US009585664B2

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

(10) **Patent No.: US 9,585,664 B2**
(45) **Date of Patent: *Mar. 7, 2017**

(54) **POWERED SURGICAL STAPLING DEVICE PLATFORM**

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

(72) Inventors: **Michael Zemlok**, Prospect, CT (US); **David C. Racenet**, Killingworth, CT (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/180,830**

(22) Filed: **Jun. 13, 2016**

(65) **Prior Publication Data**

US 2016/0287255 A1 Oct. 6, 2016

Related U.S. Application Data

(60) Continuation of application No. 13/889,580, filed on May 8, 2013, now Pat. No. 9,364,222, which is a (Continued)

(51) **Int. Cl.**
A61B 17/068 (2006.01)
A61B 17/10 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***A61B 17/105*** (2013.01); ***A61B 17/068*** (2013.01); ***A61B 17/07207*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC A61B 17/068; A61B 17/072; A61B 17/00; A61B 17/29; A61B 2017/00398;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

37,165	A	12/1862	Gary
3,079,606	A	3/1963	Bobrov et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP	0634144	A1	1/1995
EP	0647431	A2	4/1995

(Continued)

OTHER PUBLICATIONS

Extended European Search Report for EP 08 25 1568 dated Jun. 11, 2015.

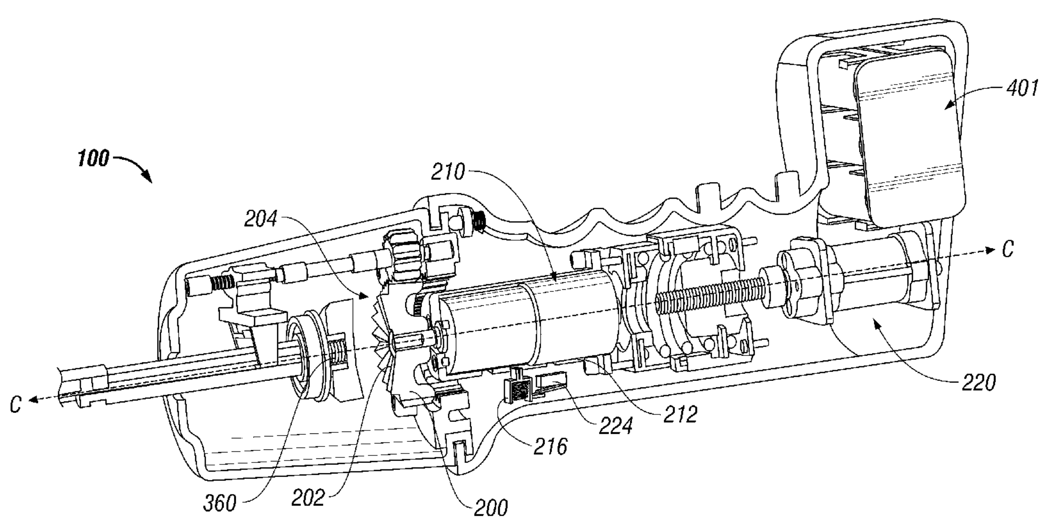
(Continued)

Primary Examiner — Michelle Lopez

(57) **ABSTRACT**

The present disclosure provides for a surgical instrument which includes a housing and an endoscopic portion extending distally from the housing and defining a first longitudinal axis. The surgical instrument also includes an end effector disposed adjacent a distal portion of the endoscopic portion. The end effector includes an anvil assembly and a cartridge assembly. The anvil assembly is pivotally coupled to the cartridge assembly to be movable from a first actuation position to at least one other second actuation position. The surgical instrument further includes a firing rod having a shaft defining a second longitudinal axis, the shaft having a cam member which is in mechanical cooperation with the anvil assembly and is configured to move the anvil assembly from the first actuation position to the at least one other second actuation position upon rotation of the firing rod about the second longitudinal axis.

21 Claims, 15 Drawing Sheets



Related U.S. Application Data

continuation of application No. 12/869,193, filed on Aug. 26, 2010, now Pat. No. 8,459,521, which is a division of application No. 11/799,766, filed on May 1, 2007, now Pat. No. 7,823,760.

(51) **Int. Cl.**
A61B 17/072 (2006.01)
A61B 17/00 (2006.01)
A61B 17/29 (2006.01)

(52) **U.S. Cl.**
CPC *A61B 2017/00084* (2013.01); *A61B 2017/00199* (2013.01); *A61B 2017/00221* (2013.01); *A61B 2017/00398* (2013.01); *A61B 2017/00734* (2013.01); *A61B 2017/2905* (2013.01); *A61B 2017/2927* (2013.01); *A61B 2090/0811* (2016.02)

(58) **Field of Classification Search**
CPC .. A61B 2090/0811; A61B 2017/00734; A61B 2017/2927; A61B 2017/00017; A61B 34/30; A61B 2017/00199
USPC 227/175.1
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,209,754 A 10/1965 Brown
3,273,562 A 9/1966 Brown
3,490,675 A 1/1970 Green et al.
3,499,591 A 3/1970 Green
3,528,693 A 9/1970 Pearson et al.
3,744,495 A 7/1973 Johnson
3,862,631 A 1/1975 Austin
3,949,924 A 4/1976 Green
4,060,089 A 11/1977 Noiles
4,204,623 A 5/1980 Green
4,217,902 A 8/1980 March
4,263,903 A 4/1981 Griggs
4,275,813 A 6/1981 Noiles
4,331,277 A 5/1982 Green
4,428,376 A 1/1984 Mericle
4,429,695 A 2/1984 Green
4,444,181 A 4/1984 Wevers et al.
4,454,875 A 6/1984 Pratt et al.
4,456,006 A 6/1984 Wevers et al.
4,473,077 A 9/1984 Noiles et al.
4,485,816 A 12/1984 Krumme
4,485,817 A 12/1984 Swiggett
4,488,523 A 12/1984 Shichman
4,508,253 A 4/1985 Green
4,508,523 A 4/1985 Leu
4,522,206 A 6/1985 Whipple et al.
4,534,350 A 8/1985 Golden et al.
4,535,772 A 8/1985 Sheehan
4,566,620 A 1/1986 Green et al.
4,570,623 A 2/1986 Ellison et al.
4,606,343 A 8/1986 Conta et al.
4,606,344 A 8/1986 Di Giovanni
4,610,383 A 9/1986 Rothfuss et al.
4,612,923 A 9/1986 Kronenthal
4,612,933 A 9/1986 Brinkerhoff et al.
D286,442 S 10/1986 Korthoff et al.
4,627,437 A 12/1986 Bedi et al.
4,635,637 A 1/1987 Schreiber
4,662,371 A 5/1987 Whipple et al.
4,671,280 A 6/1987 Dorband et al.
4,705,038 A 11/1987 Sjostrom et al.
4,712,550 A 12/1987 Sinnett
4,719,917 A 1/1988 Barrows et al.
4,724,839 A 2/1988 Bedi et al.
4,805,617 A 2/1989 Bedi et al.
4,807,628 A 2/1989 Peters et al.
4,852,558 A 8/1989 Outerbridge
4,913,144 A 4/1990 Del Medico
4,930,494 A 6/1990 Takehana et al.
4,954,952 A 9/1990 Ubhayakar et al.
4,960,420 A 10/1990 Goble et al.
4,962,877 A 10/1990 Hervas
4,990,153 A 2/1991 Richards
4,994,073 A 2/1991 Green
4,995,877 A 2/1991 Ams et al.
5,040,715 A 8/1991 Green et al.
5,042,707 A 8/1991 Taheri
5,065,929 A 11/1991 Schulze et al.
5,089,009 A 2/1992 Green
5,108,422 A 4/1992 Green et al.
5,114,399 A 5/1992 Kovalcheck
5,129,570 A 7/1992 Schulze et al.
5,143,453 A 9/1992 Weynant nee Girones
5,203,864 A 4/1993 Phillips
5,207,697 A 5/1993 Carusillo et al.
5,209,756 A 5/1993 Seedhom et al.
5,246,443 A 9/1993 Mai
5,254,130 A 10/1993 Poncet et al.
5,258,008 A 11/1993 Wilk
5,271,381 A 12/1993 Ailinger et al.
5,271,543 A 12/1993 Grant et al.
RE34,519 E 1/1994 Fox et al.
5,282,829 A 2/1994 Hermes
5,300,081 A 4/1994 Young et al.
5,307,976 A 5/1994 Olson et al.
5,312,023 A 5/1994 Green et al.
5,312,024 A 5/1994 Grant et al.
5,313,935 A 5/1994 Kortenbach et al.
5,318,221 A 6/1994 Green et al.
5,326,013 A 7/1994 Green et al.
5,330,486 A 7/1994 Wilk
5,332,142 A 7/1994 Robinson et al.
5,342,376 A 8/1994 Ruff
5,350,355 A 9/1994 Sklar
5,356,064 A 10/1994 Green et al.
5,359,993 A 11/1994 Slater et al.
5,364,001 A 11/1994 Bryan
5,381,943 A 1/1995 Allen et al.
5,383,874 A 1/1995 Jackson et al.
5,383,880 A 1/1995 Hooven
5,389,098 A 2/1995 Tsuruta et al.
5,395,030 A 3/1995 Kuramoto et al.
5,395,033 A 3/1995 Byrne et al.
5,400,267 A 3/1995 Denen et al.
5,403,312 A 4/1995 Yates et al.
5,405,344 A 4/1995 Williamson et al.
5,411,508 A 5/1995 Bessler et al.
5,413,267 A 5/1995 Solyntjes et al.
5,431,323 A 7/1995 Smith et al.
5,464,144 A 11/1995 Guy et al.
5,467,911 A 11/1995 Tsuruta et al.
5,478,344 A 12/1995 Stone et al.
5,482,100 A 1/1996 Kuhar
5,485,947 A 1/1996 Olson et al.
5,487,499 A 1/1996 Sorrentino et al.
5,497,933 A 3/1996 DeFonzo et al.
5,500,000 A 3/1996 Feagin et al.
5,503,320 A 4/1996 Webster et al.
5,507,743 A 4/1996 Edwards et al.
5,518,163 A 5/1996 Hooven
5,518,164 A 5/1996 Hooven
5,526,822 A 6/1996 Burbank et al.
5,529,235 A 6/1996 Boiarski et al.
5,531,744 A 7/1996 Nardella et al.
5,533,661 A 7/1996 Main et al.
5,535,934 A 7/1996 Boiarski et al.
5,535,937 A 7/1996 Boiarski et al.
5,558,671 A 9/1996 Yates
5,560,532 A 10/1996 DeFonzo et al.
5,562,239 A 10/1996 Boiarski et al.
5,571,285 A 11/1996 Chow et al.
5,575,799 A 11/1996 Bolanos et al.
5,582,611 A 12/1996 Tsuruta et al.
5,584,835 A 12/1996 Greenfield

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,601,224	A	2/1997	Bishop et al.
5,601,558	A	2/1997	Torrie et al.
5,607,095	A	3/1997	Smith et al.
5,609,285	A	3/1997	Grant et al.
5,609,560	A	3/1997	Ichikawa et al.
5,624,452	A	4/1997	Yates
5,632,433	A	5/1997	Grant et al.
5,634,926	A	6/1997	Jobe
5,642,848	A	7/1997	Ludwig et al.
5,653,374	A	8/1997	Young et al.
5,658,300	A	8/1997	Bito et al.
5,658,312	A	8/1997	Green et al.
5,662,662	A	9/1997	Bishop et al.
5,665,085	A	9/1997	Nardella
5,667,513	A	9/1997	Torrie et al.
5,667,517	A	9/1997	Hooven
5,667,527	A	9/1997	Cook
5,669,544	A	9/1997	Schulze et al.
5,673,841	A	10/1997	Schulze et al.
5,676,674	A	10/1997	Bolanos et al.
5,680,981	A	10/1997	Mililli et al.
5,680,982	A	10/1997	Schulze et al.
5,692,668	A	12/1997	Schulze et al.
5,695,506	A	12/1997	Pike et al.
5,695,524	A	12/1997	Kelley et al.
5,702,447	A	12/1997	Walch et al.
5,704,534	A	1/1998	Huitema et al.
5,713,505	A	2/1998	Huitema
5,713,896	A	2/1998	Nardella
5,715,987	A	2/1998	Kelley et al.
5,716,366	A	2/1998	Yates
5,720,753	A	2/1998	Sander et al.
5,725,529	A	3/1998	Nicholson et al.
5,728,110	A	3/1998	Vidal et al.
5,728,116	A	3/1998	Rosenman
5,730,757	A	3/1998	Benetti et al.
5,735,848	A	4/1998	Yates et al.
5,738,474	A	4/1998	Blewett
5,755,726	A	5/1998	Pratt et al.
5,759,171	A	6/1998	Coelho et al.
5,779,130	A	7/1998	Alesi et al.
5,782,397	A	7/1998	Koukline
5,785,713	A	7/1998	Jobe
5,788,698	A	8/1998	Savornin
5,810,811	A	9/1998	Yates et al.
5,814,038	A	9/1998	Jensen et al.
5,823,066	A	10/1998	Huitema et al.
5,829,662	A	11/1998	Allen et al.
5,830,121	A	11/1998	Enomoto et al.
5,849,023	A	12/1998	Mericle
5,849,028	A	12/1998	Chen
5,855,311	A	1/1999	Hamblin et al.
5,861,005	A	1/1999	Kontos
5,865,361	A	2/1999	Milliman et al.
5,876,401	A	3/1999	Schulze et al.
5,891,156	A	4/1999	Gessner et al.
5,893,813	A	4/1999	Yamamoto
5,895,396	A	4/1999	Day et al.
5,906,607	A	5/1999	Taylor et al.
5,911,721	A	6/1999	Nicholson et al.
5,916,146	A	6/1999	Allotta et al.
5,918,791	A	7/1999	Sorrentino et al.
5,928,222	A	7/1999	Kleinerman
5,944,717	A	8/1999	Lee et al.
5,944,736	A	8/1999	Taylor et al.
5,954,259	A	9/1999	Viola et al.
5,961,521	A	10/1999	Roger
5,964,394	A	10/1999	Robertson
5,968,044	A	10/1999	Nicholson et al.
5,976,171	A	11/1999	Taylor
5,980,518	A	11/1999	Carr et al.
5,980,548	A	11/1999	Evans et al.
5,991,355	A	11/1999	Dahlke
5,991,650	A	11/1999	Swanson et al.
5,992,724	A	11/1999	Snyder
5,997,552	A	12/1999	Person et al.
6,004,335	A	12/1999	Vaitekunas et al.
6,007,550	A	12/1999	Wang et al.
6,010,054	A	1/2000	Johnson et al.
6,013,077	A	1/2000	Harwin
6,015,417	A	1/2000	Reynolds, Jr.
6,017,354	A	1/2000	Culp et al.
6,030,410	A	2/2000	Zurbrugg
6,032,849	A	3/2000	Mastri et al.
6,039,731	A	3/2000	Taylor et al.
6,051,007	A	4/2000	Hogendijk et al.
6,063,078	A	5/2000	Wittkampf
6,063,095	A	5/2000	Wang et al.
6,077,246	A	6/2000	Kullas et al.
6,079,606	A	6/2000	Milliman et al.
6,080,150	A	6/2000	Gough
6,083,242	A	7/2000	Cook
6,090,123	A	7/2000	Culp et al.
6,092,422	A	7/2000	Binnig et al.
6,109,500	A	8/2000	Alli et al.
6,113,592	A	9/2000	Taylor
6,123,702	A	9/2000	Swanson et al.
H1904	H	10/2000	Yates et al.
6,126,058	A	10/2000	Adams et al.
6,126,651	A	10/2000	Mayer
6,127,811	A	10/2000	Shenoy et al.
6,132,425	A	10/2000	Gough
6,165,169	A	12/2000	Panescu et al.
6,166,538	A	12/2000	D'Alfonso
6,179,840	B1	1/2001	Bowman
6,187,009	B1	2/2001	Herzog et al.
6,187,019	B1	2/2001	Stefanchik et al.
6,190,401	B1	2/2001	Green et al.
6,193,501	B1	2/2001	Masel et al.
6,202,914	B1	3/2001	Geiste et al.
6,217,573	B1	4/2001	Webster
6,228,534	B1	5/2001	Takeuchi et al.
6,231,565	B1	5/2001	Tovey et al.
6,236,874	B1	5/2001	Devlin et al.
6,237,604	B1	5/2001	Burnside et al.
6,241,139	B1	6/2001	Milliman et al.
6,245,065	B1	6/2001	Panescu et al.
6,248,117	B1	6/2001	Blatter
6,250,532	B1	6/2001	Green et al.
6,258,111	B1	7/2001	Ross et al.
6,264,086	B1	7/2001	McGuckin, Jr.
6,264,087	B1	7/2001	Whitman
6,264,653	B1	7/2001	Falwell
6,281,471	B1	8/2001	Smart
6,288,534	B1	9/2001	Starkweather et al.
6,290,701	B1	9/2001	Enayati
6,293,943	B1	9/2001	Panescu et al.
6,295,330	B1	9/2001	Skog et al.
6,315,184	B1	11/2001	Whitman
6,329,778	B1	12/2001	Culp et al.
6,330,965	B1	12/2001	Milliman et al.
6,346,104	B2	2/2002	Daly et al.
6,355,066	B1	3/2002	Kim
6,364,884	B1	4/2002	Bowman et al.
6,387,092	B1	5/2002	Burnside et al.
6,388,240	B2	5/2002	Schulz et al.
6,402,766	B2	6/2002	Bowman et al.
H2037	H	7/2002	Yates et al.
6,412,279	B1	7/2002	Coleman et al.
6,425,903	B1	7/2002	Voegele
6,436,097	B1	8/2002	Nardella
6,436,107	B1	8/2002	Wang et al.
6,436,110	B2	8/2002	Bowman et al.
6,443,973	B1	9/2002	Whitman
6,447,517	B1	9/2002	Bowman
6,461,372	B1	10/2002	Jensen et al.
6,478,210	B2	11/2002	Adams et al.
6,497,707	B1	12/2002	Bowman et al.
6,505,768	B2	1/2003	Whitman
6,515,273	B2	2/2003	Al-Ali
6,524,316	B1	2/2003	Nicholson et al.
6,533,157	B1	3/2003	Whitman
6,540,751	B2	4/2003	Enayati
6,544,273	B1	4/2003	Harari et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,554,852	B1	4/2003	Oberlander
6,562,071	B2	5/2003	Jarvinen
6,578,579	B2	6/2003	Burnside et al.
6,601,748	B1	8/2003	Fung et al.
6,601,749	B2	8/2003	Sullivan et al.
6,602,252	B2	8/2003	Mollenauer
6,611,793	B1	8/2003	Burnside et al.
6,616,821	B2	9/2003	Broadley et al.
6,629,986	B1	10/2003	Ross et al.
6,651,669	B1	11/2003	Burnside
6,656,177	B2	12/2003	Truckai et al.
6,669,073	B2	12/2003	Milliman et al.
6,669,705	B2	12/2003	Westhaver et al.
6,696,008	B2	2/2004	Brandinger
6,698,643	B2	3/2004	Whitman
6,699,177	B1	3/2004	Wang et al.
6,716,233	B1	4/2004	Whitman
6,736,085	B1	5/2004	Esnouf
6,743,239	B1	6/2004	Kuehn et al.
6,792,390	B1	9/2004	Burnside et al.
6,793,652	B1	9/2004	Whitman et al.
6,817,508	B1	11/2004	Racenet et al.
6,830,174	B2	12/2004	Hillstead et al.
6,843,403	B2	1/2005	Whitman
6,846,307	B2	1/2005	Whitman et al.
6,846,308	B2	1/2005	Whitman et al.
6,846,309	B2	1/2005	Whitman et al.
6,849,071	B2	2/2005	Whitman et al.
6,861,639	B2	3/2005	Al-Ali
6,872,214	B2	3/2005	Sonnenschein et al.
6,899,538	B2	5/2005	Matoba
6,900,004	B2	5/2005	Satake
6,905,057	B2	6/2005	Swayze et al.
6,926,636	B2	8/2005	Luper
6,953,139	B2	10/2005	Milliman et al.
6,959,852	B2	11/2005	Shelton, IV et al.
6,964,363	B2	11/2005	Wales et al.
6,979,328	B2	12/2005	Baerveldt et al.
6,981,628	B2	1/2006	Wales
6,981,941	B2	1/2006	Whitman et al.
6,988,649	B2	1/2006	Shelton, IV et al.
7,000,819	B2	2/2006	Swayze et al.
7,032,798	B2	4/2006	Whitman et al.
7,044,353	B2	5/2006	Mastri et al.
7,048,687	B1	5/2006	Reuss et al.
7,055,731	B2	6/2006	Shelton, IV et al.
7,059,508	B2	6/2006	Shelton, IV et al.
7,077,856	B2	7/2006	Whitman
7,083,075	B2	8/2006	Swayze et al.
7,097,089	B2	8/2006	Marczyk
7,111,769	B2	9/2006	Wales et al.
7,118,564	B2	10/2006	Ritchie et al.
7,122,029	B2	10/2006	Koop et al.
7,128,253	B2	10/2006	Mastri et al.
7,128,254	B2	10/2006	Shelton, IV et al.
7,140,528	B2	11/2006	Shelton, IV
7,143,924	B2	12/2006	Scirica et al.
7,143,925	B2	12/2006	Shelton, IV et al.
7,143,926	B2	12/2006	Shelton, IV et al.
7,147,138	B2	12/2006	Shelton, IV
7,186,966	B2	3/2007	Al-Ali
7,193,519	B2	3/2007	Root et al.
7,217,269	B2	5/2007	El-Galley et al.
7,220,232	B2	5/2007	Suorsa et al.
7,240,817	B2	7/2007	Higuchi
7,241,270	B2	7/2007	Horzewski et al.
7,246,734	B2	7/2007	Shelton, IV
7,303,108	B2	12/2007	Shelton, IV
7,328,828	B2	2/2008	Ortiz et al.
7,335,169	B2	2/2008	Thompson et al.
7,364,061	B2	4/2008	Swayze et al.
7,380,695	B2	6/2008	Doll et al.
7,380,696	B2	6/2008	Shelton, IV et al.
7,404,508	B2	7/2008	Smith et al.
7,416,101	B2	8/2008	Shelton, IV et al.

7,419,080	B2	9/2008	Smith et al.
7,422,136	B1	9/2008	Marczyk
7,422,139	B2	9/2008	Shelton, IV et al.
7,431,188	B1	10/2008	Marczyk
7,431,189	B2	10/2008	Shelton, IV et al.
7,434,715	B2	10/2008	Shelton, IV et al.
7,441,684	B2	10/2008	Shelton, IV et al.
7,448,525	B2	11/2008	Shelton, IV et al.
7,461,767	B2	12/2008	Viola et al.
7,464,846	B2	12/2008	Shelton, IV et al.
7,464,847	B2	12/2008	Viola et al.
7,464,849	B2	12/2008	Shelton, IV et al.
7,481,348	B2	1/2009	Marczyk
7,487,899	B2	2/2009	Shelton, IV et al.
7,549,563	B2	6/2009	Mather et al.
7,552,854	B2	6/2009	Wixey et al.
7,556,185	B2	7/2009	Viola
7,568,603	B2	8/2009	Shelton, IV et al.
7,637,409	B2	12/2009	Marczyk
7,641,093	B2	1/2010	Doll et al.
7,644,848	B2	1/2010	Swayze et al.
7,648,055	B2	1/2010	Marczyk
7,670,334	B2	3/2010	Hueil et al.
7,678,117	B2	3/2010	Hinman et al.
7,721,931	B2	5/2010	Shelton, IV et al.
7,740,159	B2	6/2010	Shelton, IV et al.
7,753,248	B2	7/2010	Viola
7,757,925	B2	7/2010	Viola et al.
7,766,207	B2	8/2010	Mather et al.
7,766,210	B2	8/2010	Shelton, IV et al.
7,770,775	B2	8/2010	Shelton, IV et al.
7,815,090	B2	10/2010	Marczyk
7,823,760	B2	11/2010	Zemlok et al.
7,845,534	B2	12/2010	Viola et al.
7,950,560	B2	5/2011	Zemlok et al.
8,241,322	B2 *	8/2012	Whitman A61B 17/07207 227/175.1
8,459,521	B2 *	6/2013	Zemlok A61B 17/07207 227/175.1
9,364,222	B2 *	6/2016	Zemlok A61B 17/07207
2002/0103489	A1	8/2002	Ku
2002/0111641	A1	8/2002	Peterson et al.
2002/0165541	A1	11/2002	Whitman
2003/0114851	A1	6/2003	Truckai et al.
2003/0120306	A1	6/2003	Burbank et al.
2004/0232201	A1	11/2004	Wenchell et al.
2005/0010235	A1	1/2005	VanDusseldorp
2005/0131390	A1	6/2005	Heinrich et al.
2005/0139636	A1	6/2005	Schwemberger et al.
2005/0145674	A1	7/2005	Sonnenschein et al.
2005/0177176	A1	8/2005	Gerbi et al.
2005/0187576	A1	8/2005	Whitman et al.
2005/0192609	A1	9/2005	Whitman et al.
2005/0247753	A1	11/2005	Kelly et al.
2005/0273085	A1	12/2005	Hinman et al.
2006/0000867	A1	1/2006	Shelton et al.
2007/0023477	A1	2/2007	Whitman et al.
2007/0029363	A1	2/2007	Popov
2007/0039995	A1	2/2007	Schwemberger et al.
2007/0084897	A1	4/2007	Shelton et al.
2007/0102472	A1	5/2007	Shelton
2007/0175949	A1	8/2007	Shelton et al.
2007/0175950	A1	8/2007	Shelton et al.
2007/0175951	A1	8/2007	Shelton et al.
2007/0175953	A1	8/2007	Shelton et al.
2007/0175955	A1	8/2007	Shelton et al.
2007/0219563	A1	9/2007	Voegele
2007/0265640	A1	11/2007	Kortenbach et al.
2008/0029570	A1	2/2008	Shelton et al.
2008/0029573	A1	2/2008	Shelton et al.
2008/0029574	A1	2/2008	Shelton et al.
2008/0029575	A1	2/2008	Shelton et al.
2008/0135600	A1	6/2008	Hiranuma et al.
2008/0169329	A1	7/2008	Shelton et al.
2008/0185419	A1	8/2008	Smith et al.
2008/0197167	A1	8/2008	Viola et al.
2008/0245842	A1	10/2008	Marczyk
2008/0251568	A1	10/2008	Zemlok et al.
2008/0255413	A1	10/2008	Zemlok et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0255418	A1	10/2008	Zemlok et al.
2008/0255607	A1	10/2008	Zemlok
2008/0281353	A1	11/2008	Aranyi et al.
2008/0314959	A1	12/2008	Viola et al.
2009/0032568	A1	2/2009	Viola et al.
2009/0090201	A1	4/2009	Viola
2009/0090763	A1	4/2009	Zemlok et al.
2009/0108048	A1	4/2009	Zemlok et al.
2010/0001036	A1	1/2010	Marczyk et al.
2010/0012702	A1	1/2010	Marczyk
2010/0089972	A1	4/2010	Marczyk
2010/0163596	A1	7/2010	Marczyk
2010/0200636	A1	8/2010	Zemlok et al.
2010/0252610	A1	10/2010	Viola
2010/0312257	A1	12/2010	Aranyi
2010/0320254	A1	12/2010	Zemlok et al.

FOREIGN PATENT DOCUMENTS

EP	0705571	A1	4/1996
EP	0738501	A1	10/1996
EP	0770354	A1	5/1997
EP	537570	B1	1/1998
EP	1070487	A2	1/2001
EP	1769754	A1	4/2007
EP	1813203	A2	8/2007
FR	2849589	A1	7/2004
WO	9729694	A1	8/1997
WO	9740760	A1	11/1997
WO	9837825	A1	9/1998
WO	9952489		10/1999
WO	0234140	A2	5/2002
WO	03026511	A1	4/2003
WO	03030743	A2	4/2003
WO	2004032760	A2	4/2004
WO	2007030753	A2	3/2007
WO	2007118179	A2	10/2007

OTHER PUBLICATIONS

European Search Report dated Jul. 28, 2011 for EP 11 15 2266.
U.S. Appl. No. 12/796,194, filed Jun. 8, 2010.
U.S. Appl. No. 12/959,421, filed Dec. 3, 2010.
U.S. Appl. No. 12/965,013, filed Dec. 10, 2010.
Detemple, R, "Microtechnology in Modem Health Care", Med Device Technol. 9(9):18-25 (1998).
European Search Report EP 06026840 dated May 10, 2007.
European Search Report EP 08251357.3 dated Sep. 29, 2009.
European Search Report EP 08252703.7 dated Oct. 31, 2008.
European Search Report EP 08253184.9 dated Feb. 27, 2009.
International Search Report PCT/US06/21524 dated May 28, 2008.
U.S. Appl. No. 13/715,364, filed Dec. 14, 2012, Aranyi et al.
Patent Examination Report No. 1 for Australian Patent Appln. No. AU 2014-200667 dated Mar. 5, 2015.

* cited by examiner

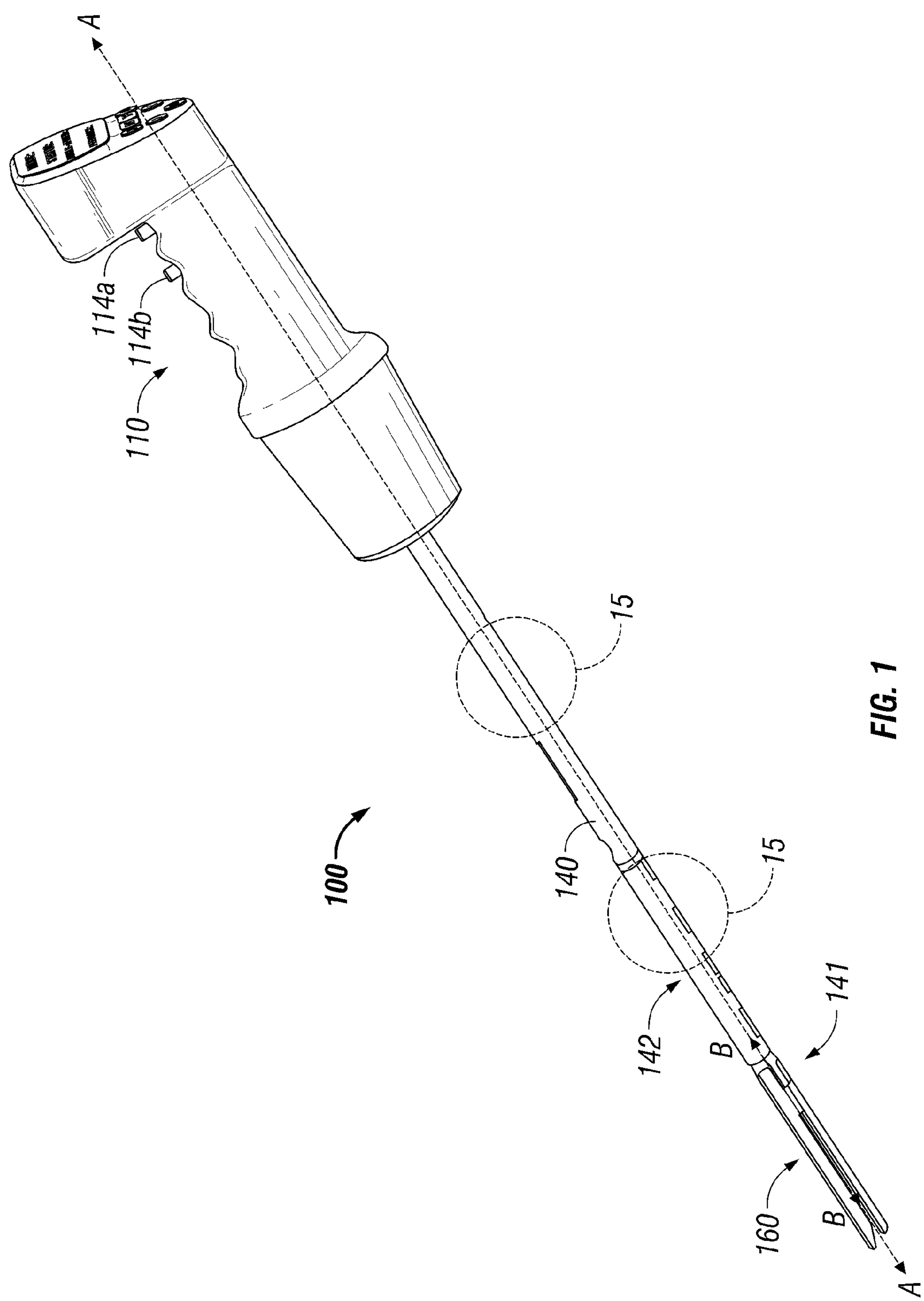


FIG. 1

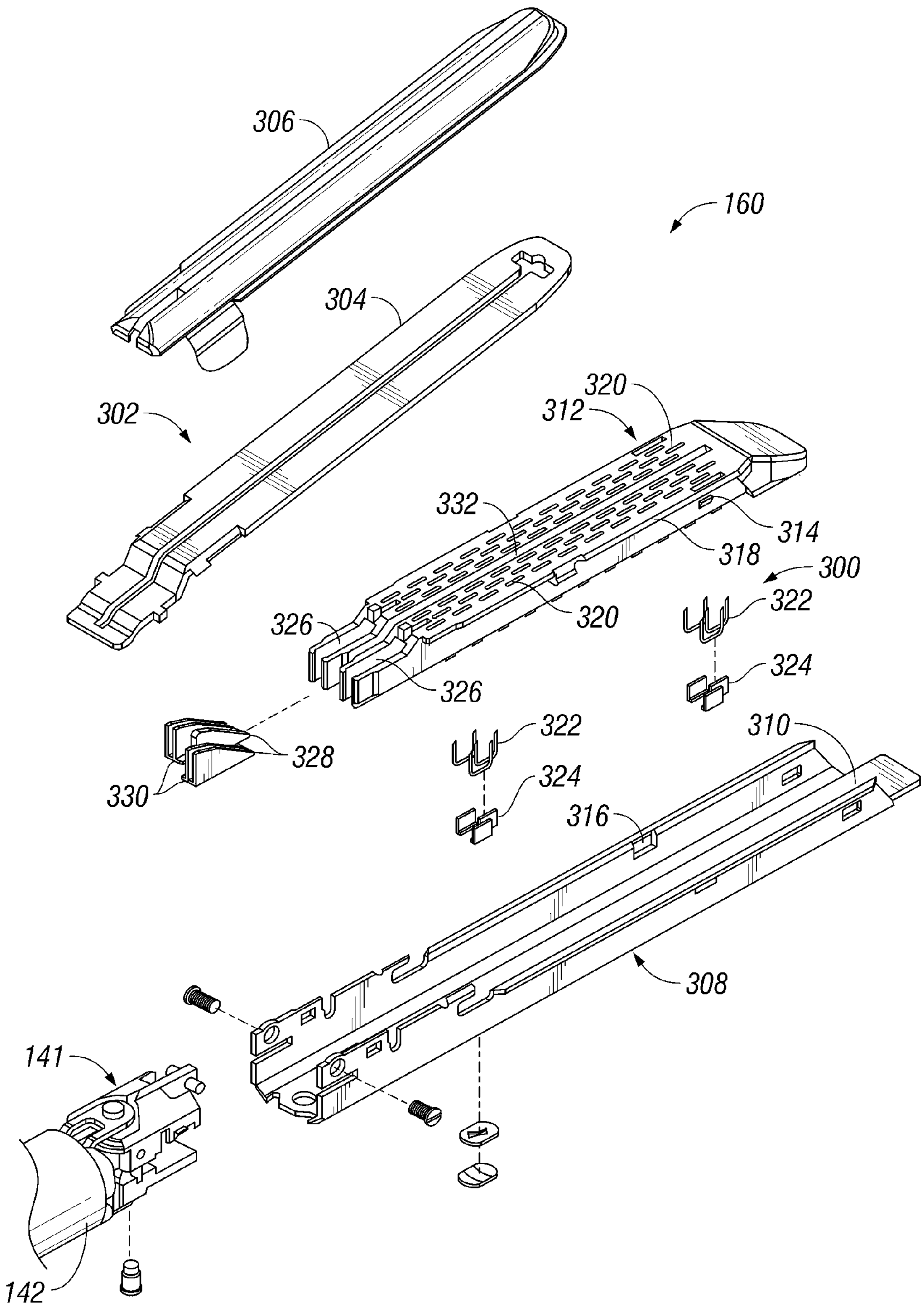

306
160
304
302
320
312
332
314
318
300
320
322
326
326
324
310
322
328
330
324
316
308
141
142

FIG. 2

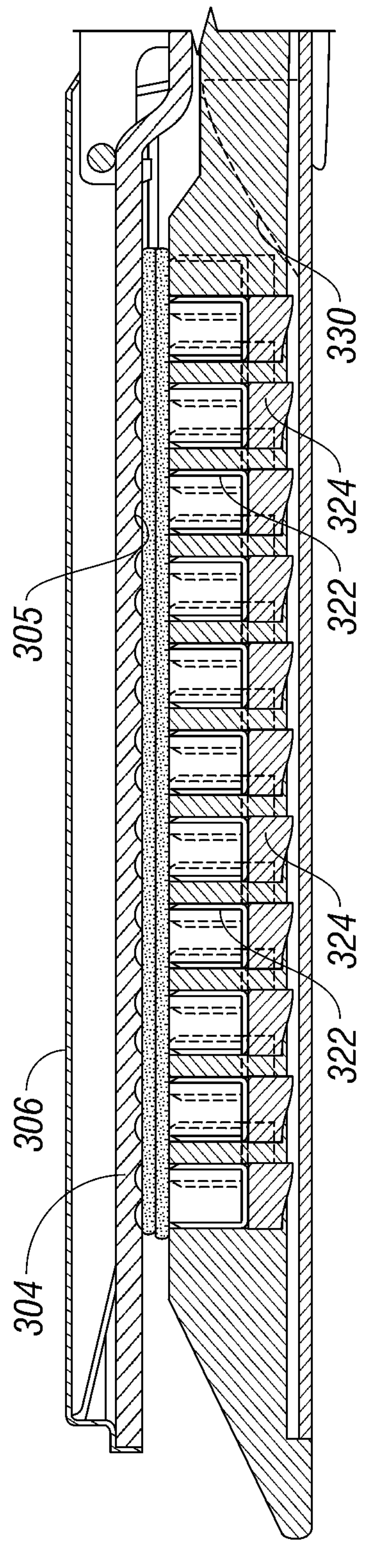


FIG. 3

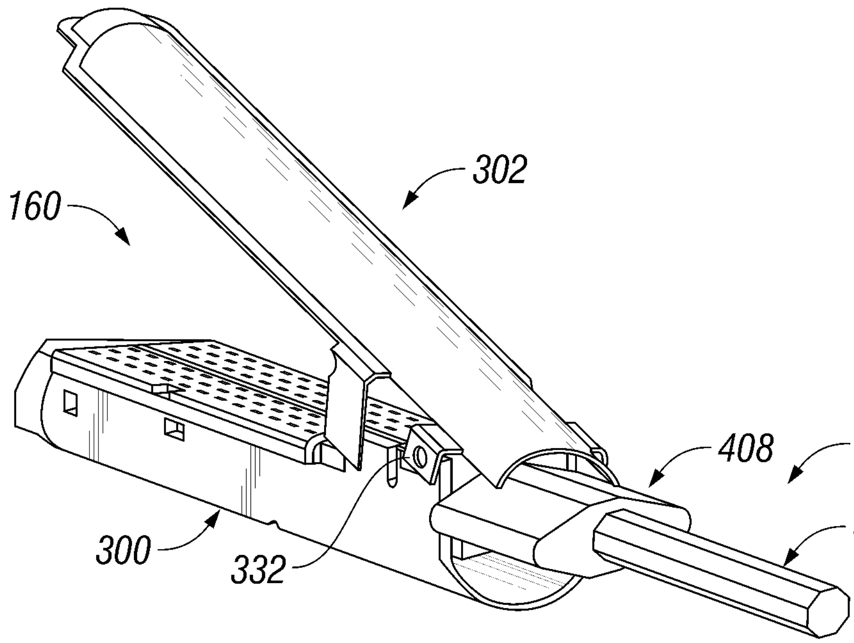


FIG. 4A

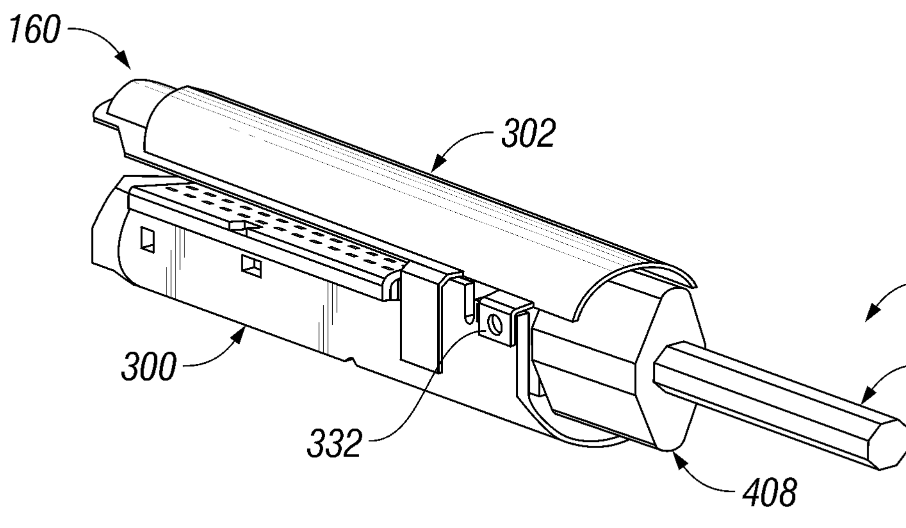


FIG. 4B

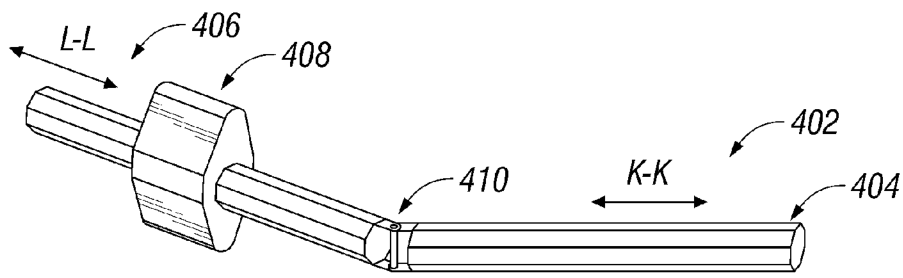

L-L
406
408
402
410
K-K
404

FIG. 5

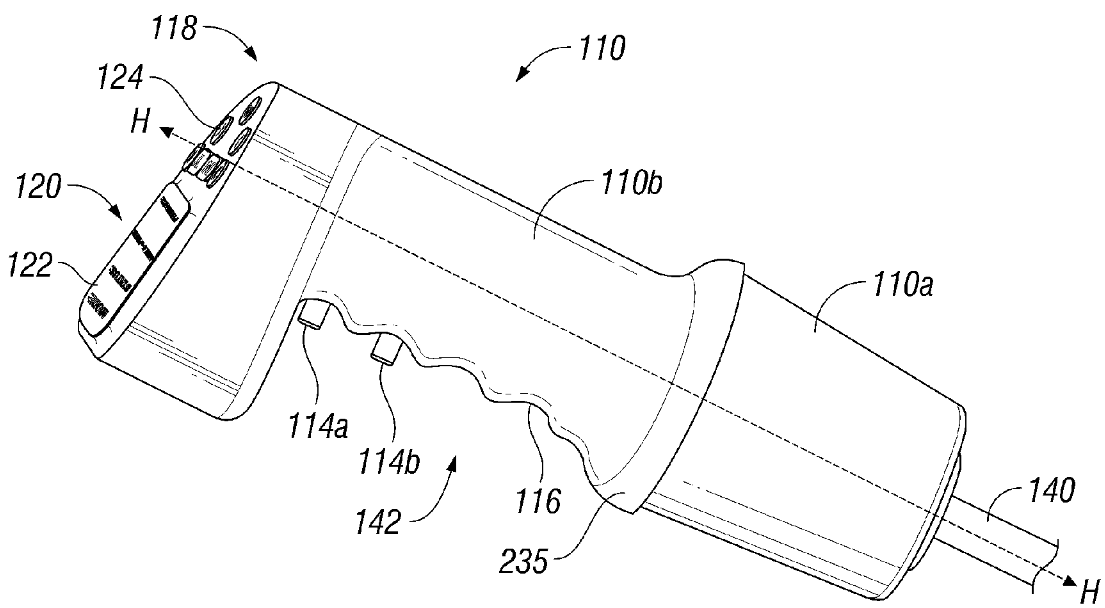
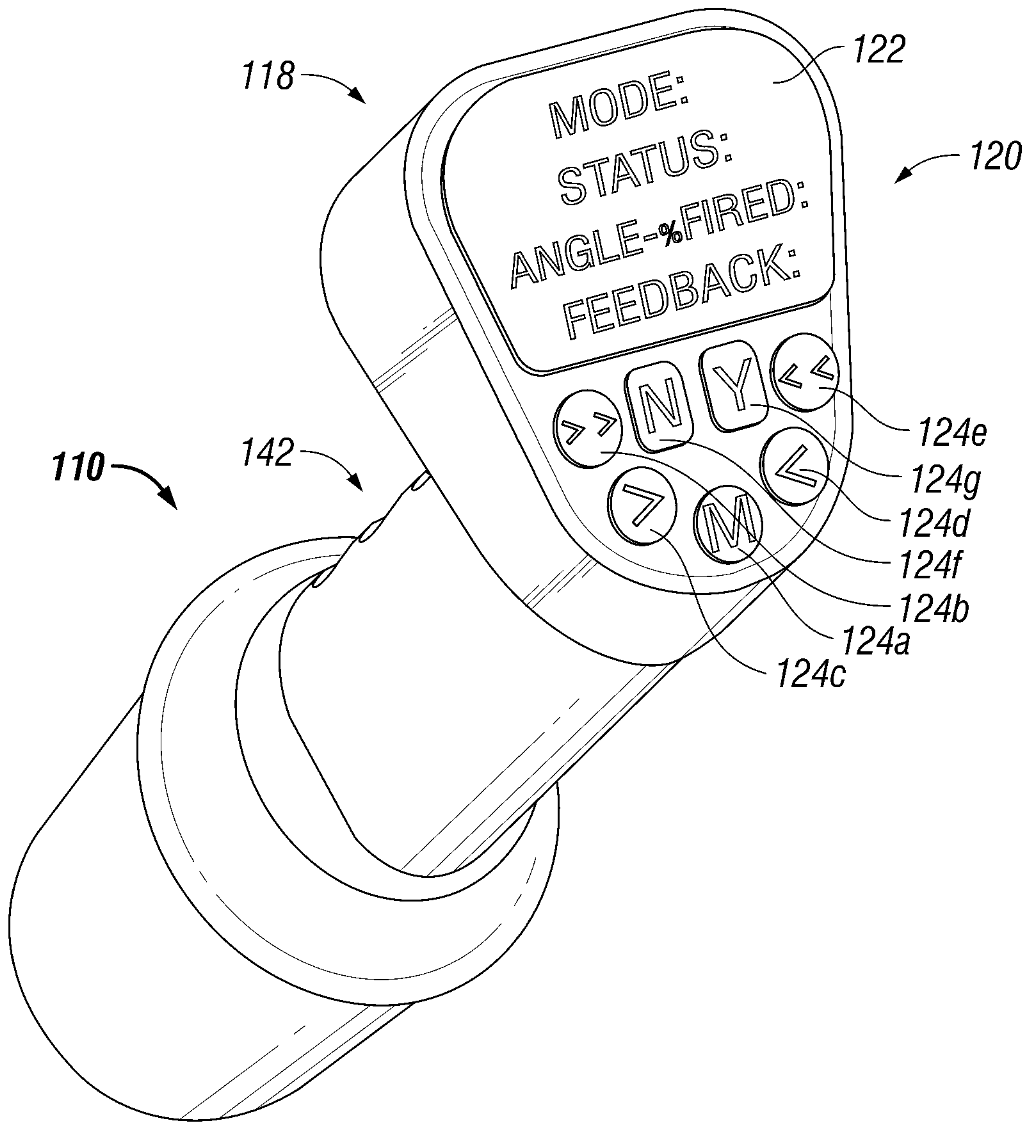

118
110
124
H
120
110b
122
110a
114a
114b
116
140
142
235
H

FIG. 6



118
122
MODE:
STATUS:
ANGLE-%FIRED:
FEEDBACK:
120
N
Y
M
124e
124g
124d
124f
124b
124a
124c
110
142

FIG. 7

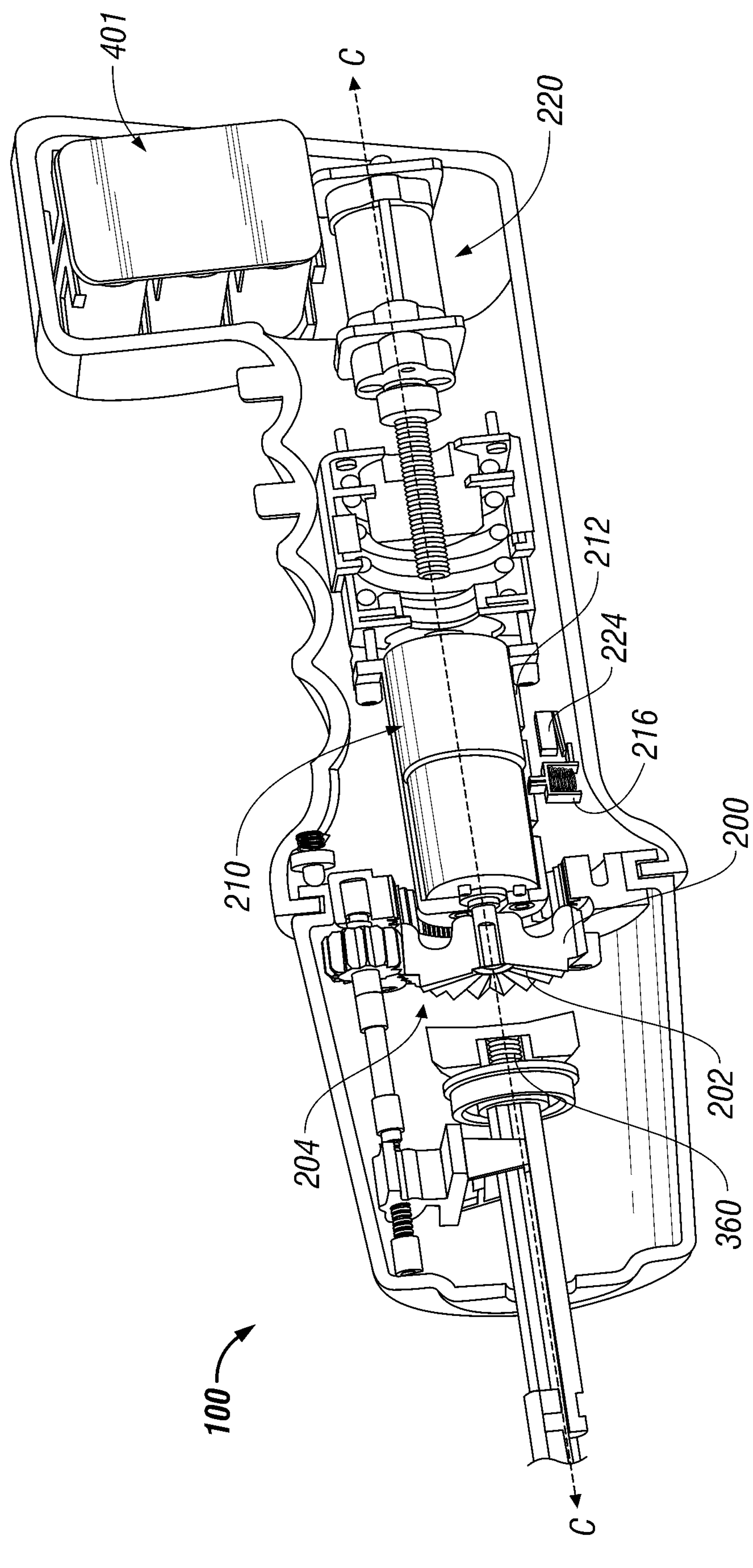


FIG. 8

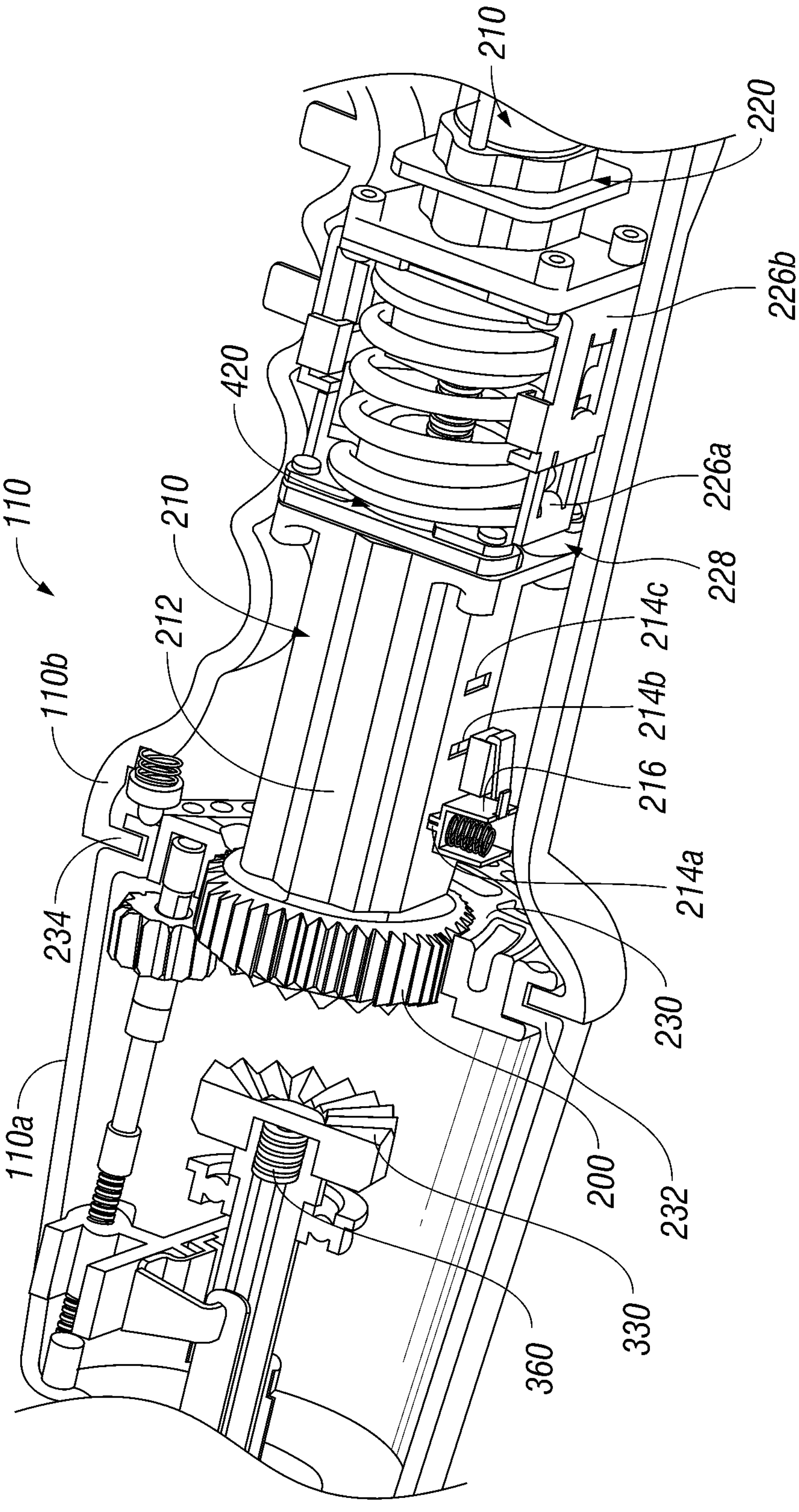

210
220
226b
420
226a
110
210
228
212
214c
110b
214b
216
214a
234
230
110a
200
232
330
360

FIG. 9

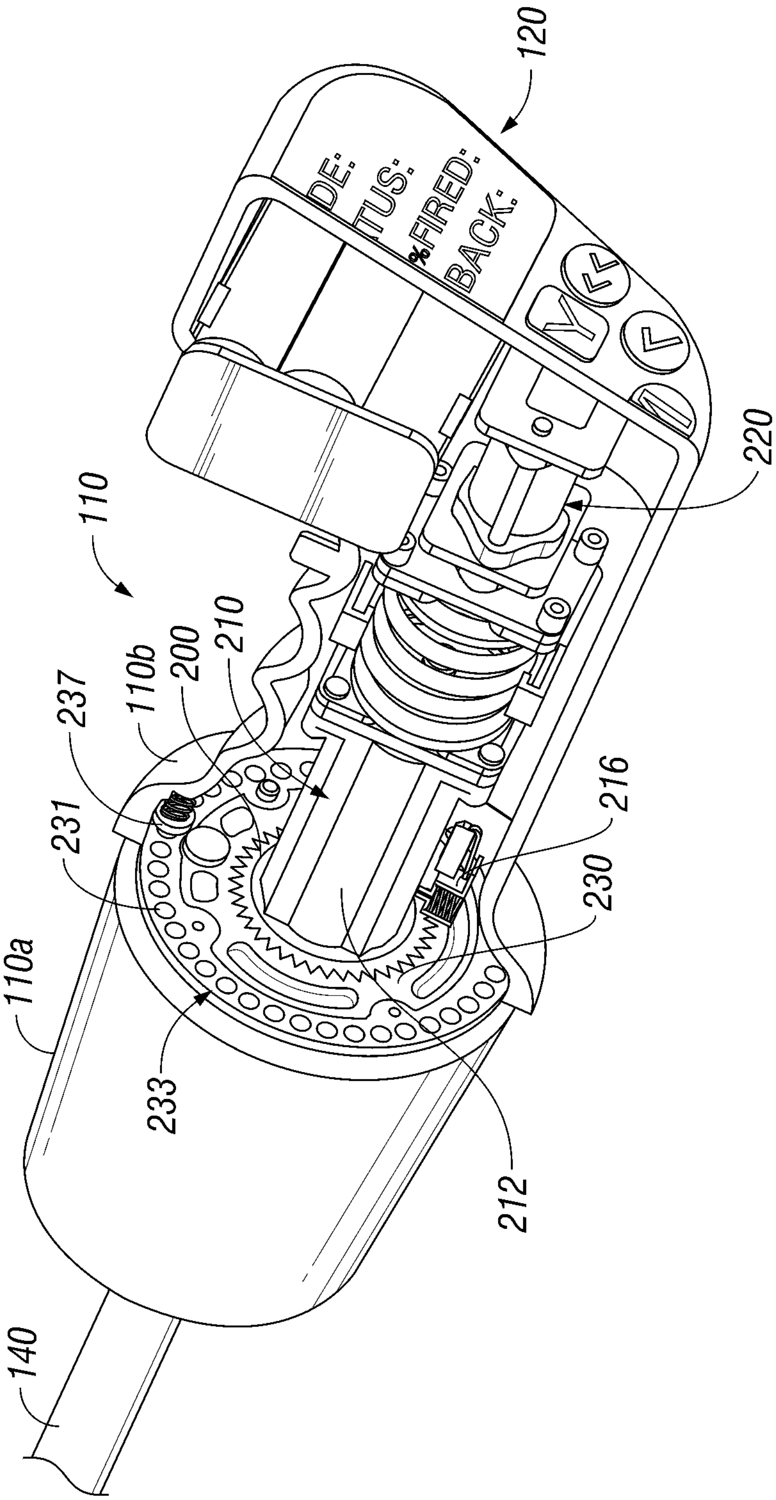

120
DE:
TUS:
%FIRED:
BACK:
220
110
210
200
110b
237
231
216
230
110a
233
212
140

FIG. 10

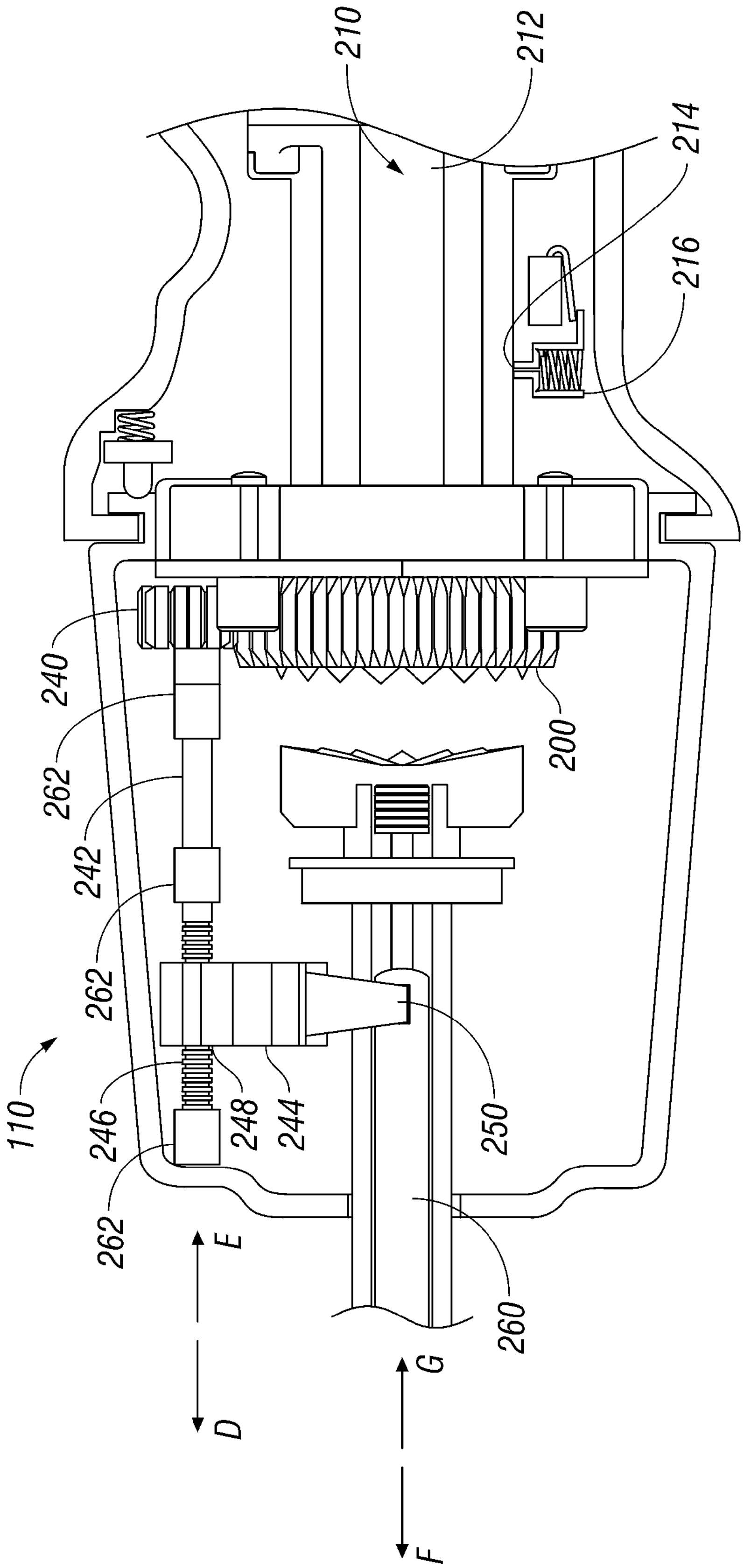

210
212
214
216
240
200
262
242
262
110
246
248
244
250
262
260
E
D
G
F

FIG. 11

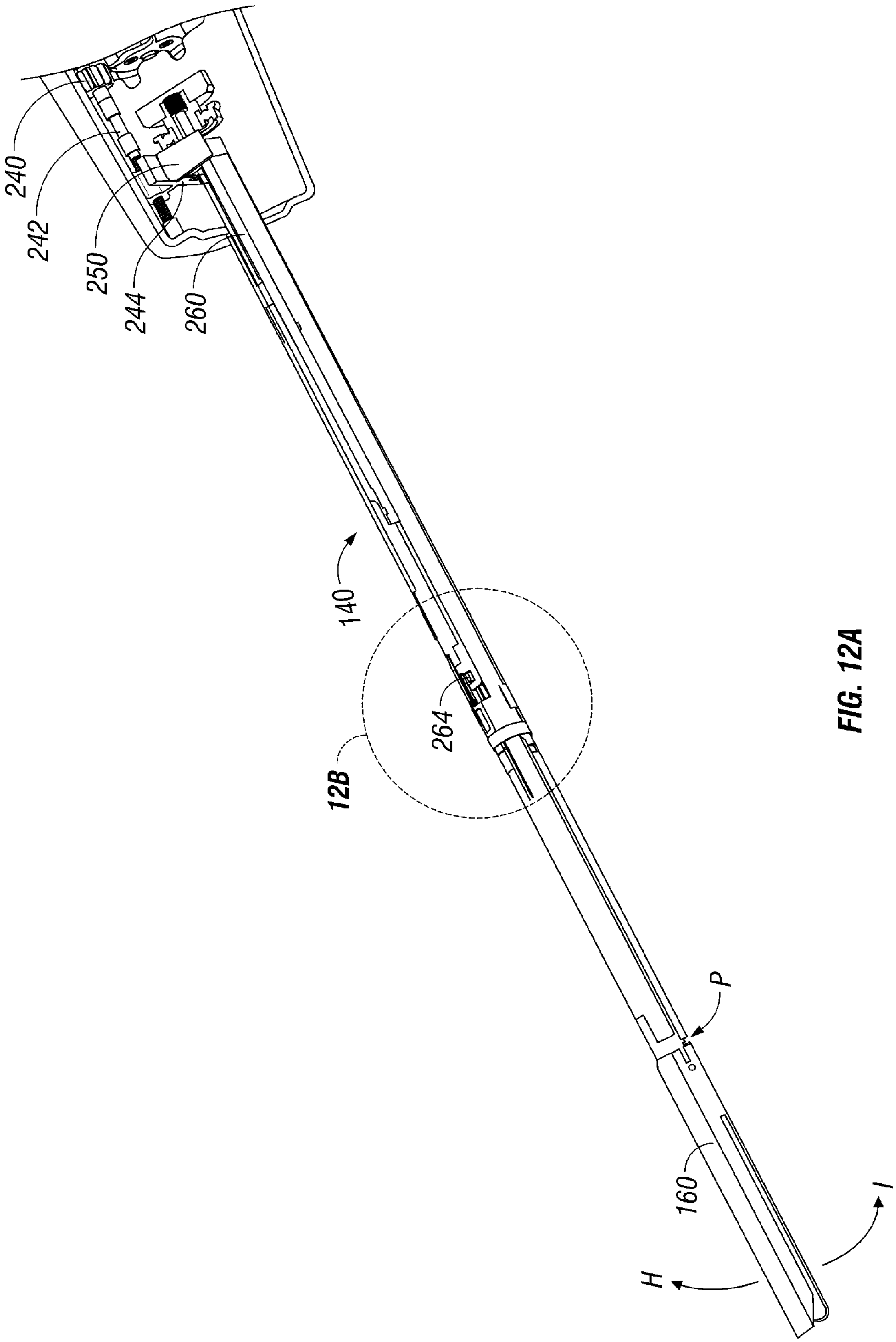


FIG. 12A

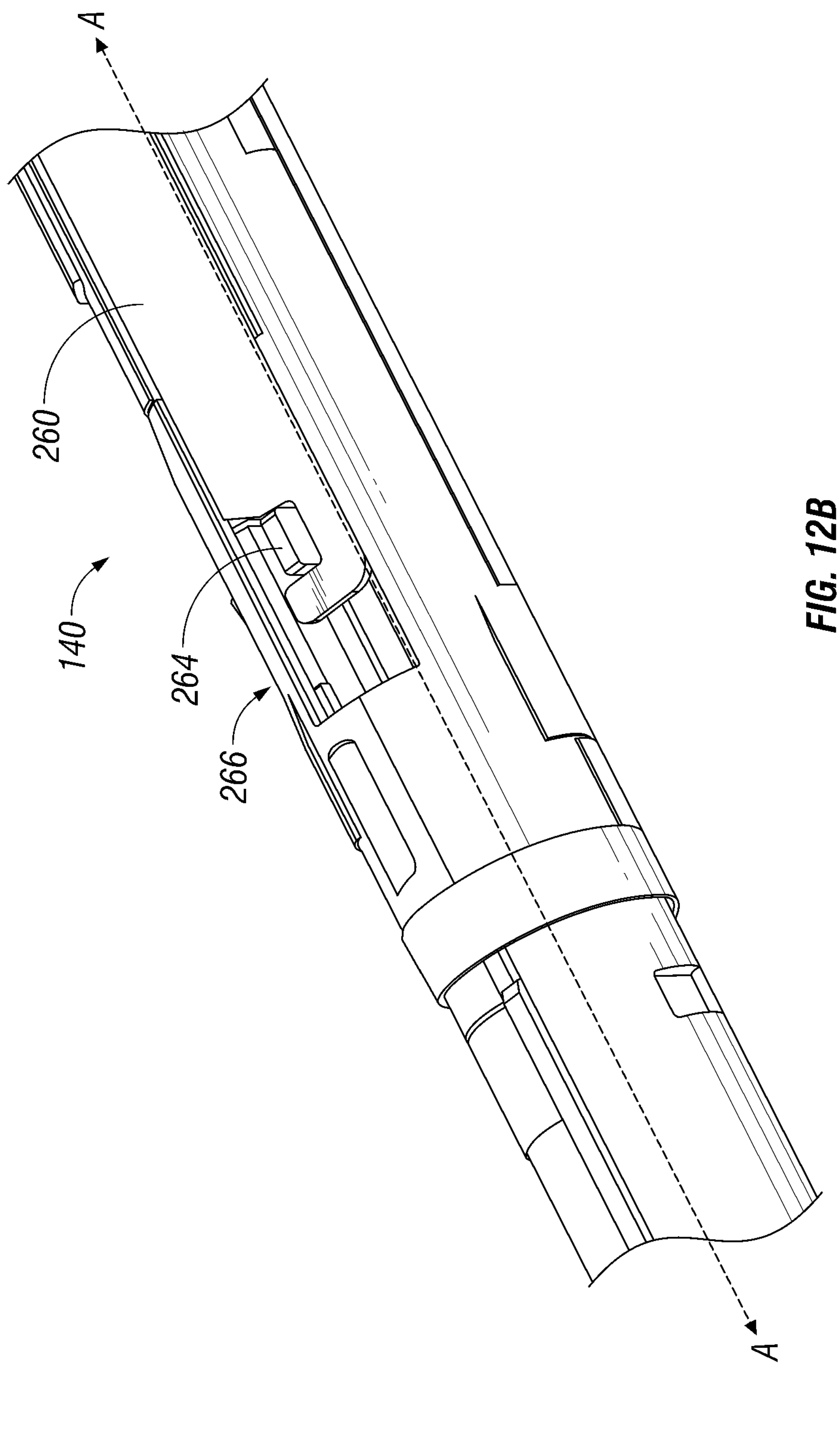


FIG. 12B

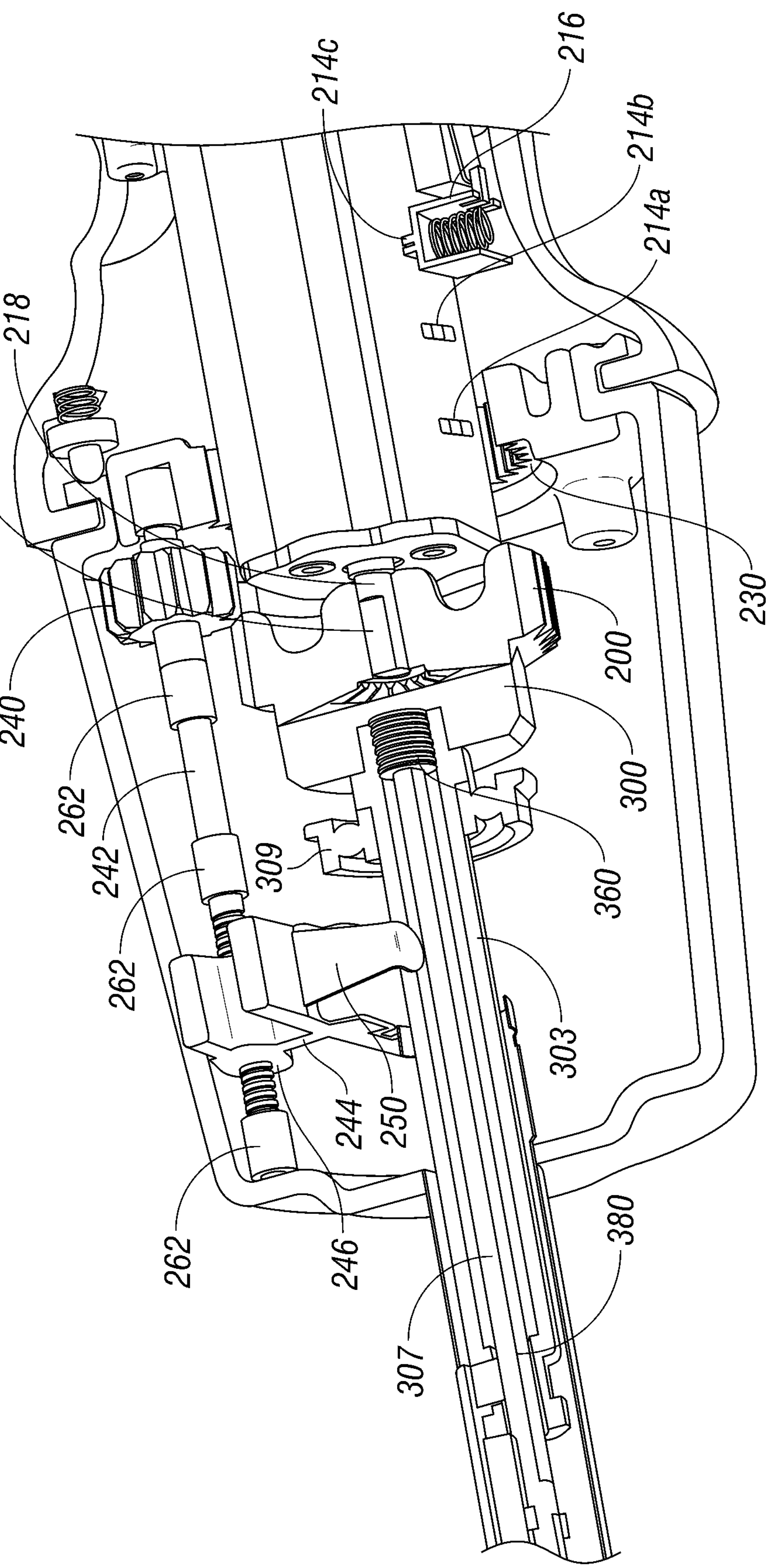

214c
216
214b
214a
218
219
230
200
240
300
262
242
309
360
262
303
244
250
262
246
380
307

FIG. 13

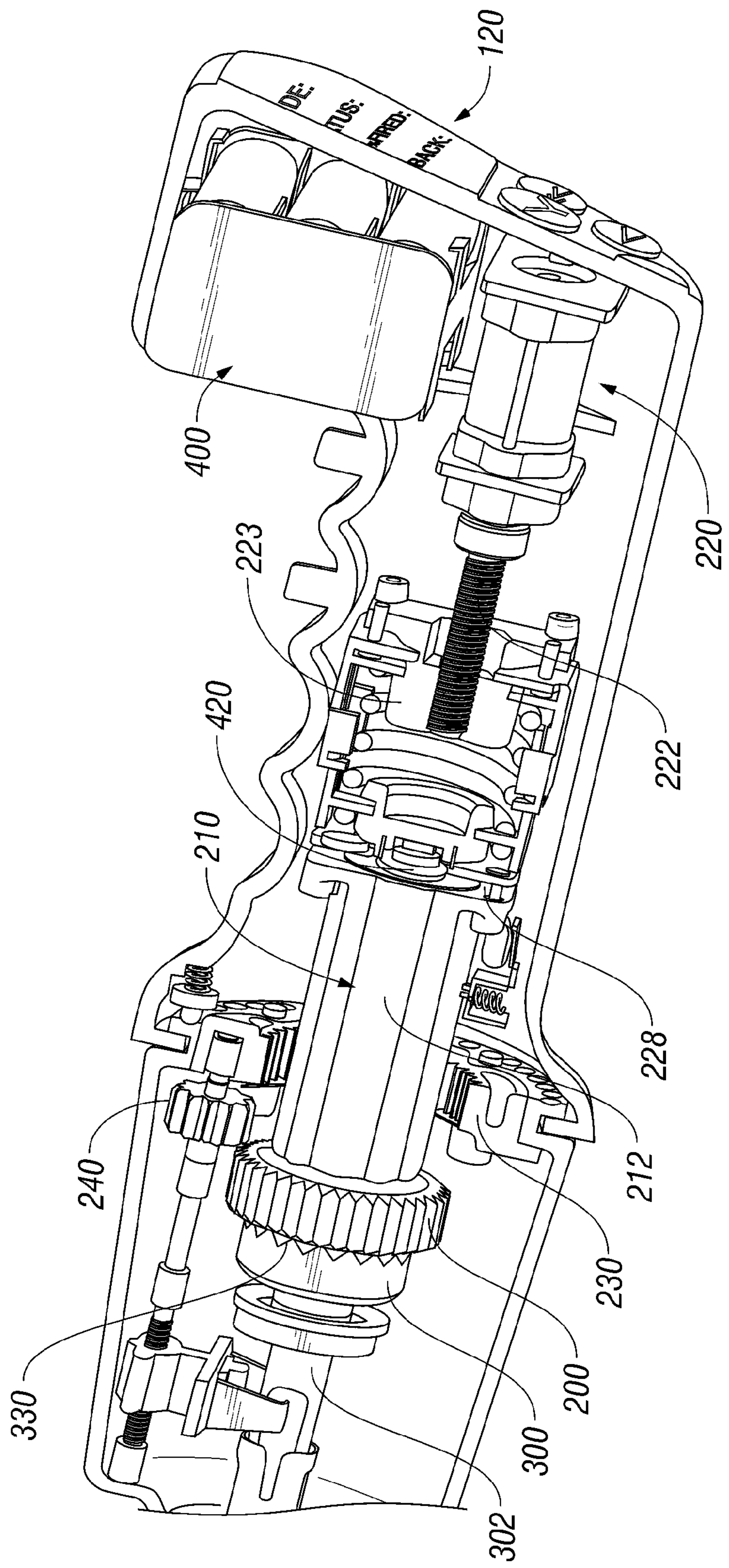


FIG. 14

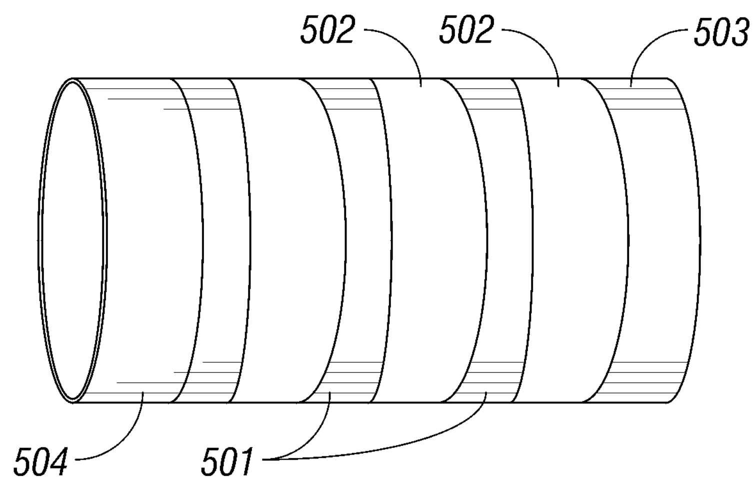


FIG. 15A

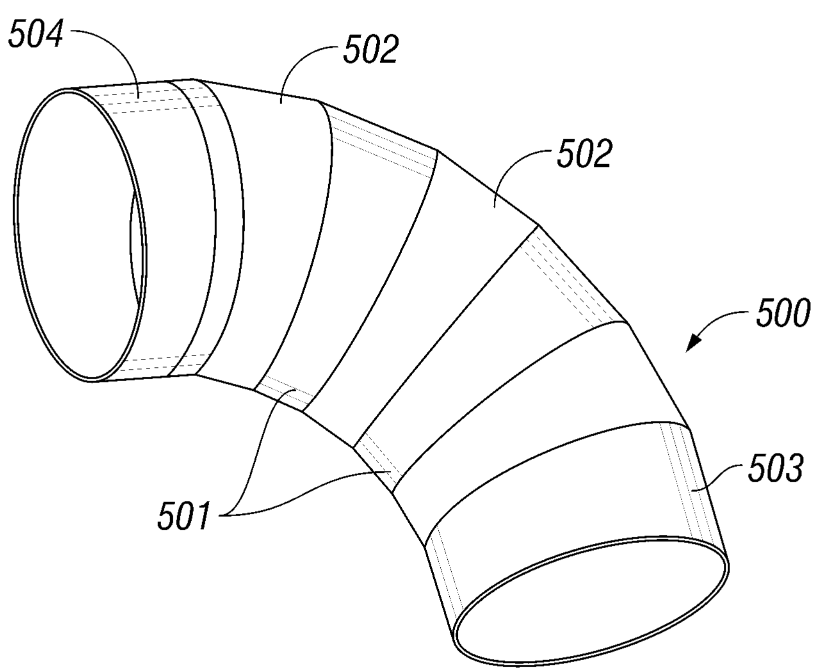


FIG. 15B

POWERED SURGICAL STAPLING DEVICE PLATFORM

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a Continuation application of U.S. patent application Ser. No. 13/889,580, filed on May 8, 2013, which is a Continuation application of U.S. patent application Ser. No. 12/869,193, filed on Aug. 26, 2010, now U.S. Pat. No. 8,459,521, which is a Divisional application of U.S. application Ser. No. 11/799,766, filed on May 1, 2007, now U.S. Pat. No. 7,823,760, the entire contents of all of which are hereby incorporated herein by reference.

BACKGROUND

Technical Field

The present disclosure relates to surgical instruments for fastening body tissue and, more particularly, to a powered surgical instrument having a firing rod configured to be movable and rotatable to affect rotation, articulation and actuation of portions of the instrument.

Background of Related Art

Surgical devices wherein tissue is grasped or clamped between opposing jaw structure and then joined by surgical fasteners are well known in the art. In some instruments, a knife is provided to cut the tissue which has been joined by the fasteners. The fasteners are typically in the form of surgical staples but two-part polymeric fasteners can also be utilized.

Instruments for this purpose may include two elongated members which are respectively used to capture or clamp tissue. Typically, one of the members carries a staple cartridge that houses a plurality of staples arranged in at least two lateral rows while the other member has an anvil that defines a surface for forming the staple legs as the staples are driven from the staple cartridge. Several instruments include clamps, handles and/or knobs to affect actuation along with rotation and articulation of an end effector. Generally, the stapling operation is effected by cam bars that travel longitudinally through the staple cartridge, with the cam bars acting upon staple pushers to sequentially eject the staples from the staple cartridge. Such stapling devices can be used in open as well as endoscopic and/or laparoscopic surgical procedures.

It would be extremely beneficial to provide a powered surgical device for use during surgical procedures that can utilize a new and improved mechanism for articulating and/or actuating the tool tip to automate the stapling process.

SUMMARY

According to one aspect of the present disclosure, a surgical instrument is provided. The surgical instrument includes a housing and an endoscopic portion extending distally from the housing and defining a first longitudinal axis. The surgical instrument also includes an end effector disposed adjacent a distal portion of the endoscopic portion. The end effector may include an anvil assembly and a cartridge assembly. The anvil assembly is pivotally coupled to the cartridge assembly to be movable from a first actuation position to at least one other second actuation position. The surgical instrument further includes a firing rod having a shaft defining a second longitudinal axis, the shaft having a cam member which is in mechanical cooperation with the anvil assembly and is configured to move the anvil assembly

from the first actuation position to the at least one other second actuation position upon rotation of the firing rod about the second longitudinal axis.

According to another aspect of the present disclosure a surgical instrument is provided with a housing and an endoscopic portion extending distally from the housing and defining a first longitudinal axis. The surgical instrument also includes an end effector disposed adjacent a distal portion of the endoscopic portion. The end effector includes a first jaw member and a second jaw member, the second jaw member is pivotally coupled to the first jaw member to be movable from a first actuation position to at least one other second actuation position. The surgical instrument further includes a firing rod including a shaft defining a second longitudinal axis. The shaft has a cam member which is in mechanical cooperation with the second jaw member and is configured to move the second jaw member from the first actuation position to the at least one other second actuation position upon rotation of the firing rod about the second longitudinal axis.

According to a further embodiment of the present disclosure, a tool assembly is provided. The tool assembly includes an end effector disposed adjacent a distal endoscopic portion. The end effector includes an anvil assembly and a cartridge assembly. The anvil assembly is pivotally coupled to the cartridge assembly to be movable from a first actuation position to at least one other second actuation position. The tool assembly also includes a firing rod including a shaft defining a second longitudinal axis. The shaft has a cam member which is in mechanical cooperation with the anvil assembly and is configured to move the anvil assembly from the first actuation position to the at least one other second actuation position upon rotation of the firing rod about the second longitudinal axis.

According to another aspect of the present disclosure, a surgical instrument is disclosed, which includes a housing, an endoscopic portion extending distally from the housing and an intermediate shaft having a proximal end configured for connection to a distal end of the endoscopic portion, the intermediate shaft being flexible. The instrument also includes a loading unit having an end effector for performing a surgical function. The loading unit includes a proximal portion configured for connection to a distal end of the intermediate shaft.

According to a further aspect of the present disclosure, a surgical instrument including a housing and an endoscopic portion extending distally from the housing is disclosed. The housing includes at least a first angled tube and a second angle tube, the first angled tube and second angled tube being rotatably movable with respect to one another between a plurality of positions including a first position defining a substantially straight shaft and a second, fully articulated position and an end effector disposed adjacent a distal portion of the endoscopic portion.

DESCRIPTION OF THE DRAWINGS

An embodiment of the presently disclosed powered surgical instrument is disclosed herein with reference to the drawings, wherein:

FIG. **1** is a perspective view of a powered surgical instrument according to an embodiment of the present disclosure;

FIG. **2** is an exploded view of the staple cartridge and anvil or business head of the surgical instrument shown in FIG. **1**;

FIG. **3** is a side cross-sectional view of the staple cartridge and anvil or business head of the surgical instrument shown in FIG. **1**;

FIGS. **4**A-B are perspective views of a shaped firing rod and cammed clamping of the stapler anvil in the open and closed positions;

FIG. **5** is a perspective view of the cam and the shaped firing rod of the surgical instrument of FIG. **1**;

FIG. **6** is an enlarged perspective view of a handle of the powered surgical instrument of FIG. **1**;

FIG. **7** is an enlarged perspective view of a user interface of the powered surgical instrument of FIG. **1**;

FIG. **8** is a perspective view of internal components of the powered surgical instrument of FIGS. **1**;

FIGS. **9** and **10** are perspective views of the internal components of the powered surgical instrument of FIG. **1** disposed in a first position, powered rotation;

FIG. **11** is a side view of the internal components of the powered surgical instrument of FIG. **1** disposed in a second position, powered articulation;

FIG. **12**A is a perspective view including an endoscopic portion of the powered surgical instrument of FIG. **1** according to an embodiment of the present disclosure;

FIG. **12**B is an enlarged perspective view of the portion of the powered surgical instrument indicated in FIG. **12**A;

FIGS. **13-14** are perspective view of the internal components of the powered surgical instrument of FIG. **1** disposed in a third position, fire, clamp, grasp, retraction; and

FIGS. **15**A-B are perspective views of articulating shaft of the distal portion of the powered surgical instrument of FIG. **1**.

DETAILED DESCRIPTION OF EMBODIMENTS

Embodiments of the presently disclosed powered surgical instrument are now described in detail with reference to the drawings, in which like reference numerals designate identical or corresponding elements in each of the several views. As used herein the term "distal" refers to that portion of the powered surgical instrument, or component thereof, farther from the user while the term "proximal" refers to that portion of the powered surgical instrument or component thereof, closer to the user.

A powered surgical instrument, e.g., a surgical stapler, in accordance with the present disclosure is referred to in the figures as reference numeral **100**. Referring initially to FIG. **1**, powered surgical instrument **100** includes a housing **110**, an endoscopic portion **140** defining a longitudinal axis A-A extending therethrough, and an end effector **160**, defining a longitudinal axis B-B (illustrated substantially aligned with axis A-A in FIG. **1**) extending therethrough. Endoscopic portion **140** extends distally from housing **110** and end effector **160** is disposed adjacent a distal portion **142** of endoscopic portion **140**.

It is envisioned that end effector **160** is reusable and is configured to accept a staple cartridge and/or is part of a disposable loading unit. Further details of a disposable loading unit are described in detail in commonly-owned U.S. Pat. No. 6,241,139 to Miliman, the entire contents of which are hereby incorporated by reference herein.

The end effector **160** is coupled to the endoscopic portion **140** via a mounting assembly **141**. The end effector **160** may be any end effector used in linear stapling devices, such as ENDO GIA™, GIA™, TA™, ENDO TA™, EEA™ staplers sold by U.S. Surgical Corp, of Norwalk, Conn. Such end effectors may be coupled to endoscopic portion **140** of powered surgical instrument **100**. Mounting assembly **141** is pivotally secured to the distal portion **142** and is fixedly secured to a proximal end of tool assembly **160**. This allows for pivotal movement of mounting assembly **141** about an axis perpendicular to the longitudinal axis A-A. Pivotal movement occurs between a non-articulated position in which the longitudinal axis of tool assembly **160** is aligned with the longitudinal axis A-A and an articulated position in which the longitudinal axis B-B of the tool assembly **160** is disposed at an angle to the longitudinal axis A-A of endoscopic portion **140**.

Referring to FIGS. **2** and **3**, tool assembly **160** includes a cartridge assembly **300** (e.g., first jaw of the tool assembly) and an anvil assembly **302** (e.g., second of the tool assembly). Anvil assembly **302** includes an anvil portion **304** having a plurality of staple deforming concavities **305** (FIG. **3**) and a cover plate **306** secured to a top surface of anvil portion **304**. Cartridge assembly **300** includes carrier **308** which defines an elongated support channel **310** which is dimensioned and configured to receive staple cartridge **312**. Corresponding tabs **314** and slots **316** formed along staple cartridge **312** and elongated support channel **310**, respectively, function to retain staple cartridge **312** at a fixed location within support channel **310**. A pair of support struts **318** formed on staple cartridge **312** is positioned to rest on side walls of carrier **308** to further stabilize staple cartridge **312** within support channel **310**.

Staple cartridge **312** includes retention slots **320** for receiving a plurality of staples or fasteners **322** and pushers **324**. A plurality of laterally spaced apart longitudinal slots **326** extends through staple cartridge **312** to accommodate upstanding cam wedges **328** of an actuation sled **330**. A central longitudinal slot **332** extends along substantially the length of staple cartridge **312** to facilitate passage of a knife blade (not explicitly shown).

FIGS. **4**A-B and **5** show a firing rod **402** for articulation and actuation of the tool assembly **160**. The firing rod **402** includes a proximal shaft **404** which extends the length of the endoscopic portion **140** and the distal portion **142** and a distal shaft **406** which is disposed within the tool assembly **160**. The proximal shaft **404** and the distal shaft **406** are pivotally linked via a pivot member **410** which passes through bores (not explicitly shown) within the distal end of the proximal shaft **404** and the proximal end of the distal shaft **406**. Pivotal movement occurs between a non-articulated position in which the longitudinal axis of distal shaft **406** is aligned with the longitudinal axis K-K and an articulated position in which the longitudinal axis L-L of the tool distal shaft **406** is disposed at an angle to the longitudinal axis K-K of proximal shaft **404**. The firing rod **402** may be formed from a rigid and/or flexible material. Forming the firing rod **402** from a flexible material obviates the need for pivot member **410** as the proximal shaft **404** can pivot with respect to the distal shaft **406** by nature of the flexibility of the material. It is envisioned that other pivoting mechanisms may be used, such as plastic or rubber bands interconnecting the proximal and distal portions **404** and **406**.

The proximal shaft **404** and the distal shaft **406** of the firing rod **402** incorporate a plurality of surface features or shapes along the length thereof. In embodiments, the firing rod **402** has a generally cylindrical structure with a non-circular cross-section (e.g., hexagonal, octagonal, star-shaped, oval, etc.) It is also envisioned the firing rod **402** may include one or more curved shapes (e.g., helix, screw, etc.) These structures allow for gripping of the firing rod **402** and rotation thereof to actuate the tool assembly **160**.

The firing rod **402** is disposed within a passage (not explicitly shown) of the endoscopic portion **140** and the distal portion **142**, the passage has the same cross-sectional profile as the firing rod **402** such that the firing rod **402** is in mechanical cooperation with the passage but can simultaneously freely slide therein. This is especially useful if the firing rod **402** is formed from a flexible material since this prevents deformation of the firing rod **402** within the passage.

The firing rod **402** is configured for opening and closing of the anvil assembly **302** as well as pushing actuation sled **330** through longitudinal slots **326** of staple cartridge **312** to advance cam wedges **328** into sequential contact with pushers **324** to staple tissue. The firing rod **402** is configured to be selectively moved between a plurality of positions. In certain embodiments, the firing rod **402** is moved between at least two positions. The first position, illustrated in FIG. **4**A, enables opening and closing of the anvil assembly **302** via rotation of the firing rod **402** about longitudinal axis K-K; the second position, illustrated in FIG. **4**B, enables advancement of pushers **324** to push fasteners **322** through tissue.

In FIG. **4**A the firing rod **402** is shown in the first position. The distal shaft **406** of the firing rod **402** includes a cam member **408**, which is shown as a dual cam, disposed thereon. In the first position, the cam member **408** is positioned in a plane perpendicular to the longitudinal axis L-L at the distal end of the anvil assembly **302**. During operation, the firing rod **402** is rotated, which causes rotation of the cam member **408**. As the cam member **408** is rotated, the proximal end of the anvil assembly **302** is pushed upwards by the perpendicular displacement of the cam member **408** thereby closing the anvil assembly **302** against the cartridge assembly **300** (FIG. **4**B).

The anvil assembly **302** is pivotally coupled to the cartridge assembly via tabs **332** which extend downwards therefrom. The tabs **332** fit into corresponding slots (not explicitly shown) to provide a hinge point for the anvil assembly **332** to pivot thereabout. This allows the anvil assembly **302** to pivot with respect to the cartridge assembly **300**. As the firing rod **408** is rotated further the anvil assembly **302** reverts to open position via one or more biasing members (e.g., springs) pushing upwards on the opposite side of the tabs **332**.

Various types of cams may be used to open and close the anvil assembly **302**, such as single cams, or multi-cams. Other cam shapes may also be utilized which have a less aggressive angle utilizing full 360° of rotation allowing the anvil assembly **302** to reach full displacement at a more gradual rate. Angle of rotation of the firing rod **402** varies with the type of cam being used, such as for the cam member **408**, the firing rod **402** is rotated 90° in order to actuate the anvil assembly **302**. In other words, the cam member **402** allows for maximum displacement of the anvil assembly **302** under 90°. It is also envisioned that the firing rod **402** may be rotated in either direction, clockwise or counterclockwise, to actuate the anvil assembly **302**.

While in the first position the firing rod **402** is prevented from longitudinal movement in the distal direction by the proximal end of the cartridge assembly **300** and the cam member **408**. The walls of the support channel **310** act as a stop member when the firing rod **402** is moved in the distal direction. Once the firing rod **402** is rotated into second position as shown in FIG. **4**B, the firing rod **402** can be advanced distally to push the actuation sled **330** through the staple cartridge **312** since the firing rod **402** is no longer stopped by the distal end of the cartridge assembly. The firing rod **402** is movable through the cam member **408**, the interface between an aperture through the cam member **408** and the firing rod **402** being shaped to allow a telescoping movement, but also shaped so that the cam member **408** and firing rod **402** rotate together. For example, the cam member **408** and firing rod **402** have a hexagonal shaped interface as shown in FIGS. **4**A and **4**B. Other shapes, such as helical, star shaped, splined, oval, slotted, and octagonal, can be used.

During operation of surgical stapler, the firing rod **402** abuts actuation sled **330** and pushes actuation sled **330** through longitudinal slots **326** of staple cartridge **312** to advance cam wedges **328** of sled **330** into sequential contact with pushers **324**. Pushers **324** translate vertically along cam wedges **328** within fastener retention slots **320** and urge fasteners **322** from retention slots **320** into staple deforming cavities **304** (FIG. **4**) of the anvil assembly **302**.

With reference to FIGS. **6** and **7**, an enlarged view of housing **110** is illustrated according to an embodiment of the present disclosure. In the illustrated embodiment, housing **110** includes a handle portion **110***b* having two buttons **114***a* and **114***b*. Handle portion **110***b*, which defines a handle axis H-H, is shown having indentations **116** that correspond to fingers of a user. Each button **114***a* and **114***b* is shown as being disposed on an indentation **116** to facilitate its depression by a user's finger.

A proximal area **118** of housing **110** includes a user interface **120**. In the illustrated embodiment, user interface **120** includes a screen **122** and at least one switch **124** (seven switches **124***a*-**124***g* are shown). Screen **122** displays readable information thereon, including status information of powered surgical instrument **100** in an embodiment.

FIG. **7** shows user interface **120** including screen **122** and seven switches **124***a*-**124***g*. In the illustrated embodiment, user interface displays the "mode" (e.g., rotation, articulation or actuation), which may be communicated to user interface **120** via shift sensor **224**, "status" (e.g., angle of articulation, speed of rotation, or type of actuation) and "feedback," such as whether staples have been fired. Switch **124***a* is shown having an "M," standing for mode, which may be used to position drive gear **200** via shift motor **220** for selecting between rotation, articulation, grasping, clamping and firing. It is also envisioned that switch **124***a* can be used to let a user input different tissue types, and various sizes and lengths of staple cartridges.

Switches **124***b*-**124***e* are shown with arrows thereon and may be used for selecting the direction, speed and/or torque at which drive gear **200** is rotated by drive motor **210**. It is also envisioned that at least one switch **124** can be used for selecting an emergency mode that overrides various settings. Further, switches **124***f* and **124***g* are illustrated having an "N" and a "Y" thereon. It is envisioned that switches **124***f* and **124***g* may be used for helping a user navigate user interface menus and select various setting of powered surgical instrument **100**. The indicia on switches **124***a*-**124***g* and their respective functions are not limited by what is shown in the accompanying figures, as deviations therefrom are contemplated and within the scope of the present disclosure. Additionally, and with reference to FIGS. **1** and **6**, buttons **114***a* and **114***b* may be used for starting and/or stopping movement of drive motor **210** and/or shift motor **220** and the like.

FIGS. **8**-**14** illustrate various internal components of powered surgical instrument **100**, including a drive gear **200**, a drive motor **210** and a shift motor **220**. Power is provided via a battery pack **401** (or fuel cell assembly). Other power-supplying means are also contemplated (e.g., electrical transformers coupled to conventional electrical power supplies).

As shown in FIG. **8**, the drive gear **200**, the drive motor **210** and the battery pack **401** are disposed within the housing **110**, specifically a proximal housing portion **110***b*. It is envisioned that these components may also be located within or closer to a distal housing portion **110***a*. The primary or a secondary motor, transmission, and/or the batteries may be disposed in the endoscopic portion **140**.

Drive gear **200** is rotatable about a drive gear axis C-C extending therethrough (FIG. **8**) and is selectively movable along drive gear axis C-C. Drive motor **210** is disposed in mechanical cooperation with drive gear **200** and is configured to rotate drive gear **200** about drive gear axis C-C. Shift motor **220** is disposed in mechanical cooperation via the drive motor **210** with drive gear **200** and is configured to translate drive gear **200** axially along drive gear axis C-C.

Shift motor **220** is configured to selectively move drive gear **200** between a plurality of positions. In embodiments, the drive gear **200** is moved between three positions. The first position, illustrated in FIGS. **9** and **10**, enables rotation of end effector **160**; the second position, illustrated in FIG. **11**, enables articulation of end effector **160**; and the third position, illustrated in FIGS. **13-14**, enables actuation of powered surgical instrument **100**.

In the embodiment illustrated in FIG. **9**, shift motor **220** is shown including a two-part housing **226**. Each part **226***a* and **226***b* of two-part housing **226** are slidably engaged with each other. It is envisioned that part **226***a* is rigidly secured to a drive motor casing **212**, while part **226***b* is affixed to drive motor **210** and is translatable within housing **110**. Additionally, a wiring slot **228** may be included to allow for wires (not explicitly shown) to pass from transducer **420** towards user interface **120**, for example.

A cut away of the drive motor casing **212**, at least partially surrounding drive motor **210**, is illustrated in FIGS. **8-11**. Drive motor casing **212** includes slots **214***a*, **214***b* and **214***c* therein. Each slot **214** is configured to mate with a position lock **216** to maintain drive gear **210** in a desired position. In FIG. **9**, position lock **216** is shown mated with slot **214***a*—corresponding to drive gear **200** being in its first position. In FIG. **11**, position lock **216** is shown mated with slot **214***b*—corresponding to drive gear **200** being in its second position. FIGS. **13** and **14** illustrate position lock **216** mated with slot **214***c*—corresponding to drive gear **200** being in its third position. Position lock **216**, in the illustrated embodiments, is spring-loaded and biased against the drive motor casing **212**, which maintains drive motor **210** is a desired position.

In the illustrated embodiments, shift motor **220** is located proximally of drive motor **210** and is configured to translate drive motor **210** along drive gear axis C-C between its first, second and third positions. Referring to FIG. **14**, shift motor **220** is illustrated being driven by a shift screw **222** in conjunction with an internally-threaded screw housing **223**, in accordance with a disclosed embodiment. It is further disclosed that a shift sensor **224** (See FIG. **8**) (e.g., micro switch or optical/ferromagnetic proximity sensor activate by position lock **216**), disposed adjacent position lock **216**, electrically communicates with at least one switch **124** to start or stop shift motor **220** and/or provides feedback relating to the position of drive motor **210** (e.g., position of drive motor **210**, such as "rotation," is displayed on screen **122** of user interface **120**).

With reference to FIGS. **9** and **10**, the first position of drive gear **200** is illustrated. Ring gear **230** is disposed within housing **110**, wherein rotation of ring gear **230** causes rotation of endoscopic portion **140**, end effector **160** and a distal housing portion **110***a*. Distal housing portion **110***a* is disposed distally of a proximal housing portion **110***b*. The housing portion **110***a* includes a guide channel **232** which is peripherally disposed therein and is configured to interface with a corresponding flange **234** which is peripherally disposed within the proximal housing portion **110***b*. In particular, the flange **234** is configured to slidably rotate within the guide channel **232** thereby allow for rotation of the housing portion **110***a* with respect to proximal housing portion **110***b*. In an embodiment, ring gear **230** is rigidly secured within distal housing portion **110***a* and is matingly engagable with drive gear **200**. Thus, rotation of drive gear **200** causes rotation of the ring gear **230** and the housing portion **110***a* along with the end effector **160** about the longitudinal axis B-B.

In FIG. **6**, a lip **235** is shown which isolates a user's hand from rotatable distal housing portion **110***a*. It is envisioned that a plurality of washers or ball-bearings (possibly made from synthetic resinous fluorine-containing polymers sold under the trademark TEFLON®) is disposed between distal housing portion **110***a* and proximal housing portion **110***b* to reduce the rotational friction therebetween.

With continued reference to the embodiment illustrated in FIG. **10**, a plurality of detents **231** is disposed around a surface **233** of distal housing portion **110***a*. A tab **237** is shown disposed on proximal housing portion **110***b*. In a disclosed embodiment, tab **237** is distally biased (e.g., via tab spring **239**) and in mechanical cooperation with at least one of plurality of detents **231**. The combination of detents **231** and tab **237** helps secure distal housing portion **110***a* in a rotational position with respect to proximal housing portion **110***b*.

In FIG. **11**, drive gear **200** is illustrated in its second position, as position lock **216** is aligned with slot **214***b*. Here, drive gear **200** is matingly engaged with an articulation gear **240**, which is disposed at least partially within housing **110**. Rotation of articulation gear **240** causes end effector **160** to move from its first position, where longitudinal axis B-B is substantially aligned with longitudinal axis A-A, towards its second position, wherein longitudinal axis B-B is disposed at an angle to longitudinal axis A-A.

In the illustrated embodiments and with specific reference to FIGS. **11** and **12**, articulation of end effector **160** is affected by an articulation gear **240**, an articulation screw **242**, an articulation linkage **244** and at least one articulation rod **260**. More specifically, articulation gear **240** is rigidly mounted to articulation screw **242**, such that as articulation gear **240** is rotated by rotation of drive gear **200** while in its second position, articulation screw **242** also rotates. A plurality of bearings **262** is illustrated at various locations on articulation screw **242** to facilitate the retaining and aligning of articulation screw drive **242** as well as reducing the friction between articulation screw **242** and housing **110**, for example.

With continued reference to FIG. **11**, articulation screw **242** includes a threaded portion **246**, which extends through an internally-threaded portion **248** of articulation linkage **244**. This relationship between articulation screw **242** and articulation linkage **244** causes articulation linkage **244** to move distally and/or proximally (in the directions of arrows F and G) along threaded portion **246** of articulation screw **242** upon rotation of articulation screw **242**. For example, as articulation screw **242** rotates in a first direction (e.g., clockwise), articulation linkage **244** move proximally, and as articulation screw **242** rotates in a second direction (e.g., counter-clockwise), articulation linkage **244** move distally.

At least one articulation arm **250** is shown extending from articulation linkage **244**. In an embodiment, articulation arm **250** is rigidly connected to articulation rod **260** and it is envisioned that more than one articulation arm **250** is connectable to more than one articulation rod **260**. As articulation linkage **244** is translated distally and/or proximally in response to rotation of articulation gear **240**, articulation rod(s) **260** is also translated distally and/or proximally (in the directions of arrows F and G, along longitudinal axis A-A) in response thereto. Any combinations of limits switches, proximity sensors (e.g., optical and/or ferromagnetic), linear variable displacement transducers and shaft encoders (disposed within housing **110**, for instance) may be utilized to control and/or record the location of articulation linkage **244** and/or articulation angle of end effector **160** and/or position of an actuation rod **306** as discussed below with reference to FIGS. **13** and **14**.

With reference to FIGS. **12**A and **12**B, articulation rod **260** is shown extending through at least a portion of endoscopic portion **140** and in mechanical cooperation with a linkage rod **264**. Thus, linkage rod **264** similarly moves along longitudinal axis A-A upon rotation of articulation gear **240**. A distal portion **266** of linkage rod **264** is in mechanical cooperation with end effector **160**, such that proximal and distal movement of linkage rod **264** causes end effector **160** to move from its first position towards its second position about pivot P. More specifically, and for illustrative purposes, as linkage rod **264** moves distally, end effector **160** is articulated in the direction of arrow H and as linkage rod **264** is translated proximally, end effector **160** is articulated in the direction of arrow I. It is also envisioned that a portion of articulation rod **260** is in mechanical cooperation with end effector **160** to affect articulation thereof. Further details of providing articulation to end effector **160** are described in detail in commonly-owned U.S. Pat. No. 6,953,139 to Milliman et al., the contents of which are hereby incorporated by reference in their entirety.

With reference to FIGS. **13** and **14**, drive gear **200** is illustrated in its third position, with position lock **216** aligned with slot **214***c*. The drive gear **200** is matingly engaged with an actuator gear **300**, which is disposed at least partially within housing **110**. More specifically, a set of teeth **202** disposed on a face **204** (FIG. **8**) of drive gear **200** matingly engage actuator gear **300** to provide at least one of grasping tissue, clamping tissue, firing of end effector **160** (e.g., stapling and cutting) and retracting elements to their original position.

With reference to FIG. **13**, a drive motor shaft **218** is shown extending from drive motor **210** and being connected to drive gear **220**. A fastener (not explicitly shown in this embodiment) may be used to retain drive gear **220** on drive motor shaft **218**. Drive motor shaft **218** is rotated by drive motor **210**, thus resulting in rotation of drive gear **220**. Drive motor shaft **218** is shown having a flat portion **219** (more than one flat portions **219** may be included), which allows "play" or "rotational float" between drive gear **220** and drive motor shaft **218** to facilitate tooth alignment and to help enable drive gear **220** to shift between positions. FIG. **13** also illustrates a bearing **309** disposed within housing **110** and at least partially surrounding drive tube **303**. Bearing **309** facilitates rotation of drive tube **303** and aligns drive tube **303** through endoscopic portion **140**.

In FIG. **14**, a transducer **420** is shown adjacent drive motor **210** and shift motor **220**. Transducer **420** (e.g., a force or pressure transducer) may measure and/or control the force required for the desired pressure on actuator gear **330**. Transducer **420** may be in communication with portions of user interface **120**, which may provide feedback to a user.

With reference to FIGS. **13** and **14**, a drive tube **303** and an actuation rod **307** are also included. Drive tube **303** is rigidly attached to actuator gear **300**. In an embodiment of the disclosure, actuation rod **307** extends at least to distal portion **142** of endoscopic portion **140** and is mechanically coupled to the firing rod **402**. In response to rotation of drive gear **200**, actuator gear **300** and drive tube **303** also rotate. As drive tube **303** rotates, the actuation rod **307** is driven forward by the threaded bung **360**. Actuation rod **307** is prevented from rotation by flat/non-round features **380** which are mated to the tube housing cross section **266**. When unlocked, rotation of actuation rod **307** rotates the firing rod **402** which closes the anvil assembly **302** of end effector **160** to grasp or clamp tissue held therebetween. Further details of firing end effector **160** (or actuation) are described in detail in commonly-owned U.S. Pat. No. 6,953,139 to Milliman et al., the entire contents of which are hereby incorporated by reference herein.

The firing rod **402** can be advanced distally to advance the actuation sled **330** either manually or automatically (e.g., via motorized mechanisms). An example of a powered stapler configured for advancing a firing rod to push fasteners through tissue is illustrated in a commonly-owned U.S. patent application entitled "Powered Surgical Stapling Device" by Marczyk, U.S. application Ser. No. 11/724,744, filed Mar. 15, 2007, the disclosure of which is hereby incorporated by reference herein in its entirety.

As discussed above, the firing rod **402** is disposed within the endoscopic portion **140** and the distal portion **142**. Therefore, in embodiments where the firing rod **402** is formed from a flexible material it is desirable to provide flexible endoscopic portion **140** and distal portion **142**. As shown in FIGS. **15**A-B, the endoscopic and distal portions **140**, **142** are shown as a flexible shaft **500**. The flexible shaft **500** includes a plurality of interconnected angled outer tubes **501** and **502**. FIG. **15**A shows the flexible shaft in a non-articulated formation and FIG. **15**B shows the flexible shaft **500** in full articulation formation. When the flexible shaft **500** is straight, narrow sections of the tubes **501** alternate with the wide sections of the tubes **502** as shown in FIG. **15**A. When the flexible shaft **500** is fully articulated, the short sides and the wide sides of the tubes **501** and **502** are aligned as shown in FIG. **15**B.

The flexible shaft **500** also includes a proximal drive end cap **503** which is in mechanical cooperation with the drive gear **200** and a distal end cap **504** which is in communication with another component of the surgical stapler **10** (e.g., the tool assembly **160** or the distal portion **142** depending where the flexible shaft **500** is disposed). The drive end cap **503** has only one angled face and is turned by the drive gear **200**. The end cap **504** is fixed from rotation and also has one angled face and includes an internal stop member for mating with the neighboring tube.

The tubes **500** are mated together by a step which is disposed on the edges of inner surfaces of the tubes **500**. The tubes **500** also include stop members at 180 degree positions which interface with neighboring tubes to turn against frictional forces. Each of the tubes **501** and **502** are angled by the same amount on corresponding mating faces and include alternative grooves and ribs which interlock the tubes **501** and **502**.

Articulation is achieved by rotation of the tubes **501** and **502** either sequentially or independently. The drive end cap **503** is rotated continuously until the flexible shaft **500** has attained desired articulation position. As the drive end cap **503** is rotated, each tube is rotated correspondingly until the tube reached 90 degree rotation and then locks with the subsequent tube which then begins rotation of the subsequent tube, etc. Use of the flexible shaft **500** in manual or motor-driven instruments is contemplated. A designated motor, or a motor driving multiple functions of the instrument may be used. One of the positions of the shift motor **220** can engage a ring gear operatively connected to proximal drive end cap **503** so that drive gear **200** can drive rotation of the proximal drive end cap **503**.

In further embodiments, the endoscopic portion **140** is configured to interchangeably mate with a variety of surgical end effectors including, but not limited to, circular surgical staplers, linear surgical staplers, and others. The endoscopic portion **140** may be relatively rigid, flexible (such as the shaft shown in FIGS. **15**A and **15**B) and/or articulating.

In certain embodiments, a digital control module (DCM) is desirably included in the housing **110** and can be configured and arranged to control or help control the operation of shift motor **220** and/or drive motor **210** to respond to the monitored information. Pulse modulation, which may include an electronic clutch, may be used in controlling the output. For example, the DCM can regulate the voltage or pulse modulate the voltage to adjust the power and/or torque output to prevent system damage or optimize energy usage. An electric braking circuit may be used for controlling the drive motor **210** and/or shift motor **220**, which uses the existing back electromotive force (EMF) of rotating drive motor **210** to counteract and substantially reduce the momentum of drive gear **200**. The electric braking circuit may improve the control of drive motor **210** and/or shift motor **220** for stopping accuracy and/or shift location of powered surgical instrument **100**. Sensors for monitoring components of powered surgical instrument **100** and to help prevent overloading of powered surgical instrument **100** may include thermal-type sensors, such as thermal sensors, thermistors, thermopiles, thermo-couples and/or thermal infrared imaging and provide feedback to the DCM. The DCM may control the components of powered surgical instrument **100** in the event that limits are reached or approached and such control can include cutting off the power from the battery pack **400**, temporarily interrupting the power or going into a pause mode, pulse modulation to limit the energy used, and the DCM can monitor the temperature of components to determine when operation can be resumed. The above uses of the DCM may be used independently of or factored with current, voltage, temperature and/or impedance measurements.

An identification system may also be included to determine and communicate to the DCM various information, including the speed, power, torque, clamping, travel length and strength limitations for operating the particular end effector **160**. The DCM may also determine the operational mode and adjust the voltage, clutch spring loading and stop points for travel of the components. More specifically, the identification system may include a component (e.g., a microchip, emitter or transmitter) in end effector **160** that communicates (e.g., wirelessly, via infrared signals, etc.) with the DCM, or a receiver therein. It is also envisioned that a signal may be sent via firing rod, such that the firing rod functions as a conduit for communications between the DCM and end effector **160**. The identification system communicates with the DCM information concerning the surgical instrument, such as, for example, the type of end effector attached to the surgical instrument and/or the status of the end effector.

In a disclosed embodiment, at least some of the information monitored by the various sensors in powered surgical instrument **100** may be provided to a video screen or monitoring system in an operating room. For instance, the data may be transmitted to a receiver for the operating room monitoring system from a communication transmitter incorporated in or associated with powered surgical instrument **100**, via technology including Blue Tooth, ANT3, KNX, Z Wave, X10, wireless USB, WiFi, IrDa, Nanonet, Tiny OS, ZigBee, radio, UHF and VHF. Such features may facilitate monitoring by the user of powered surgical instrument **100** or other operating room or hospital personnel or remotely located persons.

It will be understood that various modifications may be made to the embodiments disclosed herein. For example, a shorter elongated tubular portion containing more or less coil fasteners may be provided for greater ease of handling during open surgery. Various articulations may be provided along the length of the elongated tubular portion to facilitate positioning of the coil fastener applier within the body. Additionally various configurations of the drive rod and slots or fastener retaining structure may be provided to accommodate various types of rotary fasteners. Therefore, the above description should not be construed as limiting, but merely as exemplifications of various embodiments. Those skilled in the art will envision other modifications within the scope and spirit of the claims appended hereto.

What is claimed is:

1. A surgical instrument, comprising:

a shaft defining a longitudinal axis therethrough and enclosing a drive motor, a shift motor, and a single drive gear, the drive motor mechanically cooperates with the shift motor to actuate the single drive gear; and

an end effector connected to a distal end of the shaft.

2. The surgical instrument of claim **1**, wherein the drive motor enables rotation of the single drive gear.

3. The surgical instrument of claim **1**, wherein the shift motor is configured to move the single drive gear in a plurality of positions.

4. The surgical instrument of claim **1**, wherein the drive motor, the shift motor, and the single drive gear are disposed along the longitudinal axis defined by the shaft.

5. The surgical instrument of claim **1**, wherein the drive motor is disposed adjacent the single drive gear.

6. The surgical instrument of claim **1**, wherein the drive motor is separated from the shift motor by a housing having a first portion and a second portion, each of which is slidably engaged with the other.

7. The surgical instrument of claim **6**, wherein the first portion is coupled to a drive motor casing of the drive motor and the second portion is coupled to the drive motor and is translatable within the shaft of the surgical instrument.

8. The surgical instrument of claim **7**, further comprising a position lock configured to maintain the single drive gear in one of a plurality of positions, wherein the drive motor casing includes a plurality of slots, each of which is configured to mate with the position lock.

9. The surgical instrument of claim **8**, wherein the position lock is spring-loaded and is biased against the drive motor casing.

10. The surgical instrument of claim **9**, further comprising a shift sensor disposed adjacent the position lock, the shift sensor is configured to provide feedback relating to a position of the drive motor.

11. The surgical instrument of claim **10**, further comprising at least one switch coupled to the shift motor and configured to communicate with the shift sensor, wherein the at least one switch is further configured to activate the shift motor based on a signal from the shift sensor.

12. A surgical instrument, comprising:

a shaft including:

a rigid portion defining a longitudinal axis and enclosing a drive motor, a shift motor, and a single drive gear having a drive end cap, the drive motor mechanically cooperates with the shift motor to actuate the single drive gear;

a flexible portion having at least a first flexible segment and a second flexible segment, the first and second flexible segments being rotatably movable with respect to the other between a plurality of positions by rotation of the drive end cap, the drive end cap is configured to rotate continuously until each of the first and second flexible segments attains an articulated position; and

an end effector disposed at a distal end of the flexible portion.

13. The surgical instrument of claim **12**, wherein the drive motor enables rotation of the single drive gear.

14. The surgical instrument of claim **12**, wherein the shift motor is configured to move the single drive gear in a plurality of positions.

15. The surgical instrument of claim **12**, wherein the drive motor, the shift motor, and the single drive gear are disposed along the longitudinal axis defined by the rigid portion of the shaft.

16. The surgical instrument of claim **12**, wherein the drive motor is disposed adjacent the single drive gear.

17. The surgical instrument of claim **12**, wherein the drive motor is separated from the shift motor by a housing having a first portion and a second portion, each of which is slidably engaged with the other.

18. The surgical instrument of claim **17**, wherein the first portion is coupled to a drive motor casing of the drive motor, and the second portion is coupled to the drive motor and is translatable within the shaft of the surgical instrument.

19. The surgical instrument of claim **18**, further comprising a position lock configured to maintain the single drive gear in one of a plurality of positions, wherein the drive motor casing includes a plurality of slots, each of which is configured to mate with the position lock.

20. The surgical instrument of claim **19**, wherein the position lock is spring-loaded and biased against the drive motor casing.

21. The surgical instrument of claim **20**, further comprising a shift sensor disposed adjacent the position lock, the shift sensor is configured to provide feedback relating to a position of the drive motor.

* * * * *