below) to open and close the anvil 24. When the closure trigger 18 is actuated, that is, drawn in by a user of the instrument 10, the anvil 24 may pivot about the pivot point 25 into the clamped or closed position. If clamping of the end effector 12 is satisfactory, the operator may actuate the firing trigger 20, which, as explained in more detail below, causes the knife 32 and sled 33 to travel longitudinally along the channel 22, thereby cutting tissue clamped within the end effector 12. The movement of the sled 33 along the channel 22 causes the staples of the staple cartridge 34 to be driven through the severed tissue and against the closed anvil 24, which turns the staples to fasten the severed tissue. In various embodiments, the sled 33 may be an integral component of the cartridge 34. U.S. Pat. No. 6,978,921, entitled "Surgical stapling instrument incorporating an E-beam firing mechanism," which is incorporated herein by reference, provides more details about such two-stroke cutting and fastening instruments. The sled 33 may be part of the cartridge 34, such that when the knife 32 retracts following the cutting operation, the sled 33 does not retract.

It should be noted that although the embodiments of the instrument 10 described herein employ an end effector 12 that



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staples the severed tissue, in other embodiments different techniques for fastening or sealing the severed tissue may be used. For example, end effectors that use RF energy or adhesives to fasten the severed tissue may also be used. U.S. Pat. No. 5,709,680 entitled "ELECTROSURGICAL HEMOSTATIC DEVICE" to Yates et al., and U.S. Pat. No. 5,688,270 entitled "ELECTROSURGICAL HEMOSTATIC DEVICE WITH RECESSED AND/OR OFFSET ELECTRODES" to Yates et al., which are incorporated herein by reference, disclose an endoscopic cutting instrument that uses RF energy to seal the severed tissue. U.S. patent application Ser. No. 11/267,811 to Jerome R. Morgan, et. al, and U.S. patent application Ser. No. 11/267,383 to Frederick E. Shelton, IV, et. al., which are also incorporated herein by reference, disclose an endoscopic cutting instrument that uses adhesives to fasten the severed tissue. Accordingly, although the description herein refers to cutting/stapling operations and the like below, it should be recognized that this is an exemplary embodiment and is not meant to be limiting. Other tissue-fastening techniques may also be used.

FIGS. 4 and 5 are exploded views and FIG. 6 is a side view of the end effector 12 and shaft 8 according to various embodiments. As shown in the illustrated embodiment, the shaft 8 may include a proximate closure tube 40 and a distal closure tube 42 pivotably linked by a pivot links 44. The distal closure tube 42 includes an opening 45 into which the tab 27 on the anvil 24 is inserted in order to open and close the anvil 24, as further described below. Disposed inside the closure tubes 40, 42 may be a proximate spine tube 46. Disposed inside the proximate spine tube 46 may be a main rotational (or proximate) drive shaft 48 that communicates with a secondary (or distal) drive shaft 50 via a bevel gear assembly 52. The secondary drive shaft 50 is connected to a drive gear 54 that engages a proximate drive gear 56 of the helical screw shaft 36. The vertical bevel gear 52b may sit and pivot in an opening 57 in the distal end of the proximate spine tube 46. A distal spine tube 58 may be used to enclose the secondary drive shaft 50 and the drive gears 54, 56. Collectively, the main drive shaft 48, the secondary drive shaft 50, and the articulation assembly (e.g., the bevel gear assembly 52a-c) are sometimes referred to herein as the "main drive shaft assembly."

A bearing 38, positioned at a distal end of the staple channel 22, receives the helical drive screw 36, allowing the helical drive screw 36 to freely rotate with respect to the channel 22. The helical screw shaft 36 may interface a threaded opening (not shown) of the knife 32 such that rotation of the shaft 36 causes the knife 32 to translate distally or proximally (depending on the direction of the rotation) through the staple channel 22. Accordingly, when the main drive shaft 48 is caused to rotate by actuation of the firing trigger 20 (as explained in more detail below), the bevel gear assembly 52a-c causes the secondary drive shaft 50 to rotate, which in turn, because of the engagement of the drive gears 54, 56, causes the helical screw shaft 36 to rotate, which causes the knife driving member 32 to travel longitudinally along the channel 22 to cut any tissue clamped within the end effector. The sled 33 may be made of, for example, plastic, and may have a sloped distal surface. As the sled 33 traverse the channel 22, the sloped forward surface may push up or drive the staples in the staple cartridge through the clamped tissue and against the anvil 24. The anvil 24 turns the staples, thereby stapling the severed tissue. When the knife 32 is retracted, the knife 32 and sled 33 may become disengaged, thereby leaving the sled 33 at the distal end of the channel 22.

As described above, because of the lack of user feedback for the cutting/stapling operation, there is a general lack of

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acceptance among physicians of motor-driven endocutters where the cutting/stapling operation is actuated by merely pressing a button. In contrast, embodiments of the present invention provide a motor-driven endocutter with user-feedback of the deployment, force, and/or position of the cutting instrument in the end effector.

FIGS. 7-10 illustrate an exemplary embodiment of a motor-driven endocutter, and in particular the handle thereof, that provides user-feedback regarding the deployment and loading force of the cutting instrument in the end effector. In addition, the embodiment may use power provided by the user in retracting the firing trigger 20 to power the device (a so-called "power assist" mode). As shown in the illustrated embodiment, the handle 6 includes exterior lower side pieces 59, 60 and exterior upper side pieces 61, 62 that fit together to form, in general, the exterior of the handle 6. A battery 64, such as a Li ion battery, may be provided in the pistol grip portion 26 of the handle 6. The battery 64 powers a motor 65 disposed in an upper portion of the pistol grip portion 26 of the handle 6. According to various embodiments, the motor 65 may be a DC brushed driving motor having a maximum rotation of, approximately, 5000 RPM. The motor 65 may drive a 90° bevel gear assembly 66 comprising a first bevel gear 68 and a second bevel gear 70. The bevel gear assembly 66 may drive a planetary gear assembly 72. The planetary gear assembly 72 may include a pinion gear 74 connected to a drive shaft 76. The pinion gear 74 may drive a mating ring gear 78 that drives a helical gear drum 80 via a drive shaft 82. A ring 84 may be threaded on the helical gear drum 80. Thus, when the motor 65 rotates, the ring 84 is caused to travel along the helical gear drum 80 by means of the interposed bevel gear assembly 66, planetary gear assembly 72 and ring gear 78.

The handle 6 may also include a run motor sensor 110 in communication with the firing trigger 20 to detect when the firing trigger 20 has been drawn in (or "closed") toward the pistol grip portion 26 of the handle 6 by the operator to thereby actuate the cutting/stapling operation by the end effector 12. The sensor 110 may be a proportional sensor such as, for example, a rheostat or variable resistor. When the firing trigger 20 is drawn in, the sensor 110 detects the movement, and sends an electrical signal indicative of the voltage (or power) to be supplied to the motor 65. When the sensor 110 is a variable resistor or the like, the rotation of the motor 65 may be generally proportional to the amount of movement of the firing trigger 20. That is, if the operator only draws or closes the firing trigger 20 in a little bit, the rotation of the motor 65 is relatively low. When the firing trigger 20 is fully drawn in (or in the fully closed position), the rotation of the motor 65 is at its maximum. In other words, the harder the user pulls on the firing trigger 20, the more voltage is applied to the motor 65, causing greater rates of rotation.

The handle 6 may include a middle handle piece 104 adjacent to the upper portion of the firing trigger 20. The handle 6 also may comprise a bias spring 112 connected between posts on the middle handle piece 104 and the firing trigger 20. The bias spring 112 may bias the firing trigger 20 to its fully open position. In that way, when the operator releases the firing trigger 20, the bias spring 112 will pull the firing trigger 20 to its open position, thereby removing actuation of the sensor 110, thereby stopping rotation of the motor 65. Moreover, by virtue of the bias spring 112, any time a user closes the firing trigger 20, the user will experience resistance to the closing operation, thereby providing the user with feedback as to the amount of rotation exerted by the motor 65. Further, the operator could stop retracting the firing trigger 20 to thereby remove force from the sensor 110, to thereby stop the motor 65. As such, the user may stop the deployment of the end

effector 12, thereby providing a measure of control of the cutting/fastening operation to the operator.

The distal end of the helical gear drum 80 includes a distal drive shaft 120 that drives a ring gear 122, which mates with a pinion gear 124. The pinion gear 124 is connected to the main drive shaft 48 of the main drive shaft assembly. In that way, rotation of the motor 65 causes the main drive shaft assembly to rotate, which causes actuation of the end effector 12, as described above.

The ring 84 threaded on the helical gear drum 80 may include a post 86 that is disposed within a slot 88 of a slotted arm 90. The slotted arm 90 has an opening 92 its opposite end 94 that receives a pivot pin 96 that is connected between the handle exterior side pieces 59, 60. The pivot pin 96 is also disposed through an opening 100 in the firing trigger 20 and an opening 102 in the middle handle piece 104.

In addition, the handle 6 may include a reverse motor (or end-of-stroke sensor) 130 and a stop motor (or beginning-of-stroke) sensor 142. In various embodiments, the reverse motor sensor 130 may be a limit switch located at the distal end of the helical gear drum 80 such that the ring 84 threaded on the helical gear drum 80 contacts and trips the reverse motor sensor 130 when the ring 84 reaches the distal end of the helical gear drum 80. The reverse motor sensor 130, when activated, sends a signal to the motor 65 to reverse its rotation direction, thereby withdrawing the knife 32 of the end effector 12 following the cutting operation.

The stop motor sensor 142 may be, for example, a normally-closed limit switch. In various embodiments, it may be located at the proximate end of the helical gear drum 80 so that the ring 84 trips the switch 142 when the ring 84 reaches the proximate end of the helical gear drum 80.

In operation, when an operator of the instrument 10 pulls back the firing trigger 20, the sensor 110 detects the deployment of the firing trigger 20 and sends a signal to the motor 65 to cause forward rotation of the motor 65 at, for example, a rate proportional to how hard the operator pulls back the firing trigger 20. The forward rotation of the motor 65 in turn causes the ring gear 78 at the distal end of the planetary gear assembly 72 to rotate, thereby causing the helical gear drum 80 to rotate, causing the ring 84 threaded on the helical gear drum 80 to travel distally along the helical gear drum 80. The rotation of the helical gear drum 80 also drives the main drive shaft assembly as described above, which in turn causes deployment of the knife 32 in the end effector 12. That is, the knife 32 and sled 33 are caused to traverse the channel 22 longitudinally, thereby cutting tissue clamped in the end effector 12. Also, the stapling operation of the end effector 12 is caused to happen in embodiments where a stapling-type end effector is used.

By the time the cutting/stapling operation of the end effector 12 is complete, the ring 84 on the helical gear drum 80 will have reached the distal end of the helical gear drum 80, thereby causing the reverse motor sensor 130 to be tripped, which sends a signal to the motor 65 to cause the motor 65 to reverse its rotation. This in turn causes the knife 32 to retract, and also causes the ring 84 on the helical gear drum 80 to move back to the proximate end of the helical gear drum 80.

The middle handle piece 104 includes a backside shoulder 106 that engages the slotted arm 90 as best shown in FIGS. 8 and 9. The middle handle piece 104 also has a forward motion stop 107 that engages the firing trigger 20. The movement of the slotted arm 90 is controlled, as explained above, by rotation of the motor 65. When the slotted arm 90 rotates CCW as the ring 84 travels from the proximate end of the helical gear drum 80 to the distal end, the middle handle piece 104 will be free to rotate CCW. Thus, as the user draws in the firing trigger

20, the firing trigger 20 will engage the forward motion stop 107 of the middle handle piece 104, causing the middle handle piece 104 to rotate CCW. Due to the backside shoulder 106 engaging the slotted arm 90, however, the middle handle piece 104 will only be able to rotate CCW as far as the slotted arm 90 permits. In that way, if the motor 65 should stop rotating for some reason, the slotted arm 90 will stop rotating, and the user will not be able to further draw in the firing trigger 20 because the middle handle piece 104 will not be free to rotate CCW due to the slotted arm 90.

FIGS. 41 and 42 illustrate two states of a variable sensor that may be used as the run motor sensor 110 according to various embodiments of the present invention. The sensor 110 may include a face portion 280, a first electrode (A) 282, a second electrode (B) 284, and a compressible dielectric material 286 (e.g., EAP) between the electrodes 282, 284. The sensor 110 may be positioned such that the face portion 280 contacts the firing trigger 20 when retracted. Accordingly, when the firing trigger 20 is retracted, the dielectric material 286 is compressed, as shown in FIG. 42, such that the electrodes 282, 284 are closer together. Since the distance "b" between the electrodes 282, 284 is directly related to the impedance between the electrodes 282, 284, the greater the distance the more impedance, and the closer the distance the less impedance. In that way, the amount that the dielectric 286 is compressed due to retraction of the firing trigger 20 (denoted as force "F" in FIG. 42) is proportional to the impedance between the electrodes 282, 284, which can be used to proportionally control the motor 65.

Components of an exemplary closure system for closing (or clamping) the anvil 24 of the end effector 12 by retracting the closure trigger 18 are also shown in FIGS. 7-10. In the illustrated embodiment, the closure system includes a yoke 250 connected to the closure trigger 18 by a pin 251 that is inserted through aligned openings in both the closure trigger 18 and the yoke 250. A pivot pin 252, about which the closure trigger 18 pivots, is inserted through another opening in the closure trigger 18 which is offset from where the pin 251 is inserted through the closure trigger 18. Thus, retraction of the closure trigger 18 causes the upper part of the closure trigger 18, to which the yoke 250 is attached via the pin 251, to rotate CCW. The distal end of the yoke 250 is connected, via a pin 254, to a first closure bracket 256. The first closure bracket 256 connects to a second closure bracket 258. Collectively, the closure brackets 256, 258 define an opening in which the proximate end of the proximate closure tube 40 (see FIG. 4) is seated and held such that longitudinal movement of the closure brackets 256, 258 causes longitudinal motion by the proximate closure tube 40. The instrument 10 also includes a closure rod 260 disposed inside the proximate closure tube 40. The closure rod 260 may include a window 261 into which a post 263 on one of the handle exterior pieces, such as exterior lower side piece 59 in the illustrated embodiment, is disposed to fixedly connect the closure rod 260 to the handle 6. In that way, the proximate closure tube 40 is capable of moving longitudinally relative to the closure rod 260. The closure rod 260 may also include a distal collar 267 that fits into a cavity 269 in proximate spine tube 46 and is retained therein by a cap 271 (see FIG. 4).

In operation, when the yoke 250 rotates due to retraction of the closure trigger 18, the closure brackets 256, 258 cause the proximate closure tube 40 to move distally (i.e., away from the handle end of the instrument 10), which causes the distal closure tube 42 to move distally, which causes the anvil 24 to rotate about the pivot point 25 into the clamped or closed position. When the closure trigger 18 is unlocked from the locked position, the proximate closure tube 40 is caused to

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slide proximally, which causes the distal closure tube 42 to slide proximally, which, by virtue of the tab 27 being inserted in the window 45 of the distal closure tube 42, causes the anvil 24 to pivot about the pivot point 25 into the open or unclamped position. In that way, by retracting and locking the closure trigger 18, an operator may clamp tissue between the anvil 24 and channel 22, and may unclamp the tissue following the cutting/stapling operation by unlocking the closure trigger 20 from the locked position.

FIG. 11 is a schematic diagram of an electrical circuit of the instrument 10 according to various embodiments of the present invention. When an operator initially pulls in the firing trigger 20 after locking the closure trigger 18, the sensor 110 is activated, allowing current to flow there through. If the normally-open reverse motor sensor switch 130 is open (meaning the end of the end effector stroke has not been reached), current will flow to a single pole, double throw relay 132. Since the reverse motor sensor switch 130 is not closed, the inductor 134 of the relay 132 will not be energized, so the relay 132 will be in its non-energized state. The circuit also includes a cartridge lockout sensor 136. If the end effector 12 includes a staple cartridge 34, the sensor 136 will be in the closed state, allowing current to flow. Otherwise, if the end effector 12 does not include a staple cartridge 34, the sensor 136 will be open, thereby preventing the battery 64 from powering the motor 65.

When the staple cartridge 34 is present, the sensor 136 is closed, which energizes a single pole, single throw relay 138. When the relay 138 is energized, current flows through the relay 136, through the variable resistor sensor 110, and to the motor 65 via a double pole, double throw relay 140, thereby powering the motor 65 and allowing it to rotate in the forward direction.

When the end effector 12 reaches the end of its stroke, the reverse motor sensor 130 will be activated, thereby closing the switch 130 and energizing the relay 132. This causes the relay 132 to assume its energized state (not shown in FIG. 13), which causes current to bypass the cartridge lockout sensor 136 and variable resistor 110, and instead causes current to flow to both the normally-closed double pole, double throw relay 142 and back to the motor 65, but in a manner, via the relay 140, that causes the motor 65 to reverse its rotational direction.

Because the stop motor sensor switch 142 is normally-closed, current will flow back to the relay 132 to keep it closed until the switch 142 opens. When the knife 32 is fully retracted, the stop motor sensor switch 142 is activated, causing the switch 142 to open, thereby removing power from the motor 65.

In other embodiments, rather than a proportional-type sensor 110, an on-off type sensor could be used. In such embodiments, the rate of rotation of the motor 65 would not be proportional to the force applied by the operator. Rather, the motor 65 would generally rotate at a constant rate. But the operator would still experience force feedback because the firing trigger 20 is geared into the gear drive train.

FIG. 12 is a side-view of the handle 6 of a power-assist motorized endocutter according to another embodiment. The embodiment of FIG. 12 is similar to that of FIGS. 7-10 except that in the embodiment of FIG. 12, there is not slotted arm connected to the ring 84 threaded on the helical gear drum 80. Instead, in the embodiment of FIG. 12, the ring 84 includes a sensor portion 114 that moves with the ring 84 as the ring 84 advances down (and back) on the helical gear drum 80. The sensor portion 114 includes a notch 116. The reverse motor sensor 130 may be located at the distal end of the notch 116 and the stop motor sensor 142 may be located at the proximate

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end of the notch 116. As the ring 84 moves down the helical gear drum 80 (and back), the sensor portion 114 moves with it. Further, as shown in FIG. 12, the middle piece 104 may have an arm 118 that extends into the notch 12.

In operation, as an operator of the instrument 10 retracts the firing trigger 20 toward the pistol grip 26, the run motor sensor 110 detects the motion and sends a signal to power the motor 65, which causes, among other things, the helical gear drum 80 to rotate. As the helical gear drum 80 rotates, the ring 84 threaded on the helical gear drum 80 advances (or retracts, depending on the rotation). Also, due to the pulling in of the firing trigger 20, the middle piece 104 is caused to rotate CCW with the firing trigger 20 due to the forward motion stop 107 that engages the firing trigger 20. The CCW rotation of the middle piece 104 cause the arm 118 to rotate CCW with the sensor portion 114 of the ring 84 such that the arm 118 stays disposed in the notch 116. When the ring 84 reaches the distal end of the helical gear drum 80, the arm 118 will contact and thereby trip the reverse motor sensor 130. Similarly, when the ring 84 reaches the proximate end of the helical gear drum 80, the arm will contact and thereby trip the stop motor sensor 142. Such actions may reverse and stop the motor 65, respectively, as described above.

FIG. 13 is a side-view of the handle 6 of a power-assist motorized endocutter according to another embodiment. The embodiment of FIG. 13 is similar to that of FIGS. 7-10 except that in the embodiment of FIG. 13, there is no slot in the arm 90. Instead, the ring 84 threaded on the helical gear drum 80 includes a vertical channel 126. Instead of a slot, the arm 90 includes a post 128 that is disposed in the channel 126. As the helical gear drum 80 rotates, the ring 84 threaded on the helical gear drum 80 advances (or retracts, depending on the rotation). The arm 90 rotates CCW as the ring 84 advances due to the post 128 being disposed in the channel 126, as shown in FIG. 13.

As mentioned above, in using a two-stroke motorized instrument, the operator first pulls back and locks the closure trigger 18. FIGS. 14 and 15 show one embodiment of a way to lock the closure trigger 18 to the pistol grip portion 26 of the handle 6. In the illustrated embodiment, the pistol grip portion 26 includes a hook 150 that is biased to rotate CCW about a pivot point 151 by a torsion spring 152. Also, the closure trigger 18 includes a closure bar 154. As the operator draws in the closure trigger 18, the closure bar 154 engages a sloped portion 156 of the hook 150, thereby rotating the hook 150 upward (or CW in FIGS. 12-13) until the closure bar 154 completely passes the sloped portion 156 passes into a recessed notch 158 of the hook 150, which locks the closure trigger 18 in place. The operator may release the closure trigger 18 by pushing down on a slide button release 160 on the back or opposite side of the pistol grip portion 26. Pushing down the slide button release 160 rotates the hook 150 CW such that the closure bar 154 is released from the recessed notch 158.

FIG. 16 shows another closure trigger locking mechanism according to various embodiments. In the embodiment of FIG. 16, the closure trigger 18 includes a wedge 160 having an arrow-head portion 161. The arrow-head portion 161 is biased downward (or CW) by a leaf spring 162. The wedge 160 and leaf spring 162 may be made from, for example, molded plastic. When the closure trigger 18 is retracted, the arrow-head portion 161 is inserted through an opening 164 in the pistol grip portion 26 of the handle 6. A lower chamfered surface 166 of the arrow-head portion 161 engages a lower sidewall 168 of the opening 164, forcing the arrow-head portion 161 to rotate CCW. Eventually the lower chamfered surface 166 fully passes the lower sidewall 168, removing the

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CCW force on the arrow-head portion 161, causing the lower sidewall 168 to slip into a locked position in a notch 170 behind the arrow-head portion 161.

To unlock the closure trigger 18, a user presses down on a button 172 on the opposite side of the closure trigger 18, causing the arrow-head portion 161 to rotate CCW and allowing the arrow-head portion 161 to slide out of the opening 164.

FIGS. 17-22 show a closure trigger locking mechanism according to another embodiment. As shown in this embodiment, the closure trigger 18 includes a flexible longitudinal arm 176 that includes a lateral pin 178 extending therefrom. The arm 176 and pin 178 may be made from molded plastic, for example. The pistol grip portion 26 of the handle 6 includes an opening 180 with a laterally extending wedge 182 disposed therein. When the closure trigger 18 is retracted, the pin 178 engages the wedge 182, and the pin 178 is forced downward (i.e., the arm 176 is rotated CW) by the lower surface 184 of the wedge 182, as shown in FIGS. 17 and 18. When the pin 178 fully passes the lower surface 184, the CW force on the arm 176 is removed, and the pin 178 is rotated CCW such that the pin 178 comes to rest in a notch 186 behind the wedge 182, as shown in FIG. 19, thereby locking the closure trigger 18. The pin 178 is further held in place in the locked position by a flexible stop 188 extending from the wedge 184.

To unlock the closure trigger 18, the operator may further squeeze the closure trigger 18, causing the pin 178 to engage a sloped backwall 190 of the opening 180, forcing the pin 178 upward past the flexible stop 188, as shown in FIGS. 20 and 21. The pin 178 is then free to travel out an upper channel 192 in the opening 180 such that the closure trigger 18 is no longer locked to the pistol grip portion 26, as shown in FIG. 22.

FIGS. 23A-B show a universal joint ("u-joint") 195. The second piece 195-2 of the u-joint 195 rotates in a horizontal plane in which the first piece 195-1 lies. FIG. 23A shows the u-joint 195 in a linear (180°) orientation and FIG. 23B shows the u-joint 195 at approximately a 150° orientation. The u-joint 195 may be used instead of the bevel gears 52a-c (see FIG. 4, for example) at the articulation point 14 of the main drive shaft assembly to articulate the end effector 12. FIGS. 24A-B show a torsion cable 197 that may be used in lieu of both the bevel gears 52a-c and the u-joint 195 to realize articulation of the end effector 12.

FIGS. 25-31 illustrate another embodiment of a motorized, two-stroke surgical cutting and fastening instrument 10 with power assist according to another embodiment of the present invention. The embodiment of FIGS. 25-31 is similar to that of FIGS. 6-10 except that instead of the helical gear drum 80, the embodiment of FIGS. 23-28 includes an alternative gear drive assembly. The embodiment of FIGS. 25-31 includes a gear box assembly 200 including a number of gears disposed in a frame 201, wherein the gears are connected between the planetary gear 72 and the pinion gear 124 at the proximate end of the drive shaft 48. As explained further below, the gear box assembly 200 provides feedback to the user via the firing trigger 20 regarding the deployment and loading force of the end effector 12. Also, the user may provide power to the system via the gear box assembly 200 to assist the deployment of the end effector 12. In that sense, like the embodiments described above, the embodiment of FIGS. 23-32 is another power assist, motorized instrument 10 that provides feedback to the user regarding the loading force experienced by the cutting instrument.

In the illustrated embodiment, the firing trigger 20 includes two pieces: a main body portion 202 and a stiffening portion 204. The main body portion 202 may be made of plastic, for

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example, and the stiffening portion 204 may be made out of a more rigid material, such as metal. In the illustrated embodiment, the stiffening portion 204 is adjacent to the main body portion 202, but according to other embodiments, the stiffening portion 204 could be disposed inside the main body portion 202. A pivot pin 207 may be inserted through openings in the firing trigger pieces 202, 204 and may be the point about which the firing trigger 20 rotates. In addition, a spring 222 may bias the firing trigger 20 to rotate in a CCW direction. The spring 222 may have a distal end connected to a pin 224 that is connected to the pieces 202, 204 of the firing trigger 20. The proximate end of the spring 222 may be connected to one of the handle exterior lower side pieces 59, 60.

In the illustrated embodiment, both the main body portion 202 and the stiffening portion 204 includes gear portions 206, 208 (respectively) at their upper end portions. The gear portions 206, 208 engage a gear in the gear box assembly 200, as explained below, to drive the main drive shaft assembly and to provide feedback to the user regarding the deployment of the end effector 12.

The gear box assembly 200 may include as shown, in the illustrated embodiment, six (6) gears. A first gear 210 of the gear box assembly 200 engages the gear portions 206, 208 of the firing trigger 20. In addition, the first gear 210 engages a smaller second gear 212, the smaller second gear 212 being coaxial with a large third gear 214. The third gear 214 engages a smaller fourth gear 216, the smaller fourth gear being coaxial with a fifth gear 218. The fifth gear 218 is a 90° bevel gear that engages a mating 90° bevel gear 220 (best shown in FIG. 31) that is connected to the pinion gear 124 that drives the main drive shaft 48.

In operation, when the user retracts the firing trigger 20, a run motor sensor (not shown) is activated, which may provide a signal to the motor 65 to rotate at a rate proportional to the extent or force with which the operator is retracting the firing trigger 20. This causes the motor 65 to rotate at a speed proportional to the signal from the sensor. The sensor is not shown for this embodiment, but it could be similar to the run motor sensor 110 described above. The sensor could be located in the handle 6 such that it is depressed when the firing trigger 20 is retracted. Also, instead of a proportional-type sensor, an on/off type sensor may be used.

Rotation of the motor 65 causes the bevel gears 68, 70 to rotate, which causes the planetary gear 72 to rotate, which causes, via the drive shaft 76, the ring gear 122 to rotate. The ring gear 122 meshes with the pinion gear 124, which is connected to the main drive shaft 48. Thus, rotation of the pinion gear 124 drives the main drive shaft 48, which causes actuation of the cutting/stapling operation of the end effector 12.

Forward rotation of the pinion gear 124 in turn causes the bevel gear 220 to rotate, which causes, by way of the rest of the gears of the gear box assembly 200, the first gear 210 to rotate. The first gear 210 engages the gear portions 206, 208 of the firing trigger 20, thereby causing the firing trigger 20 to rotate CCW when the motor 65 provides forward drive for the end effector 12 (and to rotate CCW when the motor 65 rotates in reverse to retract the end effector 12). In that way, the user experiences feedback regarding loading force and deployment of the end effector 12 by way of the user's grip on the firing trigger 20. Thus, when the user retracts the firing trigger 20, the operator will experience a resistance related to the load force experienced by the end effector 12. Similarly, when the operator releases the firing trigger 20 after the cutting/stapling operation so that it can return to its original position, the

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user will experience a CW rotation force from the firing trigger 20 that is generally proportional to the reverse speed of the motor 65.

It should also be noted that in this embodiment the user can apply force (either in lieu of or in addition to the force from the motor 65) to actuate the main drive shaft assembly (and hence the cutting/stapling operation of the end effector 12) through retracting the firing trigger 20. That is, retracting the firing trigger 20 causes the gear portions 206, 208 to rotate CCW, which causes the gears of the gear box assembly 200 to rotate, thereby causing the pinion gear 124 to rotate, which causes the main drive shaft 48 to rotate.

Although not shown in FIGS. 25-31, the instrument 10 may further include reverse motor and stop motor sensors. As described above, the reverse motor and stop motor sensors may detect, respectively, the end of the cutting stroke (full deployment of the knife/sled driving member 32) and the end of retraction operation (full retraction of the knife/sled driving member 32). A similar circuit to that described above in connection with FIG. 11 may be used to appropriately power the motor 65.

FIGS. 32-36 illustrate a two-stroke, motorized surgical cutting and fastening instrument 10 with power assist according to another embodiment. The embodiment of FIGS. 32-36 is similar to that of FIGS. 25-31 except that in the embodiment of FIGS. 32-36, the firing trigger 20 includes a lower portion 228 and an upper portion 230. Both portions 228, 230 are connected to and pivot about a pivot pin 207 that is disposed through each portion 228, 230. The upper portion 230 includes a gear portion 232 that engages the first gear 210 of the gear box assembly 200. The spring 222 is connected to the upper portion 230 such that the upper portion is biased to rotate in the CW direction. The upper portion 230 may also include a lower arm 234 that contacts an upper surface of the lower portion 228 of the firing trigger 20 such that when the upper portion 230 is caused to rotate CW the lower portion 228 also rotates CW, and when the lower portion 228 rotates CCW the upper portion 230 also rotates CCW. Similarly, the lower portion 228 includes a rotational stop 238 that engages a lower shoulder of the upper portion 230. In that way, when the upper portion 230 is caused to rotate CCW the lower portion 228 also rotates CCW, and when the lower portion 228 rotates CW the upper portion 230 also rotates CW.

The illustrated embodiment also includes the run motor sensor 110 that communicates a signal to the motor 65 that, in various embodiments, may cause the motor 65 to rotate at a speed proportional to the force applied by the operator when retracting the firing trigger 20. The sensor 110 may be, for example, a rheostat or some other variable resistance sensor, as explained herein. In addition, the instrument 10 may include a reverse motor sensor 130 that is tripped or switched when contacted by a front face 242 of the upper portion 230 of the firing trigger 20. When activated, the reverse motor sensor 130 sends a signal to the motor 65 to reverse direction. Also, the instrument 10 may include a stop motor sensor 142 that is tripped or actuated when contacted by the lower portion 228 of the firing trigger 20. When activated, the stop motor sensor 142 sends a signal to stop the reverse rotation of the motor 65.

In operation, when an operator retracts the closure trigger 18 into the locked position, the firing trigger 20 is retracted slightly (through mechanisms known in the art, including U.S. Pat. No. 6,978,921 to Frederick Shelton, IV et. al and U.S. Pat. No. 6,905,057 to Jeffery S. Swayze et. al, which are incorporated herein by reference) so that the user can grasp the firing trigger 20 to initiate the cutting/stapling operation, as shown in FIGS. 32 and 33. At that point, as shown in FIG.

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33, the gear portion 232 of the upper portion 230 of the firing trigger 20 moves into engagement with the first gear 210 of the gear box assembly 200. When the operator retracts the firing trigger 20, according to various embodiments, the firing trigger 20 may rotate a small amount, such as five degrees, before tripping the run motor sensor 110, as shown in FIG. 34. Activation of the sensor 110 causes the motor 65 to forward rotate at a rate proportional to the retraction force applied by the operator. The forward rotation of the motor 65 causes, as described above, the main drive shaft 48 to rotate, which causes the knife 32 in the end effector 12 to be deployed (i.e., begin traversing the channel 22). Rotation of the pinion gear 124, which is connected to the main drive shaft 48, causes the gears 210-220 in the gear box assembly 200 to rotate. Since the first gear 210 is in engagement with the gear portion 232 of the upper portion 230 of the firing trigger 20, the upper portion 232 is caused to rotate CCW, which causes the lower portion 228 to also rotate CCW.

When the knife 32 is fully deployed (i.e., at the end of the cutting stroke), the front face 242 of the upper portion 230 trips the reverse motor sensor 130, which sends a signal to the motor 65 to reverse rotational directional. This causes the main drive shaft assembly to reverse rotational direction to retract the knife 32. Reverse rotation of the main drive shaft assembly causes the gears 210-220 in the gear box assembly to reverse direction, which causes the upper portion 230 of the firing trigger 20 to rotate CW, which causes the lower portion 228 of the firing trigger 20 to rotate CW until the lower portion 228 trips or actuates the stop motor sensor 142 when the knife 32 is fully retracted, which causes the motor 65 to stop. In that way, the user experiences feedback regarding deployment of the end effector 12 by way of the user's grip on the firing trigger 20. Thus, when the user retracts the firing trigger 20, the operator will experience a resistance related to the deployment of the end effector 12 and, in particular, to the loading force experienced by the knife 32. Similarly, when the operator releases the firing trigger 20 after the cutting/stapling operation so that it can return to its original position, the user will experience a CW rotation force from the firing trigger 20 that is generally proportional to the reverse speed of the motor 65.

It should also be noted that in this embodiment the user can apply force (either in lieu of or in addition to the force from the motor 65) to actuate the main drive shaft assembly (and hence the cutting/stapling operation of the end effector 12) through retracting the firing trigger 20. That is, retracting the firing trigger 20 causes the gear portion 232 of the upper portion 230 to rotate CCW, which causes the gears of the gear box assembly 200 to rotate, thereby causing the pinion gear 124 to rotate, which causes the main drive shaft assembly to rotate.

The above-described embodiments employed power-assist user feedback systems, with or without adaptive control (e.g., using a sensor 110, 130, and 142 outside of the closed loop system of the motor, gear drive train, and end effector) for a two-stroke, motorized surgical cutting and fastening instrument. That is, force applied by the user in retracting the firing trigger 20 may be added to the force applied by the motor 65 by virtue of the firing trigger 20 being geared into (either directly or indirectly) the gear drive train between the motor 65 and the main drive shaft 48. In other embodiments of the present invention, the user may be provided with tactile feedback regarding the position of the knife 32 in the end effector, but without having the firing trigger 20 geared into the gear drive train. FIGS. 37-40 illustrate a motorized surgical cutting and fastening instrument with such a tactile position feedback system.

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In the illustrated embodiment of FIGS. 37-40, the firing trigger 20 may have a lower portion 228 and an upper portion 230, similar to the instrument 10 shown in FIGS. 32-36. Unlike the embodiment of FIG. 32-36, however, the upper portion 230 does not have a gear portion that mates with part of the gear drive train. Instead, the instrument includes a second motor 265 with a threaded rod 266 threaded therein. The threaded rod 266 reciprocates longitudinally in and out of the motor 265 as the motor 265 rotates, depending on the direction of rotation. The instrument 10 also includes an encoder 268 that is responsive to the rotations of the main drive shaft 48 for translating the incremental angular motion of the main drive shaft 48 (or other component of the main drive assembly) into a corresponding series of digital signals, for example. In the illustrated embodiment, the pinion gear 124 includes a proximate drive shaft 270 that connects to the encoder 268.

The instrument 10 also includes a control circuit (not shown), which may be implemented using a microcontroller or some other type of integrated circuit, that receives the digital signals from the encoder 268. Based on the signals from the encoder 268, the control circuit may calculate the stage of deployment of the knife 32 in the end effector 12. That is, the control circuit can calculate if the knife 32 is fully deployed, fully retracted, or at an intermittent stage. Based on the calculation of the stage of deployment of the end effector 12, the control circuit may send a signal to the second motor 265 to control its rotation to thereby control the reciprocating movement of the threaded rod 266.

In operation, as shown in FIG. 37, when the closure trigger 18 is not locked into the clamped position, the firing trigger 20 rotated away from the pistol grip portion 26 of the handle 6 such that the front face 242 of the upper portion 230 of the firing trigger 20 is not in contact with the proximate end of the threaded rod 266. When the operator retracts the closure trigger 18 and locks it in the clamped position, the firing trigger 20 rotates slightly towards the closure trigger 20 so that the operator can grasp the firing trigger 20, as shown in FIG. 38. In this position, the front face 242 of the upper portion 230 contacts the proximate end of the threaded rod 266.

As the user then retracts the firing trigger 20, after an initial rotational amount (e.g., 5 degrees of rotation) the run motor sensor 110 may be activated such that, as explained above, the sensor 110 sends a signal to the motor 65 to cause it to rotate at a forward speed proportional to the amount of retraction force applied by the operator to the firing trigger 20. Forward rotation of the motor 65 causes the main drive shaft 48 to rotate via the gear drive train, which causes the knife 32 and sled 33 to travel down the channel 22 and sever tissue clamped in the end effector 12. The control circuit receives the output signals from the encoder 268 regarding the incremental rotations of the main drive shaft assembly and sends a signal to the second motor 265 to caused the second motor 265 to rotate, which causes the threaded rod 266 to retract into the motor 265. This allows the upper portion 230 of the firing trigger 20 to rotate CCW, which allows the lower portion 228 of the firing trigger to also rotate CCW. In that way, because the reciprocating movement of the threaded rod 266 is related to the rotations of the main drive shaft assembly, the operator of the instrument 10, by way of his/her grip on the firing trigger 20, experiences tactile feedback as to the position of the end effector 12. The retraction force applied by the operator, however, does not directly affect the drive of the main drive shaft assembly because the firing trigger 20 is not geared into the gear drive train in this embodiment.

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By virtue of tracking the incremental rotations of the main drive shaft assembly via the output signals from the encoder 268, the control circuit can calculate when the knife 32 is fully deployed (i.e., fully extended). At this point, the control circuit may send a signal to the motor 65 to reverse direction to cause retraction of the knife 32. The reverse direction of the motor 65 causes the rotation of the main drive shaft assembly to reverse direction, which is also detected by the encoder 268. Based on the reverse rotation detected by the encoder 268, the control circuit sends a signal to the second motor 265 to cause it to reverse rotational direction such that the threaded rod 266 starts to extend longitudinally from the motor 265. This motion forces the upper portion 230 of the firing trigger 20 to rotate CW, which causes the lower portion 228 to rotate CW. In that way, the operator may experience a CW force from the firing trigger 20, which provides feedback to the operator as to the retraction position of the knife 32 in the end effector 12. The control circuit can determine when the knife 32 is fully retracted. At this point, the control circuit may send a signal to the motor 65 to stop rotation.

According to other embodiments, rather than having the control circuit determine the position of the knife 32, reverse motor and stop motor sensors may be used, as described above. In addition, rather than using a proportional sensor 110 to control the rotation of the motor 65, an on/off switch or sensor can be used. In such an embodiment, the operator would not be able to control the rate of rotation of the motor 65. Rather, it would rotate at a preprogrammed rate.

The various embodiments of the present invention have been described above in connection with cutting-type surgical instruments. It should be noted, however, that in other embodiments, the inventive surgical instrument disclosed herein need not be a cutting-type surgical instrument. For example, it could be a non-cutting endoscopic instrument, a grasper, a stapler, a clip applier, an access device, a drug/gene therapy delivery device, an energy device using ultrasound, RF, laser, etc.

Although the present invention has been described herein in connection with certain disclosed embodiments, many modifications and variations to those embodiments may be implemented. For example, different types of end effectors may be employed. Also, where materials are disclosed for certain components, other materials may be used. The foregoing description and following claims are intended to cover all such modification and variations.

Any patent, publication, or other disclosure material, in whole or in part, that is said to be incorporated by reference herein is incorporated herein only to the extent that the incorporated materials does not conflict with existing definitions, statements, or other disclosure material set forth in this disclosure. As such, and to the extent necessary, the disclosure as explicitly set forth herein supersedes any conflicting material incorporated herein by reference. Any material, or portion thereof, that is said to be incorporated by reference herein, but which conflicts with existing definitions, statements, or other disclosure material set forth herein will only be incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material.

What is claimed is:

1. A surgical cutting and fastening instrument comprising: an end effector comprising:
  - an elongate channel;
  - a clamping member pivotably connected to the channel;
  - and

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a moveable cutting instrument for traversing the channel to cut an object clamped in the end effector by the clamping member when the clamping member is in a clamped position;

a main drive shaft assembly for actuating the cutting instrument in the end effector;

a gear drive train connected to the main drive shaft assembly;

a motor for actuating the gear drive train;

a closure trigger;

a mechanical closure system connected to the closure trigger and to the clamping member for causing the clamping member to pivot to the clamped position when the closure trigger is retracted; and

a firing trigger separate from the closure trigger for actuating the motor when the firing trigger is retracted to cause the cutting instrument to traverse the channel such that a loading force on the firing trigger when retracted is related to another loading force experienced by the cutting instrument as the cutting instrument cuts the object clamped in the end effector.

2. The surgical cutting and fastening instrument of claim 1, wherein the mechanical closure system comprises:

a bracket connected to the closure trigger; and

a closure tube assembly having a distal end connected to the clamping member and a proximate end seated in the bracket.

3. The surgical cutting and fastening instrument of claim 2, wherein retraction of the closure trigger causes the closure tube assembly to slide proximally such that the clamping member rotates from an open position to the clamped position.

4. The surgical cutting and fastening instrument of claim 3, wherein the end effector includes a staple cartridge seated in the elongate channel and the clamping member comprises an anvil.

5. The surgical cutting and fastening instrument of claim 3, further comprising a locking mechanism for locking the closure trigger when retracted.

6. The surgical cutting and fastening instrument of claim 3, wherein the end effector further comprises a helical drive screw, such that forward rotation of the helical drive screw causes the cutting instrument to undertake the cutting stroke by traveling distally along the channel, and reverse rotation of the helical drive screw causes the cutting instrument to retract by traveling proximally along the channel.

7. The surgical cutting and fastening instrument of claim 3, wherein the main drive shaft assembly includes articulation means for articulating the end effector.

8. The surgical cutting and fastening instrument of claim 3, wherein the firing trigger is geared into the gear drive train.

9. The surgical cutting and fastening instrument of claim 3, further comprising a tactile position feedback system for applying force to the firing trigger such that the position of the firing trigger is related to the position of the cutting instrument in the end effector.

10. The surgical cutting and fastening instrument of claim 3, further comprising a run motor sensor for sensing retraction of the firing trigger, wherein, when retraction of the firing trigger is sensed by the run motor sensor, the motor is signaled to forward rotate to cause cutting of the object positioned in the end effector by the cutting instrument.

11. The surgical cutting and fastening instrument of claim 10, wherein the run motor sensor comprises a proportional switch such that the rate of rotation of the motor is proportional to the retraction force applied to the firing trigger.

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12. The surgical cutting and fastening instrument of claim 11, further comprising:

a reverse motor sensor for sensing a condition indicative of an end of a cutting stroke by the cutting instrument; and

a stop motor sensor for sensing a condition indicative of retraction of the cutting instrument.

13. The surgical cutting and fastening instrument of claim 3, wherein the mechanical closure system further comprises a yoke connecting the closure trigger to the bracket.

14. The surgical cutting and fastening instrument of claim 3, wherein the motor and a battery for powering the motor are disposed in a handle of the instrument.

15. The surgical cutting and fastening instrument of claim 3, wherein the closure tube assembly comprises a proximate closure tube and a distal closure tube, and wherein the main drive shaft assembly is disposed inside the closure tube assembly.

16. The surgical cutting and fastening instrument of claim 15, further comprising a spine tube disposed between the closure tube assembly and the main drive shaft assembly.

17. The surgical cutting and fastening instrument of claim 1, wherein the rotational position of the firing trigger is related to the position of the cutting instrument in the end effector.

18. A surgical cutting and fastening instrument comprising:

an end effector comprising:

an elongate channel;

a clamping member pivotably connected to the channel; and

a moveable cutting instrument for traversing the channel to cut an object clamped in the end effector by the clamping member when the clamping member is in a clamped position;

a main drive shaft assembly for actuating the cutting instrument in the end effector;

a handle comprising:

a gear drive train connected to the main drive shaft assembly;

a motor for actuating the gear drive train;

a closure trigger; and

a firing trigger separate from the closure trigger for actuating the motor when the firing trigger is retracted, wherein a loading force on the firing trigger when retracted is related to another loading force experienced by the cutting instrument; and

a mechanical closure system connected to the closure trigger and to the clamping member for causing the clamping member to pivot to the clamped position when the closure trigger is retracted, wherein the mechanical closure system comprises:

a bracket connected to the closure trigger; and

a closure tube assembly having a distal end connected to the clamping member and a proximate end seated in the bracket.

19. The surgical cutting and fastening instrument of claim 18, wherein retraction of the closure trigger causes the closure tube assembly to slide proximally such that the clamping member rotates from an open position to the clamped position.

20. The surgical cutting and fastening instrument of claim 19, wherein the end effector further comprises a helical drive screw, such that forward rotation of the helical drive screw causes the cutting instrument to undertake the cutting stroke by traveling distally along the channel, and reverse rotation of the helical drive screw causes the cutting instrument to retract by traveling proximally along the channel.

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**21.** The surgical cutting and fastening instrument of claim **18**, wherein the rotational position of the firing trigger is related to the position of the cutting instrument in the end effector.

**22.** A surgical cutting and fastening instrument comprising: 5

an end effector comprising:

an elongate channel;

a clamping member pivotably connected to the channel; 10 and

a moveable cutting instrument for traversing the channel to cut an object clamped in the end effector by the clamping member when the clamping member is in a clamped position;

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a main drive shaft assembly for actuating the cutting instrument in the end effector;

a gear drive train connected to the main drive shaft assembly;

a motor for actuating the gear drive train;

a closure trigger;

means for causing the clamping member to pivot to the clamped position when the closure trigger is retracted; and

a firing trigger separate from the closure trigger for actuating the motor when the firing trigger is retracted, wherein the rotational position of the firing trigger is related to the position of the cutting instrument in the end effector.

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