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(54) **SURGICAL DEVICE WITH ARTICULATION AND WRIST ROTATION**

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(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,453,862 A * 11/1948 Salisbury A61B 1/00177 600/146
3,079,606 A 3/1963 Bobrov et al.
(Continued)

FOREIGN PATENT DOCUMENTS

AU 5476586 A 9/1986
AU 198654765 9/1986
(Continued)

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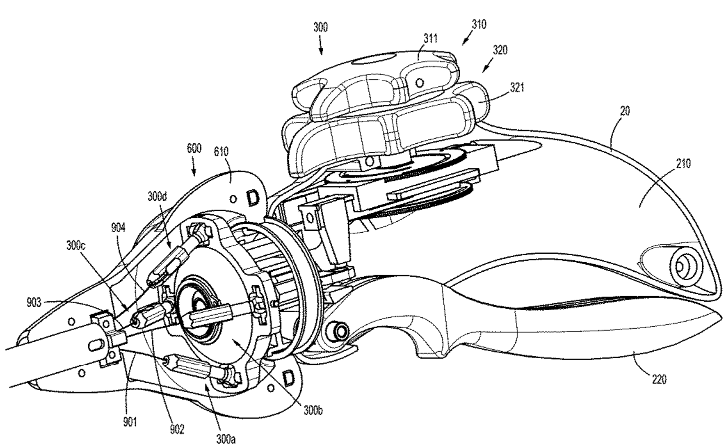
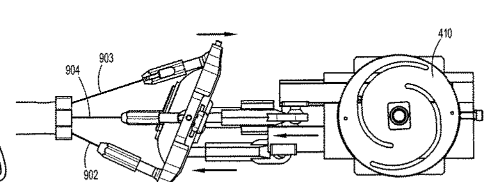
(57) **ABSTRACT**

A surgical instrument comprising a handle assembly, an elongated shaft, an end effector, a rotation mechanism, and an articulation mechanism is disclosed. The rotation mechanism is disposed in mechanical cooperation with the handle assembly and effects rotation of the end effector about the second longitudinal axis. The articulation mechanism is disposed in mechanical cooperation with the handle assembly and effects movement of the end effector from a first position where the first longitudinal axis is substantially aligned with the second longitudinal axis to a second position where the second longitudinal axis is displaced from the first longitudinal axis. The articulation mechanism comprises a first articulation control disposed in mechanical cooperation with the handle assembly, a first cable and a second cable. Actuation of the first articulation control in a first direction causes the first cable to move distally and causes the second cable to move proximally.

17 Claims, 20 Drawing Sheets





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(56) **References Cited**

U.S. PATENT DOCUMENTS

3,190,286 A 6/1965 Stokes
3,252,524 A 5/1966 Van Der Lely et al.
3,490,675 A 1/1970 Green et al.
3,499,591 A 3/1970 Green
3,557,780 A * 1/1971 Sato A61B 1/0055 600/141
3,572,325 A * 3/1971 Bazell et al. A61B 1/00165 600/164
3,605,725 A 9/1971 Bentov
3,610,231 A 10/1971 Takahashi et al.
3,777,538 A 12/1973 Weatherly et al.
3,788,303 A 1/1974 Hall
3,882,854 A 5/1975 Hulka et al.
4,027,510 A 6/1977 Hiltebrandt
4,086,926 A 5/1978 Green et al.
4,207,873 A 6/1980 Kruy
4,244,372 A 1/1981 Kapitanov et al.
4,429,695 A 2/1984 Green
4,483,326 A 11/1984 Yamaka et al.
4,499,895 A 2/1985 Takayama
4,505,414 A 3/1985 Filipi
4,520,817 A 6/1985 Green
4,530,568 A 7/1985 Haduch et al.
4,589,413 A 5/1986 Malyshev et al.
4,596,351 A 6/1986 Fedotov et al.
4,602,634 A 7/1986 Barkley
4,605,001 A 8/1986 Rothfuss et al.
4,608,981 A 9/1986 Rothfuss et al.
4,610,383 A 9/1986 Rothfuss et al.
4,633,861 A 1/1987 Chow et al.
4,633,874 A 1/1987 Chow et al.
4,671,445 A 6/1987 Barker et al.
4,700,703 A 10/1987 Resnick et al.
4,703,887 A 11/1987 Clanton et al.
4,728,020 A 3/1988 Green et al.
4,752,024 A 6/1988 Green et al.
4,762,118 A 8/1988 Lia et al.
4,784,137 A 11/1988 Kulik et al.
4,863,088 A 9/1989 Redmond et al.
4,869,415 A 9/1989 Fox
4,892,244 A 1/1990 Fox et al.
4,911,148 A * 3/1990 Sosnowski A61B 1/00165 600/164
4,955,959 A 9/1990 Tompkins et al.
4,978,049 A 12/1990 Green
4,991,764 A 2/1991 Mericle
5,014,899 A 5/1991 Presty et al.
5,031,814 A 7/1991 Tompkins et al.
5,040,715 A 8/1991 Green et al.
5,065,929 A 11/1991 Schulze et al.
5,071,430 A 12/1991 de Salis et al.
5,074,454 A 12/1991 Peters
5,083,695 A 1/1992 Foslien et al.
5,084,057 A 1/1992 Green et al.
5,106,008 A 4/1992 Tompkins et al.
5,111,987 A 5/1992 Moeinzadeh et al.
5,129,570 A 7/1992 Schulze et al.
5,141,144 A 8/1992 Foslien et al.
5,156,315 A 10/1992 Green et al.
5,156,614 A 10/1992 Green et al.
5,163,943 A 11/1992 Mohiuddin et al.
5,170,925 A 12/1992 Madden et al.
5,171,247 A 12/1992 Hughett et al.
5,173,133 A 12/1992 Morin et al.
5,180,092 A 1/1993 Crainich
5,188,274 A 2/1993 Moeinzadeh et al.
5,220,928 A 6/1993 Oddsen et al.
5,221,036 A 6/1993 Takase
5,242,457 A 9/1993 Akopov et al.
5,246,156 A 9/1993 Rothfuss et al.
5,253,793 A 10/1993 Green et al.
5,263,629 A 11/1993 Trumbull et al.
RE34,519 E 1/1994 Fox et al.
5,275,323 A 1/1994 Schulze et al.
5,282,807 A 2/1994 Knoepfler
5,289,963 A 3/1994 McGarry et al.
5,307,976 A 5/1994 Olson et al.
5,308,576 A 5/1994 Green et al.
5,312,023 A * 5/1994 Green A61B 17/07207 227/19
5,318,221 A 6/1994 Green et al.
5,325,845 A * 7/1994 Adair A61B 1/0055 604/95.04
5,326,013 A 7/1994 Green et al.
5,328,077 A 7/1994 Lou
5,330,486 A 7/1994 Wilk
5,332,142 A 7/1994 Robinson et al.
5,336,232 A 8/1994 Green et al.
5,344,061 A 9/1994 Crainich
5,352,238 A 10/1994 Green et al.
5,356,064 A * 10/1994 Green A61B 17/0684 606/139
5,358,478 A * 10/1994 Thompson A61M 25/0144 604/95.04
5,358,506 A 10/1994 Green et al.
5,364,001 A 11/1994 Bryan
5,364,002 A 11/1994 Green et al.
5,364,003 A 11/1994 Williamson, IV
5,366,133 A 11/1994 Geiste
5,376,095 A 12/1994 Ortiz
5,379,933 A 1/1995 Green et al.
5,381,943 A 1/1995 Allen et al.
5,382,255 A 1/1995 Castro et al.
5,383,880 A 1/1995 Hooven
5,388,568 A * 2/1995 van der Heide .. A61M 25/0136 600/146
5,389,098 A 2/1995 Tsuruta et al.
5,395,033 A 3/1995 Byrne et al.
5,395,034 A 3/1995 Mien et al.
5,397,046 A 3/1995 Savage et al.
5,397,324 A 3/1995 Carroll et al.
5,402,793 A 4/1995 Gruner et al.
5,403,312 A 4/1995 Yates et al.
5,405,072 A 4/1995 Zlock et al.
5,405,344 A * 4/1995 Williamson A61B 17/1285 606/1
5,407,293 A 4/1995 Crainich
5,409,498 A * 4/1995 Braddock A61B 17/1285 606/139
5,413,107 A * 5/1995 Oakley A61M 25/0136 600/463
5,413,268 A 5/1995 Green et al.
5,415,334 A 5/1995 Williamson et al.
5,415,335 A 5/1995 Knodell, Jr.
5,417,361 A 5/1995 Williamson, IV
5,423,471 A 6/1995 Mastri et al.
5,425,745 A 6/1995 Green et al.
5,431,322 A 7/1995 Green et al.
5,431,323 A 7/1995 Smith et al.
5,433,721 A 7/1995 Hooven et al.
5,441,193 A 8/1995 Gravener
5,445,304 A 8/1995 Plyley et al.
5,447,265 A 9/1995 Vidal et al.
5,452,837 A 9/1995 Williamson, IV et al.
5,454,827 A 10/1995 Aust et al.
5,456,401 A 10/1995 Green et al.
5,462,527 A 10/1995 Stevens-Wright et al.
5,464,300 A 11/1995 Crainich
5,465,895 A 11/1995 Knodel et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,467,911 A 11/1995 Tsuruta et al.
5,470,007 A 11/1995 Plyley et al.
5,470,010 A 11/1995 Rothfuss et al.
5,472,132 A 12/1995 Savage et al.
5,474,566 A 12/1995 Alesi et al.
5,476,206 A 12/1995 Green et al.
5,478,003 A * 12/1995 Green A61B 17/07207 227/176.1
5,480,089 A 1/1996 Blewett
5,482,197 A 1/1996 Green et al.
5,484,095 A 1/1996 Green et al.
5,484,451 A 1/1996 Akopov et al.
5,485,947 A 1/1996 Olson et al.
5,485,952 A 1/1996 Fontayne
5,486,185 A 1/1996 Freitas et al.
5,487,499 A 1/1996 Sorrentino et al.
5,487,500 A 1/1996 Knodel et al.
5,489,058 A 2/1996 Plyley et al.
5,490,856 A 2/1996 Person et al.
5,497,933 A 3/1996 DeFonzo et al.
5,501,689 A 3/1996 Green et al.
5,505,363 A 4/1996 Green et al.
5,507,426 A 4/1996 Young et al.
5,518,163 A 5/1996 Hooven
5,518,164 A 5/1996 Hooven
5,529,235 A 6/1996 Boiarski et al.
5,531,744 A 7/1996 Nardella et al.
5,535,934 A 7/1996 Boiarski et al.
5,535,935 A 7/1996 Vidal et al.
5,535,937 A 7/1996 Boiarski et al.
5,540,375 A * 7/1996 Bolanos A61B 17/072 227/19
5,542,594 A 8/1996 McKean et al.
5,549,628 A 8/1996 Cooper et al.
5,551,622 A 9/1996 Yoon
5,553,765 A 9/1996 Knodel et al.
5,554,164 A 9/1996 Wilson et al.
5,554,169 A 9/1996 Green et al.
5,560,530 A 10/1996 Bolanos et al.
5,560,532 A * 10/1996 DeFonzo A61B 17/0684 227/176.1
5,562,239 A 10/1996 Boiarski et al.
5,562,241 A 10/1996 Knodel et al.
5,562,682 A 10/1996 Oberlin et al.
5,562,701 A 10/1996 Huitema et al.
5,564,615 A * 10/1996 Bishop A61B 17/0682 227/19
5,571,116 A 11/1996 Bolanos et al.
5,573,169 A 11/1996 Green et al.
5,573,543 A 11/1996 Akopov et al.
5,575,799 A 11/1996 Bolanos et al.
5,575,803 A 11/1996 Cooper et al.
5,577,654 A 11/1996 Bishop
5,579,107 A 11/1996 Wright et al.
5,584,425 A 12/1996 Savage et al.
5,586,711 A 12/1996 Plyley et al.
5,588,580 A 12/1996 Paul et al.
5,588,581 A 12/1996 Conlon et al.
5,597,107 A 1/1997 Knodel et al.
5,601,224 A 2/1997 Bishop et al.
5,607,095 A 3/1997 Smith et al.
5,615,820 A 4/1997 Viola
5,618,291 A 4/1997 Thompson et al.
5,624,452 A 4/1997 Yates
5,626,587 A 5/1997 Bishop et al.
5,628,446 A 5/1997 Geiste et al.
5,630,539 A 5/1997 Plyley et al.
5,630,540 A 5/1997 Blewett
5,630,541 A 5/1997 Williamson, IV et al.
5,632,432 A 5/1997 Schulze et al.
5,634,584 A 6/1997 Okorocha et al.
5,636,780 A 6/1997 Green et al.
5,645,209 A 7/1997 Green et al.
5,647,526 A 7/1997 Green et al.
5,651,491 A 7/1997 Heaton et al.
5,653,373 A 8/1997 Green et al.
5,653,374 A 8/1997 Young et al.
5,653,721 A 8/1997 Knodel et al.
5,655,698 A 8/1997 Yoon
5,657,921 A 8/1997 Young et al.
5,658,300 A 8/1997 Bito et al.
5,662,258 A 9/1997 Knodel et al.
5,662,259 A 9/1997 Yoon
5,662,260 A 9/1997 Yoon
5,662,662 A * 9/1997 Bishop A61B 17/0684 606/139
5,662,666 A 9/1997 Onuki et al.
5,665,085 A 9/1997 Nardella
5,667,517 A 9/1997 Hooven
5,669,544 A 9/1997 Schulze et al.
5,673,840 A 10/1997 Schulze et al.
5,673,841 A 10/1997 Schulze et al.
5,673,842 A 10/1997 Bittner 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.
5,680,983 A 10/1997 Plyley et al.
5,690,269 A 11/1997 Bolanos et al.
5,690,675 A 11/1997 Sawyer et al.
5,692,668 A 12/1997 Schulze et al.
5,697,542 A 12/1997 Knodel et al.
5,702,408 A 12/1997 Wales et al.
5,702,409 A 12/1997 Raybum et al.
5,704,534 A 1/1998 Huitema et al.
5,706,997 A 1/1998 Green et al.
5,709,334 A 1/1998 Sorrentino et al.
5,711,472 A 1/1998 Bryan
5,713,505 A 2/1998 Huitema
5,715,988 A 2/1998 Palmer
5,716,366 A 2/1998 Yates
5,718,359 A 2/1998 Palmer et al.
5,725,536 A 3/1998 Oberlin et al.
5,725,554 A 3/1998 Simon et al.
5,728,110 A 3/1998 Vidal et al.
5,732,806 A 3/1998 Foshee et al.
5,735,848 A 4/1998 Yates et al.
5,743,456 A * 4/1998 Jones A61B 17/0684 227/176.1
5,749,893 A 5/1998 Vidal et al.
5,752,644 A 5/1998 Bolanos et al.
5,762,255 A 6/1998 Chrisman et al.
5,762,256 A 6/1998 Mastri et al.
5,766,196 A * 6/1998 Griffiths A61B 17/29 606/174
5,769,303 A 6/1998 Knodel et al.
5,769,892 A 6/1998 Kingwell
5,772,099 A 6/1998 Gravener
5,772,673 A 6/1998 Cuny et al.
5,779,130 A 7/1998 Alesi et al.
5,779,131 A 7/1998 Knodel et al.
5,779,132 A 7/1998 Knodel et al.
5,782,396 A 7/1998 Mastri et al.
5,782,397 A 7/1998 Koukline
5,782,834 A 7/1998 Lucey et al.
5,785,232 A 7/1998 Vidal et al.
5,797,536 A 8/1998 Smith et al.
5,797,537 A 8/1998 Oberlin et al.
5,797,538 A 8/1998 Heaton et al.
5,810,811 A 9/1998 Yates et al.
5,810,855 A 9/1998 Rayburn et al.
5,814,055 A 9/1998 Knodel et al.
5,814,057 A 9/1998 Oi et al.
5,816,471 A 10/1998 Plyley et al.
5,817,109 A 10/1998 McGarry et al.
5,820,009 A 10/1998 Melling et al.
5,823,066 A 10/1998 Huitema et al.
5,826,776 A 10/1998 Schulze et al.
5,829,662 A 11/1998 Allen et al.
5,833,695 A 11/1998 Yoon
5,836,147 A 11/1998 Schnipke
5,862,972 A 1/1999 Green et al.
5,865,361 A 2/1999 Milliman et al.
5,871,135 A 2/1999 Williamson IV et al.
5,873,873 A 2/1999 Smith et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,878,938 A 3/1999 Bittner et al.
5,891,088 A * 4/1999 Thompson A61M 25/0136 604/524
5,893,506 A 4/1999 Powell
5,894,979 A 4/1999 Powell
5,897,562 A 4/1999 Bolanos et al.
5,901,895 A * 5/1999 Heaton A61B 17/07207 227/176.1
5,911,352 A 6/1999 Racenet et al.
5,911,353 A 6/1999 Bolanos et al.
5,918,791 A 7/1999 Sorrentino et al.
5,919,198 A 7/1999 Graves, Jr. et al.
5,922,001 A 7/1999 Yoon
5,931,847 A 8/1999 Bittner et al.
5,941,442 A 8/1999 Geiste et al.
5,954,259 A 9/1999 Viola et al.
5,954,654 A * 9/1999 Eaton A61M 25/0136 600/459
5,964,774 A 10/1999 McKean et al.
5,980,510 A 11/1999 Tsonton et al.
5,988,479 A 11/1999 Palmer
6,004,335 A 12/1999 Vaitekunas et al.
6,010,054 A 1/2000 Johnson et al.
6,032,849 A 3/2000 Mastri et al.
6,045,560 A 4/2000 McKean et al.
6,063,097 A 5/2000 Oi et al.
6,079,606 A 6/2000 Milliman et al.
6,099,551 A 8/2000 Gabbay
6,109,500 A 8/2000 Alli et al.
6,131,789 A 10/2000 Schulze et al.
6,131,790 A 10/2000 Piraka
6,155,473 A 12/2000 Tompkins et al.
6,162,208 A * 12/2000 Hipps A61F 2/2427 606/1
6,197,017 B1 3/2001 Brock et al.
6,202,914 B1 3/2001 Geiste et al.
6,241,139 B1 6/2001 Milliman et al.
6,250,532 B1 6/2001 Green et al.
6,264,086 B1 7/2001 McGuckin, Jr.
6,264,087 B1 7/2001 Whitman
6,269,977 B1 8/2001 Moore
6,279,809 B1 8/2001 Nicolo
6,315,183 B1 11/2001 Piraka
6,315,184 B1 11/2001 Whitman
6,325,810 B1 12/2001 Hamilton et al.
6,330,965 B1 12/2001 Milliman et al.
6,391,038 B2 5/2002 Vargas et al.
6,398,797 B2 6/2002 Bombard et al.
6,436,097 B1 8/2002 Nardella
6,439,446 B1 8/2002 Perry et al.
6,443,973 B1 9/2002 Whitman
6,463,623 B2 10/2002 Ahn et al.
6,478,804 B2 11/2002 Vargas et al.
6,488,196 B1 12/2002 Fenton, Jr.
6,503,257 B2 1/2003 Grant et al.
6,505,768 B2 1/2003 Whitman
6,544,274 B2 4/2003 Danitz et al.
6,554,844 B2 4/2003 Lee et al.
6,565,554 B1 5/2003 Niemeyer
6,587,750 B2 7/2003 Gerbi et al.
6,592,573 B2 7/2003 Castaneda et al.
6,592,597 B2 7/2003 Grant et al.
6,594,552 B1 7/2003 Nowlin et al.
6,602,252 B2 8/2003 Mollenauer
6,612,053 B2 9/2003 Liao
6,619,529 B2 9/2003 Green et al.
D480,808 S 10/2003 Wells et al.
6,644,532 B2 11/2003 Green et al.
6,656,193 B2 12/2003 Grant et al.
6,666,854 B1 * 12/2003 Lange A61B 17/2909 606/1
6,669,073 B2 12/2003 Milliman et al.
6,681,978 B2 1/2004 Geiste et al.
6,698,643 B2 3/2004 Whitman
6,716,232 B1 4/2004 Vidal et al.
6,722,552 B2 4/2004 Fenton, Jr.
6,731,473 B2 5/2004 Li et al.
6,755,338 B2 6/2004 Hahnen et al.
6,783,524 B2 8/2004 Anderson et al.
6,786,382 B1 9/2004 Hoffman
6,808,262 B2 10/2004 Chapoy et al.
6,817,509 B2 11/2004 Geiste et al.
6,830,174 B2 12/2004 Hillstead et al.
6,835,199 B2 12/2004 McGuckin, Jr. et al.
6,843,403 B2 1/2005 Whitman
RE38,708 E 3/2005 Bolanos et al.
6,877,647 B2 4/2005 Green et al.
6,879,880 B2 4/2005 Nowlin et al.
6,889,116 B2 5/2005 Jinno
6,905,057 B2 6/2005 Swayze et al.
6,953,138 B1 10/2005 Dworak et al.
6,953,139 B2 10/2005 Milliman et al.
6,958,036 B2 10/2005 Seki et al.
6,959,852 B2 11/2005 Shelton, IV et al.
6,962,594 B1 11/2005 Thevenet
6,964,363 B2 11/2005 Wales et al.
6,978,921 B2 12/2005 Shelton, IV et al.
6,981,628 B2 1/2006 Wales
6,986,451 B1 1/2006 Mastri et al.
6,988,649 B2 1/2006 Shelton, IV et al.
6,991,627 B2 1/2006 Madhani et al.
6,994,714 B2 2/2006 Vargas et al.
7,000,818 B2 2/2006 Shelton, IV et al.
7,000,819 B2 2/2006 Swayze et al.
7,032,799 B2 4/2006 Viola et al.
7,044,352 B2 5/2006 Shelton, IV et al.
7,044,353 B2 5/2006 Mastri et al.
7,055,730 B2 6/2006 Ehrenfels et al.
7,055,731 B2 6/2006 Shelton, IV et al.
7,059,508 B2 6/2006 Shelton, IV et al.
7,070,083 B2 7/2006 Jankowski
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.
7,114,642 B2 10/2006 Whitman
7,121,446 B2 10/2006 Arad et al.
7,128,253 B2 10/2006 Mastri et al.
7,128,254 B2 10/2006 Shelton, IV et al.
7,140,527 B2 11/2006 Ehrenfels et al.
7,140,528 B2 11/2006 Shelton, IV
7,143,923 B2 12/2006 Shelton, IV et al.
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
7,159,750 B2 1/2007 Racenet et al.
7,172,104 B2 2/2007 Scirica et al.
7,188,758 B2 3/2007 Viola et al.
7,207,471 B2 4/2007 Heinrich et al.
7,213,736 B2 5/2007 Wales et al.
7,225,963 B2 6/2007 Scirica
7,225,964 B2 6/2007 Mastri et al.
7,238,195 B2 7/2007 Viola
7,246,734 B2 7/2007 Shelton, IV
7,258,262 B2 8/2007 Mastri et al.
7,267,682 B1 9/2007 Bender et al.
7,278,562 B2 10/2007 Mastri et al.
7,278,563 B1 10/2007 Green
7,287,682 B1 10/2007 Ezzat et al.
7,293,685 B2 11/2007 Ehrenfels et al.
7,296,722 B2 11/2007 Ivanko
7,296,724 B2 11/2007 Green et al.
7,296,772 B2 11/2007 Wang
7,300,444 B1 11/2007 Nielsen et al.
7,303,108 B2 12/2007 Shelton, IV
7,308,998 B2 12/2007 Mastri et al.
7,326,232 B2 2/2008 Viola et al.
7,328,828 B2 2/2008 Ortiz et al.
7,328,829 B2 2/2008 Arad et al.
7,334,717 B2 2/2008 Rethy et al.
7,354,447 B2 4/2008 Shelton, IV et al.
7,357,287 B2 4/2008 Shelton, IV et al.
7,364,061 B2 4/2008 Swayze et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,367,485 B2 5/2008 Shelton, IV et al.
7,380,695 B2 6/2008 Doll et al.
7,380,696 B2 6/2008 Shelton, IV et al.
7,398,907 B2 7/2008 Racenet et al.
7,399,310 B2 7/2008 Edoga et al.
7,401,720 B1 7/2008 Durrani
7,401,721 B2 7/2008 Holsten et al.
7,404,508 B2 7/2008 Smith et al.
7,404,509 B2 7/2008 Ortiz et al.
7,407,074 B2 8/2008 Ortiz et al.
7,407,075 B2 8/2008 Holsten et al.
7,407,077 B2 8/2008 Ortiz et al.
7,407,078 B2 8/2008 Shelton, IV et al.
7,416,101 B2 8/2008 Shelton, IV et al.
7,419,080 B2 9/2008 Smith et al.
7,419,081 B2 9/2008 Ehrenfels et al.
7,419,495 B2 9/2008 Menn et al.
7,422,139 B2 9/2008 Shelton, IV et al.
7,431,189 B2 10/2008 Shelton, IV et al.
7,431,730 B2 10/2008 Viola
7,434,715 B2 10/2008 Shelton, IV et al.
7,434,717 B2 10/2008 Shelton, IV et al.
7,438,208 B2 10/2008 Larson
7,438,209 B1 10/2008 Hess et al.
7,441,684 B2 10/2008 Shelton, IV et al.
7,441,685 B1 10/2008 Boudreaux
7,448,525 B2 11/2008 Shelton, IV et al.
7,449,002 B1 * 11/2008 Wenstad A61M 25/09041 600/585
7,451,904 B2 11/2008 Shelton, IV
7,455,208 B2 11/2008 Wales et al.
7,455,676 B2 11/2008 Holsten et al.
7,458,494 B2 12/2008 Matsutani et al.
7,461,767 B2 12/2008 Viola et al.
7,462,185 B1 12/2008 Knodel
7,464,846 B2 12/2008 Shelton, IV et al.
7,464,848 B2 12/2008 Green et al.
7,464,849 B2 12/2008 Shelton, IV et al.
7,467,740 B2 12/2008 Shelton, IV et al.
7,472,814 B2 1/2009 Mastri et al.
7,472,815 B2 1/2009 Shelton, IV et al.
7,472,816 B2 1/2009 Holsten et al.
7,473,258 B2 1/2009 Clauson et al.
7,481,347 B2 1/2009 Roy
7,481,348 B2 1/2009 Marczyk
7,481,349 B2 1/2009 Holsten et al.
7,487,899 B2 2/2009 Shelton, IV et al.
7,490,749 B2 2/2009 Schall et al.
7,494,039 B2 * 2/2009 Racenet A61B 34/71 227/180.1
7,500,979 B2 3/2009 Hueil et al.
7,503,474 B2 3/2009 Hillstead et al.
7,506,790 B2 3/2009 Shelton, IV
7,510,107 B2 3/2009 Timm et al.
7,513,408 B2 4/2009 Shelton, IV et al.
7,517,356 B2 4/2009 Heinrich
7,537,602 B2 5/2009 Whitman
7,543,729 B2 6/2009 Ivanko
7,543,730 B1 6/2009 Marczyk
7,543,731 B2 6/2009 Green et al.
7,556,185 B2 7/2009 Viola
7,556,186 B2 7/2009 Milliman
7,559,450 B2 7/2009 Wales et al.
7,559,452 B2 7/2009 Wales et al.
7,559,453 B2 7/2009 Heinrich et al.
7,559,937 B2 7/2009 de la Torre et al.
7,565,993 B2 7/2009 Milliman et al.
7,568,603 B2 8/2009 Shelton, IV et al.
7,568,604 B2 8/2009 Ehrenfels et al.
7,571,845 B2 8/2009 Viola
7,575,144 B2 8/2009 Ortiz et al.
7,584,880 B2 9/2009 Racenet et al.
7,588,174 B2 9/2009 Holsten et al.
7,588,175 B2 9/2009 Timm et al.
7,588,176 B2 9/2009 Timm et al.
7,588,177 B2 9/2009 Racenet
7,588,536 B2 9/2009 Peszynski
7,597,229 B2 10/2009 Boudreaux et al.
7,597,230 B2 10/2009 Racenet et al.
7,604,150 B2 10/2009 Boudreaux
7,604,151 B2 10/2009 Hess et al.
7,607,557 B2 10/2009 Shelton, IV et al.
7,611,038 B2 11/2009 Racenet et al.
7,617,961 B2 11/2009 Viola
7,624,902 B2 12/2009 Marczyk et al.
7,624,903 B2 12/2009 Green et al.
7,631,793 B2 12/2009 Rethy et al.
7,631,794 B2 12/2009 Rethy et al.
7,635,073 B2 12/2009 Heinrich
7,635,074 B2 12/2009 Olson et al.
7,635,373 B2 12/2009 Ortiz
7,637,409 B2 12/2009 Marczyk
7,637,410 B2 12/2009 Marczyk
7,641,091 B2 1/2010 Olson et al.
7,641,093 B2 1/2010 Doll et al.
7,641,095 B2 1/2010 Viola
7,644,848 B2 1/2010 Swayze et al.
7,648,055 B2 1/2010 Marczyk
7,648,519 B2 * 1/2010 Lee A61B 17/2909 606/205
7,651,017 B2 1/2010 Ortiz et al.
7,654,431 B2 2/2010 Hueil et al.
7,658,311 B2 2/2010 Boudreaux
7,658,312 B2 2/2010 Vidal et al.
7,665,646 B2 2/2010 Prommersberger
7,665,647 B2 2/2010 Shelton, IV et al.
7,669,746 B2 3/2010 Shelton, IV
7,670,334 B2 3/2010 Hueil et al.
7,673,780 B2 3/2010 Shelton, IV et al.
7,673,781 B2 3/2010 Swayze et al.
7,673,782 B2 3/2010 Hess et al.
7,673,783 B2 3/2010 Morgan et al.
7,678,121 B1 3/2010 Knodel
7,681,772 B2 3/2010 Green et al.
7,682,367 B2 3/2010 Shah et al.
7,682,368 B1 3/2010 Bombard et al.
7,690,547 B2 4/2010 Racenet et al.
7,694,865 B2 4/2010 Scirica
7,699,205 B2 4/2010 Ivanko
7,721,933 B2 5/2010 Ehrenfels et al.
7,726,538 B2 6/2010 Holsten et al.
7,726,539 B2 6/2010 Holsten et al.
7,740,160 B2 6/2010 Viola
7,744,628 B2 6/2010 Viola
7,757,924 B2 7/2010 Gerbi et al.
7,757,925 B2 7/2010 Viola et al.
7,762,445 B2 7/2010 Heinrich et al.
7,766,209 B2 8/2010 Baxter, III et al.
7,766,210 B2 8/2010 Shelton, IV et al.
7,766,924 B1 8/2010 Bombard et al.
7,766,928 B2 8/2010 Ezzat et al.
7,770,774 B2 8/2010 Mastri et al.
7,770,775 B2 8/2010 Shelton, IV et al.
7,771,416 B2 8/2010 Spivey et al.
7,776,060 B2 8/2010 Mooradian et al.
7,780,055 B2 8/2010 Scirica et al.
7,784,662 B2 8/2010 Wales et al.
7,789,283 B2 9/2010 Shah
7,793,812 B2 9/2010 Moore et al.
7,793,814 B2 9/2010 Racenet et al.
7,794,475 B2 9/2010 Hess et al.
7,798,386 B2 9/2010 Schall et al.
7,799,039 B2 9/2010 Shelton, IV et al.
7,810,690 B2 10/2010 Bilotti et al.
7,810,692 B2 10/2010 Hall et al.
7,810,693 B2 10/2010 Broehl et al.
7,815,091 B2 10/2010 Marczyk
7,815,092 B2 10/2010 Whitman et al.
7,819,296 B2 10/2010 Hueil et al.
7,819,297 B2 10/2010 Doll et al.
7,819,298 B2 10/2010 Hall et al.
7,819,299 B2 10/2010 Shelton, IV et al.
7,823,760 B2 11/2010 Zemlok et al.
7,824,426 B2 11/2010 Racenet et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,828,186 B2 11/2010 Wales
7,828,187 B2 11/2010 Green et al.
7,828,188 B2 11/2010 Jankowski
7,828,189 B2 11/2010 Holsten et al.
7,832,408 B2 11/2010 Shelton, IV et al.
7,832,612 B2 11/2010 Baxter, III et al.
7,837,079 B2 11/2010 Holsten et al.
7,837,081 B2 11/2010 Holsten et al.
7,841,503 B2 11/2010 Sonnenschein et al.
7,842,028 B2 11/2010 Lee
7,845,533 B2 12/2010 Marczyk et al.
7,845,534 B2 12/2010 Viola et al.
7,845,535 B2 12/2010 Scircia
7,845,537 B2 12/2010 Shelton, IV et al.
7,845,538 B2 12/2010 Whitman
7,850,703 B2 12/2010 Bombard et al.
7,857,183 B2 12/2010 Shelton, IV
7,857,184 B2 12/2010 Viola
7,857,185 B2 12/2010 Swayze et al.
7,857,186 B2 12/2010 Baxter, III et al.
7,861,906 B2 1/2011 Doll et al.
7,861,907 B2 1/2011 Green et al.
7,866,524 B2 1/2011 Krehel
7,866,525 B2 1/2011 Scirica
7,866,527 B2 1/2011 Hall et al.
7,866,528 B2 1/2011 Olson et al.
7,870,989 B2 1/2011 Viola et al.
7,881,809 B2 2/2011 Rashidi
7,886,952 B2 2/2011 Scirica et al.
7,891,532 B2 2/2011 Mastri et al.
7,891,533 B2 2/2011 Green et al.
7,891,534 B2 2/2011 Wenchell et al.
7,896,214 B2 3/2011 Farascioni
7,900,805 B2 3/2011 Shelton, IV et al.
7,901,416 B2 3/2011 Nolan et al.
7,905,380 B2 3/2011 Shelton, IV et al.
7,905,381 B2 3/2011 Baxter, III et al.
7,909,039 B2 3/2011 Hur
7,909,220 B2 3/2011 Viola
7,909,221 B2 3/2011 Viola et al.
7,909,224 B2 3/2011 Prommersberger
7,913,891 B2 3/2011 Doll et al.
7,913,893 B2 3/2011 Mastri et al.
7,914,543 B2 3/2011 Roth et al.
7,918,230 B2 4/2011 Whitman et al.
7,918,276 B2 4/2011 Guignard et al.
7,922,061 B2 4/2011 Shelton, IV et al.
7,922,063 B2 4/2011 Zemlok et al.
7,926,691 B2 4/2011 Viola et al.
7,926,692 B2 4/2011 Racenet et al.
7,934,628 B2 5/2011 Wenchell et al.
7,934,630 B2 5/2011 Shelton, IV et al.
7,934,631 B2 5/2011 Balbierz et al.
7,942,300 B2 5/2011 Rethy et al.
7,942,303 B2 5/2011 Shah
7,950,560 B2 5/2011 Zemlok et al.
7,950,561 B2 5/2011 Aranyi
7,950,562 B2 5/2011 Beardsley et al.
7,954,682 B2 6/2011 Giordano et al.
7,954,683 B1 6/2011 Knodel et al.
7,954,684 B2 6/2011 Boudreaux
7,954,685 B2 6/2011 Viola
7,954,686 B2 6/2011 Baxter, III et al.
7,954,687 B2 6/2011 Zemlok et al.
7,959,051 B2 6/2011 Smith et al.
7,963,431 B2 6/2011 Scirica
7,963,432 B2 6/2011 Knodel et al.
7,963,433 B2 6/2011 Whitman et al.
7,967,178 B2 6/2011 Scirica et al.
7,967,179 B2 6/2011 Olson et al.
7,967,180 B2 6/2011 Scirica
7,980,443 B2 7/2011 Scheib et al.
7,988,026 B2 8/2011 Knodel et al.
7,988,027 B2 8/2011 Olson et al.
7,988,028 B2 8/2011 Farascioni et al.
7,992,758 B2 8/2011 Whitman et al.
7,997,468 B2 8/2011 Farascioni
7,997,469 B2 8/2011 Olson et al.
8,002,795 B2 8/2011 Beetel
8,006,885 B2 8/2011 Marczyk
8,006,887 B2 8/2011 Marczyk
8,007,505 B2 8/2011 Weller et al.
8,007,513 B2 8/2011 Nalagatla et al.
8,011,550 B2 9/2011 Aranyi et al.
8,011,551 B2 9/2011 Marczyk et al.
8,011,552 B2 9/2011 Ivanko
8,011,553 B2 9/2011 Mastri et al.
8,011,555 B2 9/2011 Tarinelli et al.
8,012,170 B2 9/2011 Whitman et al.
8,015,976 B2 9/2011 Shah
8,016,177 B2 9/2011 Bettuchi et al.
8,016,178 B2 9/2011 Olson et al.
8,020,742 B2 9/2011 Marczyk
8,028,882 B2 10/2011 Viola
8,028,883 B2 10/2011 Stopek
8,033,438 B2 10/2011 Scirica
8,033,440 B2 10/2011 Wenchell et al.
8,033,441 B2 10/2011 Marczyk
8,033,442 B2 10/2011 Racenet et al.
8,034,077 B2 10/2011 Smith et al.
8,038,044 B2 10/2011 Viola
8,038,045 B2 10/2011 Bettuchi et al.
8,333,780 B1 12/2012 Pedros et al.
8,574,263 B2 11/2013 Mueller
8,603,135 B2 * 12/2013 Mueller A61B 18/1445 606/205
8,783,542 B2 * 7/2014 Riestenberg A61B 17/00491 227/176.1
8,888,775 B2 * 11/2014 Nau, Jr. A61B 18/1445 606/49
2003/0074014 A1 * 4/2003 Castaneda A61B 17/320016 606/167
2003/0092965 A1 5/2003 Konomura et al.
2004/0007608 A1 1/2004 Ehrenfels et al.
2004/0050902 A1 * 3/2004 Green A61B 17/07207 227/176.1
2004/0059191 A1 3/2004 Krupa et al.
2004/0093029 A1 5/2004 Zubik et al.
2004/0094597 A1 5/2004 Whitman et al.
2004/0108357 A1 6/2004 Milliman et al.
2004/0149802 A1 8/2004 Whitman
2004/0173659 A1 9/2004 Green et al.
2004/0199180 A1 10/2004 Knodel et al.
2004/0199181 A1 10/2004 Knodel et al.
2004/0232199 A1 11/2004 Shelton et al.
2004/0232200 A1 11/2004 Shelton et al.
2004/0232201 A1 11/2004 Wenchell et al.
2004/0243151 A1 12/2004 Demmy et al.
2004/0267310 A1 12/2004 Racenet et al.
2004/0267311 A1 12/2004 Viola et al.
2005/0006429 A1 1/2005 Wales et al.
2005/0006430 A1 1/2005 Wales
2005/0006431 A1 1/2005 Shelton et al.
2005/0006432 A1 * 1/2005 Racenet A61B 17/105 227/176.1
2005/0006433 A1 1/2005 Milliman et al.
2005/0006434 A1 * 1/2005 Wales A61B 17/07207 227/19
2005/0023324 A1 2/2005 Doll et al.
2005/0023325 A1 2/2005 Gresham et al.
2005/0067457 A1 3/2005 Shelton et al.
2005/0067458 A1 3/2005 Swayze et al.
2005/0067459 A1 3/2005 Swayze et al.
2005/0067460 A1 3/2005 Milliman et al.
2005/0070925 A1 3/2005 Shelton et al.
2005/0070958 A1 3/2005 Swayze et al.
2005/0072827 A1 4/2005 Mollenauer
2005/0082336 A1 4/2005 Ivanko
2005/0103819 A1 5/2005 Racenet et al.
2005/0119669 A1 6/2005 Demmy
2005/0127131 A1 6/2005 Mastri et al.
2005/0145671 A1 7/2005 Viola
2005/0159778 A1 7/2005 Heinrich et al.
2005/0165415 A1 7/2005 Wales

(56) **References Cited**

U.S. PATENT DOCUMENTS

2005/0173490 A1 8/2005 Shelton
2005/0178813 A1 8/2005 Swayze et al.
2005/0184121 A1 8/2005 Heinrich
2005/0184123 A1 8/2005 Scirica
2005/0184124 A1 8/2005 Scirica et al.
2005/0184125 A1 8/2005 Marczyk
2005/0184126 A1 8/2005 Green et al.
2005/0189397 A1 9/2005 Jankowski
2005/0192628 A1 9/2005 Viola
2005/0216055 A1 9/2005 Scirica et al.
2005/0230453 A1 10/2005 Viola
2005/0256452 A1 11/2005 DeMarchi et al.
2005/0263562 A1 12/2005 Shelton et al.
2005/0279804 A1 12/2005 Scirica et al.
2006/0000867 A1 1/2006 Shelton et al.
2006/0000868 A1 1/2006 Shelton et al.
2006/0011699 A1 1/2006 Olson et al.
2006/0016853 A1 1/2006 Racenet
2006/0022014 A1 2/2006 Shelton et al.
2006/0022015 A1 2/2006 Shelton et al.
2006/0025809 A1 2/2006 Shelton
2006/0043147 A1 3/2006 Mastri et al.
2006/0049229 A1 3/2006 Milliman et al.
2006/0049230 A1 3/2006 Shelton et al.
2006/0060630 A1 3/2006 Shelton et al.
2006/0081678 A1 4/2006 Ehrenfels et al.
2006/0097026 A1 5/2006 Shelton
2006/0124688 A1 6/2006 Racenet et al.
2006/0124689 A1 6/2006 Arad et al.
2006/0138193 A1 6/2006 Viola et al.
2006/0138194 A1 6/2006 Viola et al.
2006/0151567 A1 7/2006 Roy
2006/0151568 A1 7/2006 Weller et al.
2006/0151569 A1 7/2006 Ehrenfels et al.
2006/0175375 A1 8/2006 Shelton et al.
2006/0180634 A1 8/2006 Shelton et al.
2006/0201990 A1 9/2006 Mastri et al.
2006/0201991 A1 9/2006 Mastri et al.
2006/0226195 A1 10/2006 Scirica et al.
2006/0226196 A1 10/2006 Hueil et al.
2006/0252993 A1* 11/2006 Freed A61M 25/0147 604/95.04
2006/0255090 A1 11/2006 Milliman et al.
2006/0278680 A1 12/2006 Viola et al.
2006/0278681 A1 12/2006 Viola et al.
2006/0289600 A1 12/2006 Wales et al.
2006/0289602 A1 12/2006 Wales et al.
2007/0021737 A1* 1/2007 Lee A61B 17/22 606/1
2007/0023477 A1 2/2007 Whitman et al.
2007/0027469 A1 2/2007 Smith et al.
2007/0034669 A1 2/2007 de la Torre et al.
2007/0034670 A1 2/2007 Racenet et al.
2007/0045379 A1 3/2007 Shelton
2007/0045380 A1 3/2007 Mastri et al.
2007/0068989 A1 3/2007 Shelton
2007/0068990 A1 3/2007 Shelton et al.
2007/0073340 A1 3/2007 Shelton et al.
2007/0073341 A1 3/2007 Smith et al.
2007/0075114 A1 4/2007 Shelton et al.
2007/0075115 A1 4/2007 Olson et al.
2007/0075116 A1 4/2007 Whitman
2007/0083233 A1 4/2007 Ortiz et al.
2007/0083234 A1 4/2007 Shelton et al.
2007/0084896 A1 4/2007 Doll et al.
2007/0084897 A1 4/2007 Shelton et al.
2007/0084898 A1* 4/2007 Scirica A61B 17/07207 227/176.1
2007/0084899 A1 4/2007 Taylor
2007/0102472 A1 5/2007 Shelton
2007/0102473 A1 5/2007 Shelton et al.
2007/0102474 A1 5/2007 Shelton et al.
2007/0102475 A1 5/2007 Ortiz et al.
2007/0102476 A1 5/2007 Shelton et al.
2007/0106317 A1 5/2007 Shelton et al.
2007/0108252 A1 5/2007 Racenet et al.
2007/0114261 A1 5/2007 Ortiz et al.
2007/0114262 A1 5/2007 Mastri et al.
2007/0119900 A1 5/2007 Ehrenfels et al.
2007/0119901 A1 5/2007 Ehrenfels et al.
2007/0125826 A1 6/2007 Shelton
2007/0125827 A1 6/2007 Viola
2007/0125828 A1 6/2007 Rethy et al.
2007/0145095 A1 6/2007 Heinrich et al.
2007/0145096 A1 6/2007 Viola et al.
2007/0152014 A1 7/2007 Gillum et al.
2007/0158385 A1 7/2007 Hueil et al.
2007/0170225 A1 7/2007 Shelton et al.
2007/0175947 A1 8/2007 Ortiz et al.
2007/0175948 A1* 8/2007 Scirica A61B 17/07207 227/175.1
2007/0175949 A1 8/2007 Shelton et al.
2007/0175950 A1 8/2007 Shelton et al.
2007/0175951 A1 8/2007 Shelton et al.
2007/0175952 A1 8/2007 Shelton et al.
2007/0175953 A1 8/2007 Shelton et al.
2007/0175954 A1 8/2007 Viola
2007/0175955 A1 8/2007 Shelton et al.
2007/0175956 A1 8/2007 Swayze et al.
2007/0175957 A1 8/2007 Shelton et al.
2007/0175958 A1 8/2007 Shelton et al.
2007/0175959 A1 8/2007 Shelton et al.
2007/0175960 A1 8/2007 Shelton et al.
2007/0175961 A1 8/2007 Shelton et al.
2007/0175962 A1 8/2007 Shelton et al.
2007/0175964 A1 8/2007 Shelton et al.
2007/0179528 A1 8/2007 Soltz et al.
2007/0187453 A1 8/2007 Smith et al.
2007/0187454 A1 8/2007 Scirica
2007/0187455 A1 8/2007 Demmy et al.
2007/0194079 A1 8/2007 Hueil et al.
2007/0194080 A1 8/2007 Swayze et al.
2007/0194081 A1 8/2007 Hueil et al.
2007/0194082 A1 8/2007 Morgan et al.
2007/0221700 A1 9/2007 Ortiz et al.
2007/0221701 A1 9/2007 Ortiz et al.
2007/0225562 A1 9/2007 Spivey et al.
2007/0250113 A1* 10/2007 Hegeman H04W 24/08 606/207
2007/0276430 A1* 11/2007 Lee A61B 1/00071 606/205
2007/0278277 A1 12/2007 Wixey et al.
2007/0282371 A1* 12/2007 Lee A61B 17/29 606/205
2007/0295780 A1 12/2007 Shelton et al.
2008/0029570 A1 2/2008 Shelton et al.
2008/0029571 A1 2/2008 Shelton et al.
2008/0029572 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.
2008/0029576 A1 2/2008 Shelton et al.
2008/0029577 A1 2/2008 Shelton et al.
2008/0048002 A1 2/2008 Smith et al.
2008/0078800 A1 4/2008 Hess et al.
2008/0078801 A1 4/2008 Shelton et al.
2008/0078802 A1 4/2008 Hess et al.
2008/0078803 A1 4/2008 Shelton et al.
2008/0078804 A1 4/2008 Shelton et al.
2008/0078805 A1 4/2008 Omaits et al.
2008/0078806 A1 4/2008 Omaits et al.
2008/0078807 A1 4/2008 Hess et al.
2008/0078808 A1 4/2008 Hess et al.
2008/0110958 A1 5/2008 McKenna et al.
2008/0110961 A1 5/2008 Voegele et al.
2008/0125812 A1 5/2008 Zubik et al.
2008/0149685 A1 6/2008 Smith et al.
2008/0164296 A1 7/2008 Shelton et al.
2008/0169327 A1 7/2008 Shelton et al.
2008/0169328 A1 7/2008 Shelton
2008/0169329 A1 7/2008 Shelton et al.
2008/0169330 A1 7/2008 Shelton et al.
2008/0169331 A1 7/2008 Shelton et al.
2008/0169332 A1 7/2008 Shelton et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0169333 A1 7/2008 Shelton et al.
2008/0188868 A1 8/2008 Weitzner et al.
2008/0210738 A1 9/2008 Shelton et al.
2008/0223903 A1 9/2008 Marczyk
2008/0237296 A1 10/2008 Boudreaux et al.
2008/0237298 A1 10/2008 Schall et al.
2008/0277447 A1 11/2008 Smith et al.
2008/0283570 A1 11/2008 Boyden et al.
2008/0283571 A1 11/2008 Boyden et al.
2008/0283572 A1 11/2008 Boyden et al.
2008/0283574 A1 11/2008 Boyden et al.
2008/0283576 A1 11/2008 Boyden et al.
2008/0283577 A1 11/2008 Boyden et al.
2008/0287987 A1 11/2008 Boyden et al.
2008/0296343 A1 12/2008 Schall et al.
2008/0296344 A1 12/2008 Cropper et al.
2008/0296345 A1 12/2008 Shelton, IV et al.
2008/0296346 A1 12/2008 Shelton, IV et al.
2008/0296347 A1 12/2008 Shelton, IV et al.
2008/0302854 A1 12/2008 Rethy et al.
2008/0308601 A1 12/2008 Timm et al.
2008/0308602 A1 12/2008 Timm et al.
2008/0308603 A1 12/2008 Shelton et al.
2008/0308604 A1 12/2008 Timm et al.
2008/0308606 A1 12/2008 Timm et al.
2008/0308607 A1 12/2008 Timm et al.
2008/0314954 A1 12/2008 Boudreaux
2008/0314955 A1 12/2008 Boudreaux et al.
2008/0314957 A1 12/2008 Boudreaux
2008/0314961 A1 12/2008 Boudreaux et al.
2008/0314962 A1 12/2008 Boudreaux
2009/0001121 A1 1/2009 Hess et al.
2009/0001123 A1 1/2009 Morgan et al.
2009/0001124 A1 1/2009 Hess et al.
2009/0001125 A1 1/2009 Hess et al.
2009/0001126 A1 1/2009 Hess et al.
2009/0001130 A1 1/2009 Hess et al.
2009/0005808 A1 1/2009 Hess et al.
2009/0008424 A1 1/2009 Green
2009/0050671 A1 2/2009 Racenet et al.
2009/0054728 A1 2/2009 Trusty
2009/0054734 A1 2/2009 DeSantis et al.
2009/0057370 A1 3/2009 Marczyk et al.
2009/0065549 A1* 3/2009 Viola A61B 17/10
606/205
2009/0065550 A1 3/2009 Green et al.
2009/0065551 A1 3/2009 Green et al.
2009/0078738 A1 3/2009 Racenet et al.
2009/0078739 A1 3/2009 Viola
2009/0084826 A1 4/2009 Shah et al.
2009/0088792 A1 4/2009 Hoell, Jr. et al.
2009/0090763 A1 4/2009 Zemlok et al.
2009/0090764 A1* 4/2009 Viola A61B 17/07207
227/176.1
2009/0090765 A1 4/2009 Blier et al.
2009/0090766 A1 4/2009 Knodel
2009/0095790 A1 4/2009 Whitman et al.
2009/0101692 A1 4/2009 Whitman et al.
2009/0101694 A1 4/2009 Marczyk
2009/0105535 A1 4/2009 Green et al.
2009/0108048 A1 4/2009 Zemlok et al.
2009/0108049 A1 4/2009 Roy
2009/0114699 A1 5/2009 Viola
2009/0114700 A1 5/2009 Marczyk
2009/0114701 A1 5/2009 Zemlok et al.
2009/0134199 A1 5/2009 Heinrich et al.
2009/0198272 A1* 8/2009 Kerver A61B 17/29
606/205
2009/0206124 A1* 8/2009 Hall A61B 17/115
227/175.1
2009/0209946 A1 8/2009 Swayze et al.
2009/0209990 A1 8/2009 Yates et al.
2009/0218384 A1 9/2009 Aranyi
2009/0234280 A1 9/2009 Tah et al.
2009/0236393 A1 9/2009 Viola
2009/0236395 A1 9/2009 Scirica
2009/0242610 A1 10/2009 Shelton, IV et al.
2009/0242611 A1 10/2009 Hathaway et al.
2009/0255974 A1 10/2009 Viola
2009/0255975 A1 10/2009 Zemlok et al.
2009/0255976 A1 10/2009 Marczyk et al.
2009/0255977 A1 10/2009 Zemlok
2009/0261142 A1 10/2009 Milliman et al.
2009/0261144 A1 10/2009 Sniffin et al.
2009/0261145 A1 10/2009 Heinrich et al.
2009/0266868 A1 10/2009 Wenchell et al.
2009/0272784 A1 11/2009 Farascioni
2009/0272787 A1 11/2009 Scirica
2009/0277946 A1 11/2009 Marczyk
2009/0277947 A1 11/2009 Viola
2009/0277949 A1 11/2009 Viola et al.
2009/0283568 A1 11/2009 Racenet et al.
2009/0289096 A1 11/2009 Shelton, IV et al.
2009/0302090 A1 12/2009 Shah
2009/0302091 A1 12/2009 Shah
2009/0306708 A1 12/2009 Shah
2009/0308907 A1 12/2009 Nalagatla et al.
2009/0308908 A1 12/2009 Green et al.
2009/0308909 A1 12/2009 Nalagatla et al.
2009/0312773 A1* 12/2009 Cabrera A61B 17/0469
606/144
2009/0314820 A1 12/2009 Green et al.
2009/0314821 A1 12/2009 Racenet
2010/0001036 A1 1/2010 Marczyk et al.
2010/0004633 A1* 1/2010 Rothe A61M 25/0136
604/528
2010/0006620 A1 1/2010 Sorrentino et al.
2010/0010512 A1* 1/2010 Taylor A61B 17/0491
606/144
2010/0012702 A1 1/2010 Marczyk
2010/0012703 A1 1/2010 Calabrese et al.
2010/0012704 A1 1/2010 Tarinelli Racenet et al.
2010/0025452 A1 2/2010 Whitman
2010/0030018 A1* 2/2010 Fortier A61B 18/1445
600/104
2010/0032470 A1 2/2010 Hess et al.
2010/0044411 A1 2/2010 Viola
2010/0065605 A1 3/2010 Shelton, VI et al.
2010/0065606 A1 3/2010 Stopek
2010/0065608 A1 3/2010 Olson et al.
2010/0069834 A1* 3/2010 Schultz A61M 25/0147
604/95.04
2010/0069942 A1 3/2010 Shelton, IV
2010/0072251 A1 3/2010 Baxter, III et al.
2010/0072252 A1 3/2010 Baxter, III
2010/0072253 A1 3/2010 Baxter, III et al.
2010/0072254 A1 3/2010 Aranyi et al.
2010/0072255 A1 3/2010 Olson et al.
2010/0072256 A1 3/2010 Baxter, III et al.
2010/0072258 A1 3/2010 Farascioni et al.
2010/0076260 A1 3/2010 Taylor et al.
2010/0076429 A1 3/2010 Heinrich
2010/0076459 A1 3/2010 Farascioni
2010/0076460 A1* 3/2010 Taylor A61B 17/0491
606/144
2010/0089970 A1 4/2010 Smith et al.
2010/0089972 A1 4/2010 Marczyk
2010/0089974 A1 4/2010 Shelton, IV
2010/0096432 A1 4/2010 Scirica
2010/0096433 A1 4/2010 Mastri et al.
2010/0096434 A1 4/2010 Viola et al.
2010/0108739 A1 5/2010 Holsten et al.
2010/0116867 A1 5/2010 Balbierz et al.
2010/0116868 A1 5/2010 Prommersberger
2010/0121147 A1 5/2010 Oskin et al.
2010/0127040 A1 5/2010 Smith et al.
2010/0127041 A1 5/2010 Morgan et al.
2010/0127042 A1 5/2010 Shelton, IV
2010/0127043 A1 5/2010 Olson et al.
2010/0133317 A1 6/2010 Shelton, IV et al.
2010/0133318 A1 6/2010 Boudreaux
2010/0133319 A1 6/2010 Milliman et al.
2010/0133321 A1 6/2010 Racenet et al.
2010/0147921 A1 6/2010 Olson

(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0147922 A1 6/2010 Olson
2010/0155453 A1 6/2010 Bombard et al.
2010/0163596 A1 7/2010 Marczyk
2010/0163597 A1 7/2010 Shah et al.
2010/0170931 A1 7/2010 Viola
2010/0170933 A1 7/2010 Ivanko
2010/0179540 A1* 7/2010 Marczyk A61B 18/1445 606/41
2010/0193566 A1 8/2010 Scheib et al.
2010/0224668 A1 9/2010 Fontayne et al.
2010/0230468 A1 9/2010 Viola
2010/0237130 A1 9/2010 Scirica
2010/0237131 A1 9/2010 Milliman et al.
2010/0237133 A1 9/2010 Shah
2010/0243706 A1 9/2010 Cohen et al.
2010/0243707 A1 9/2010 Olson et al.
2010/0243708 A1 9/2010 Aranyi et al.
2010/0243709 A1 9/2010 Hess et al.
2010/0243710 A1 9/2010 Mastri et al.
2010/0243711 A1 9/2010 Olson et al.
2010/0249497 A1* 9/2010 Peine A61B 17/2909 600/104
2010/0249802 A1 9/2010 May et al.
2010/0252610 A1 10/2010 Viola
2010/0252611 A1 10/2010 Ezzat et al.
2010/0252612 A1 10/2010 Viola
2010/0264192 A1 10/2010 Marczyk
2010/0264193 A1 10/2010 Huang et al.
2010/0264194 A1 10/2010 Huang et al.
2010/0270356 A1 10/2010 Holsten et al.
2010/0282816 A1 11/2010 Scirica et al.
2010/0282817 A1 11/2010 Ehrenfels et al.
2010/0282819 A1 11/2010 Racenet et al.
2010/0294828 A1 11/2010 Bindra et al.
2010/0294829 A1 11/2010 Giordano et al.
2010/0301095 A1 12/2010 Shelton, IV et al.
2010/0301096 A1 12/2010 Moore et al.
2010/0305552 A1 12/2010 Shelton, IV et al.
2010/0308099 A1* 12/2010 Marczyk A61B 17/07207 227/175.1
2010/0308100 A1 12/2010 Boudreaux
2010/0320252 A1* 12/2010 Viola A61B 17/068 227/176.1
2010/0320253 A1 12/2010 Marczyk
2010/0320254 A1 12/2010 Zemlok et al.
2011/0006099 A1 1/2011 Hall et al.
2011/0006101 A1 1/2011 Hall et al.
2011/0006103 A1 1/2011 Laurent et al.
2011/0009863 A1* 1/2011 Marczyk A61B 18/1445 606/51
2011/0011914 A1 1/2011 Baxter, III et al.
2011/0011915 A1 1/2011 Shelton, IV
2011/0017801 A1 1/2011 Zemlok et al.
2011/0024477 A1 2/2011 Hall
2011/0024478 A1 2/2011 Shelton, IV
2011/0024479 A1 2/2011 Swensgard et al.
2011/0024480 A1 2/2011 Marczyk
2011/0036887 A1 2/2011 Zemlok et al.
2011/0036888 A1 2/2011 Pribanic et al.
2011/0036890 A1 2/2011 Ma
2011/0036891 A1 2/2011 Zemlok et al.
2011/0036892 A1 2/2011 Marczyk et al.
2011/0036893 A1 2/2011 Viola
2011/0036895 A1 2/2011 Marczyk et al.
2011/0040308 A1* 2/2011 Cabrera A61B 17/06166 606/144
2011/0042439 A1 2/2011 Johnson et al.
2011/0042440 A1 2/2011 Holsten et al.
2011/0042441 A1 2/2011 Shelton, IV et al.
2011/0062212 A1 3/2011 Shelton, IV et al.
2011/0062213 A1 3/2011 Scirica et al.
2011/0068144 A1 3/2011 Krehel
2011/0068145 A1 3/2011 Bedi et al.
2011/0068146 A1 3/2011 Viola et al.
2011/0068148 A1 3/2011 Hall et al.
2011/0079626 A1 4/2011 Viola et al.
2011/0079628 A1 4/2011 Racenet et al.
2011/0084112 A1 4/2011 Kostrzewski
2011/0084113 A1 4/2011 Bedi et al.
2011/0084114 A1 4/2011 Marczyk et al.
2011/0084115 A1 4/2011 Bedi et al.
2011/0087276 A1 4/2011 Bedi et al.
2011/0089220 A1 4/2011 Ingmanson et al.
2011/0089221 A1 4/2011 Masiakos et al.
2011/0095067 A1 4/2011 Ohdaira
2011/0101066 A1 5/2011 Farascioni et al.
2011/0101067 A1 5/2011 Johnson et al.
2011/0101069 A1 5/2011 Bombard et al.
2011/0101070 A1 5/2011 Bettuchi et al.
2011/0106073 A1* 5/2011 Mueller A61B 18/1445 606/41
2011/0106078 A1* 5/2011 Mueller A61B 17/29 606/205
2011/0108603 A1 5/2011 Racenet et al.
2011/0108605 A1 5/2011 Sapienza
2011/0108606 A1 5/2011 Whitman
2011/0114702 A1 5/2011 Farascioni
2011/0121049 A1 5/2011 Malinouskas et al.
2011/0121050 A1 5/2011 Nicholas et al.
2011/0121051 A1 5/2011 Shelton, IV et al.
2011/0121052 A1 5/2011 Shelton, IV et al.
2011/0132960 A1 6/2011 Whitman et al.
2011/0132961 A1 6/2011 Whitman et al.
2011/0132962 A1 6/2011 Hall et al.
2011/0132963 A1 6/2011 Giordano et al.
2011/0132964 A1 6/2011 Weisenburgh, II et al.
2011/0132965 A1 6/2011 Moore et al.
2011/0139851 A1 6/2011 McCuen
2011/0144576 A1 6/2011 Rothe et al.
2011/0144640 A1 6/2011 Heinrich et al.
2011/0147433 A1 6/2011 Shelton, IV et al.
2011/0147434 A1 6/2011 Hueil et al.
2011/0155780 A1 6/2011 Boudreaux
2011/0155781 A1 6/2011 Swensgard et al.
2011/0155784 A1 6/2011 Shelton, IV et al.
2011/0155785 A1 6/2011 Laurent et al.
2011/0155786 A1 6/2011 Shelton, IV
2011/0155787 A1 6/2011 Baxter, III et al.
2011/0155788 A1 6/2011 Hillstead et al.
2011/0163146 A1 7/2011 Ortiz et al.
2011/0163147 A1 7/2011 Laurent et al.
2011/0163148 A1 7/2011 Wenchell et al.
2011/0163149 A1 7/2011 Viola
2011/0163150 A1 7/2011 Farascioni
2011/0168756 A1 7/2011 Racenet et al.
2011/0168757 A1 7/2011 Viola et al.
2011/0168758 A1 7/2011 Mastri et al.
2011/0168759 A1 7/2011 Prommersberger
2011/0168760 A1 7/2011 Viola et al.
2011/0174862 A1 7/2011 Shelton, IV et al.
2011/0174863 A1 7/2011 Shelton, IV et al.
2011/0180585 A1 7/2011 Czernik et al.
2011/0180586 A1 7/2011 Shah
2011/0184443 A1 7/2011 Tzakis et al.
2011/0184459 A1* 7/2011 Malkowski A61B 18/1445 606/206
2011/0186614 A1 8/2011 Kasvikis
2011/0192881 A1 8/2011 Balbierz et al.
2011/0192882 A1 8/2011 Hess et al.
2011/0192883 A1 8/2011 Whitman et al.
2011/0192884 A1 8/2011 Whitman et al.
2011/0198385 A1 8/2011 Whitman et al.
2011/0198386 A1 8/2011 Viola
2011/0204119 A1* 8/2011 McCuen A61B 17/07207 227/175.1
2011/0204120 A1 8/2011 Crainich
2011/0208211 A1* 8/2011 Whitfield A61B 17/1285 606/142
2011/0210157 A1 9/2011 Knodel et al.
2011/0213363 A1* 9/2011 Cunningham A61B 18/1445 606/41
2011/0215132 A1 9/2011 Aranyi et al.
2011/0215133 A1 9/2011 Aranyi

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0226837	A1	9/2011	Baxter, III et al.	
2011/0233258	A1	9/2011	Boudreaux	
2011/0233259	A1	9/2011	Olson	
2011/0233260	A1	9/2011	Milliman et al.	
2011/0240711	A1	10/2011	Scirica	
2011/0240712	A1	10/2011	Kostrzewski	
2011/0240713	A1	10/2011	Scirica et al.	
2011/0240714	A1	10/2011	Whitman et al.	
2011/0253765	A1	10/2011	Nicholas et al.	
2011/0253766	A1	10/2011	Baxter, III et al.	
2011/0257679	A1	10/2011	Ishitsuki et al.	
2011/0290856	A1	12/2011	Shelton, IV et al.	
2012/0109186	A1*	5/2012	Parrott	A61B 17/29 606/206
2012/0234893	A1	9/2012	Schuckmann et al.	
2012/0239009	A1	9/2012	Mollere et al.	
2012/0253326	A1*	10/2012	Kleyman	A61B 34/30 606/1
2013/0012929	A1*	1/2013	Malkowski	A61B 17/29 606/1
2013/0131593	A1*	5/2013	Selkee	A61M 25/09 604/95.04
2014/0039470	A1*	2/2014	Mueller	A61B 18/1445 606/1
2014/0114293	A1*	4/2014	Jeong	A61B 34/70 606/1
2014/0194893	A1*	7/2014	Jeong	A61B 34/70 606/130
2014/0275763	A1*	9/2014	King	A61B 1/00105 600/110

FOREIGN PATENT DOCUMENTS

DE	2744824	A1	4/1978	
DE	2903159	A1	7/1980	
DE	3114135	A1	10/1982	
DE	4213426	A1	10/1992	
DE	4300307	A1	7/1994	
EP	0041022	A1	12/1981	
EP	0136950	A2	4/1985	
EP	0140552	A2	5/1985	
EP	0156774	A2	10/1985	
EP	0213817	A1	3/1987	
EP	0216532	A1	4/1987	
EP	0220029	A1	4/1987	
EP	0273468	A2	7/1988	
EP	0324166	A2	7/1989	
EP	0324635	A1	7/1989	
EP	0324637	A1	7/1989	
EP	0324638	A1	7/1989	
EP	0365153	A1	4/1990	
EP	0369324	A1	5/1990	
EP	0373762	A1	6/1990	
EP	0380025	A2	8/1990	
EP	0399701	A1	11/1990	
EP	0449394	A2	10/1991	
EP	0484677	A1	5/1992	
EP	0489436	A1	6/1992	
EP	0503662	A1	9/1992	
EP	0514139	A2	11/1992	
EP	0536903	A2	4/1993	
EP	0537572	A2	4/1993	
EP	0539762	A1	5/1993	
EP	0545029	A1	6/1993	
EP	0552050	A2	7/1993	
EP	0552423	A2	7/1993	
EP	0579038	A1	1/1994	
EP	0589306	A2	3/1994	
EP	0591946	A1	4/1994	
EP	0592243	A2	4/1994	
EP	0593920	A1	4/1994	
EP	0598202	A1	5/1994	
EP	0598579	A1	5/1994	
EP	0600182	A2	6/1994	
EP	0621006	A1	10/1994	
EP	0621009	A1	10/1994	
EP	0656188	A2	6/1995	
EP	0666057	A2	8/1995	
EP	0705571	A1	4/1996	
EP	0760230	A1	3/1997	
FR	2542188	A1	9/1984	
FR	2660851	A1	10/1991	
FR	2681775	A1	4/1993	
GB	1352554	A	5/1974	
GB	1452185	A	10/1976	
GB	1555455	A	11/1979	
GB	2048685	A	12/1980	
GB	2070499	A	9/1981	
GB	2141066	A	12/1984	
GB	2165559	A	4/1986	
SU	659146	A1	4/1979	
SU	728848	A1	4/1980	
SU	980703		12/1982	
SU	980703	A1	12/1982	
SU	990220		1/1983	
SU	990220	A1	1/1983	
WO	8302247	A1	7/1983	
WO	2008302247		7/1983	
WO	8910094	A1	11/1989	
WO	9210976	A1	7/1992	
WO	9308754	A1	5/1993	
WO	9314706	A1	8/1993	
WO	2008045333	A2	4/2008	
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* cited by examiner

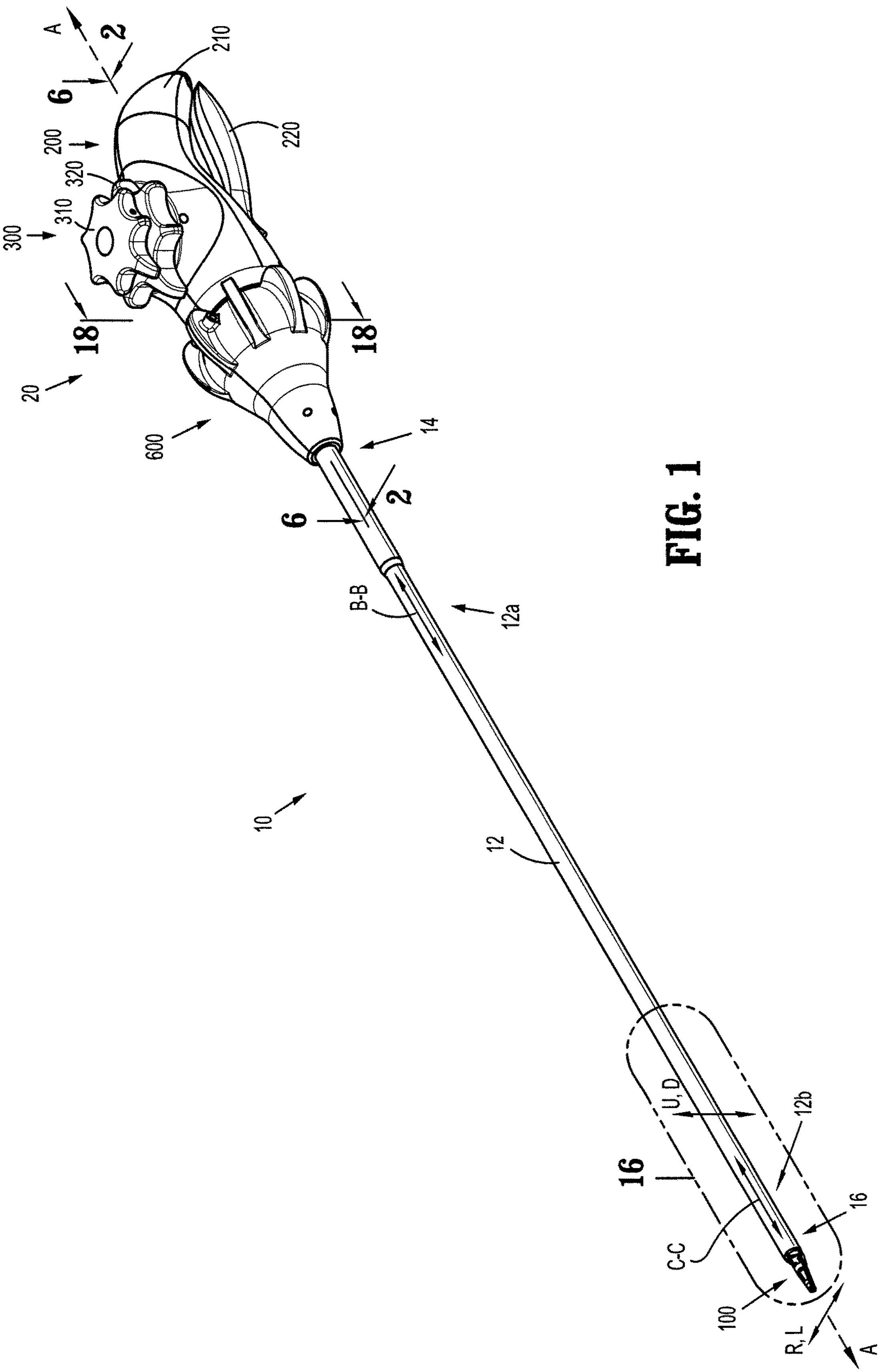
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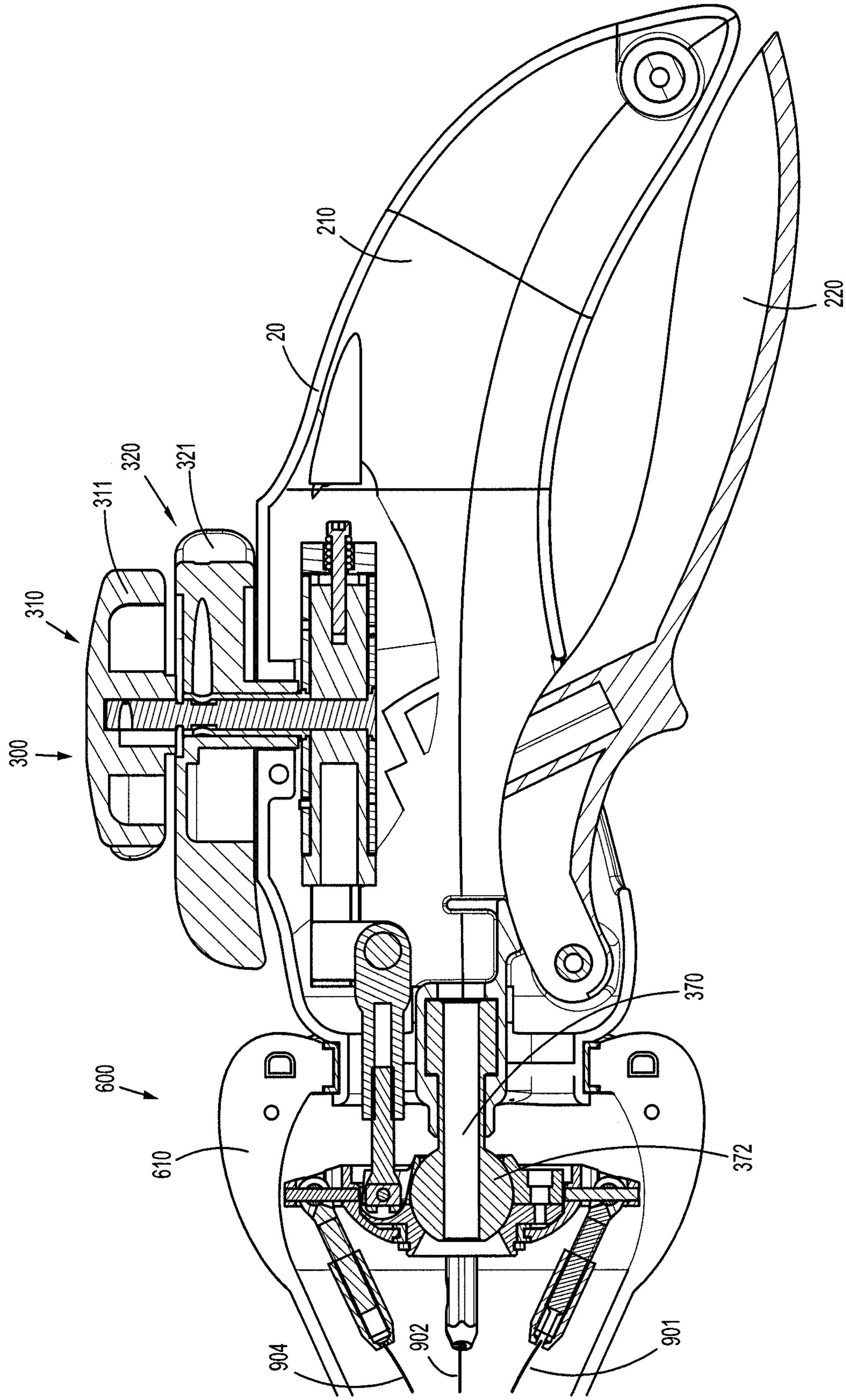
FIG. 1



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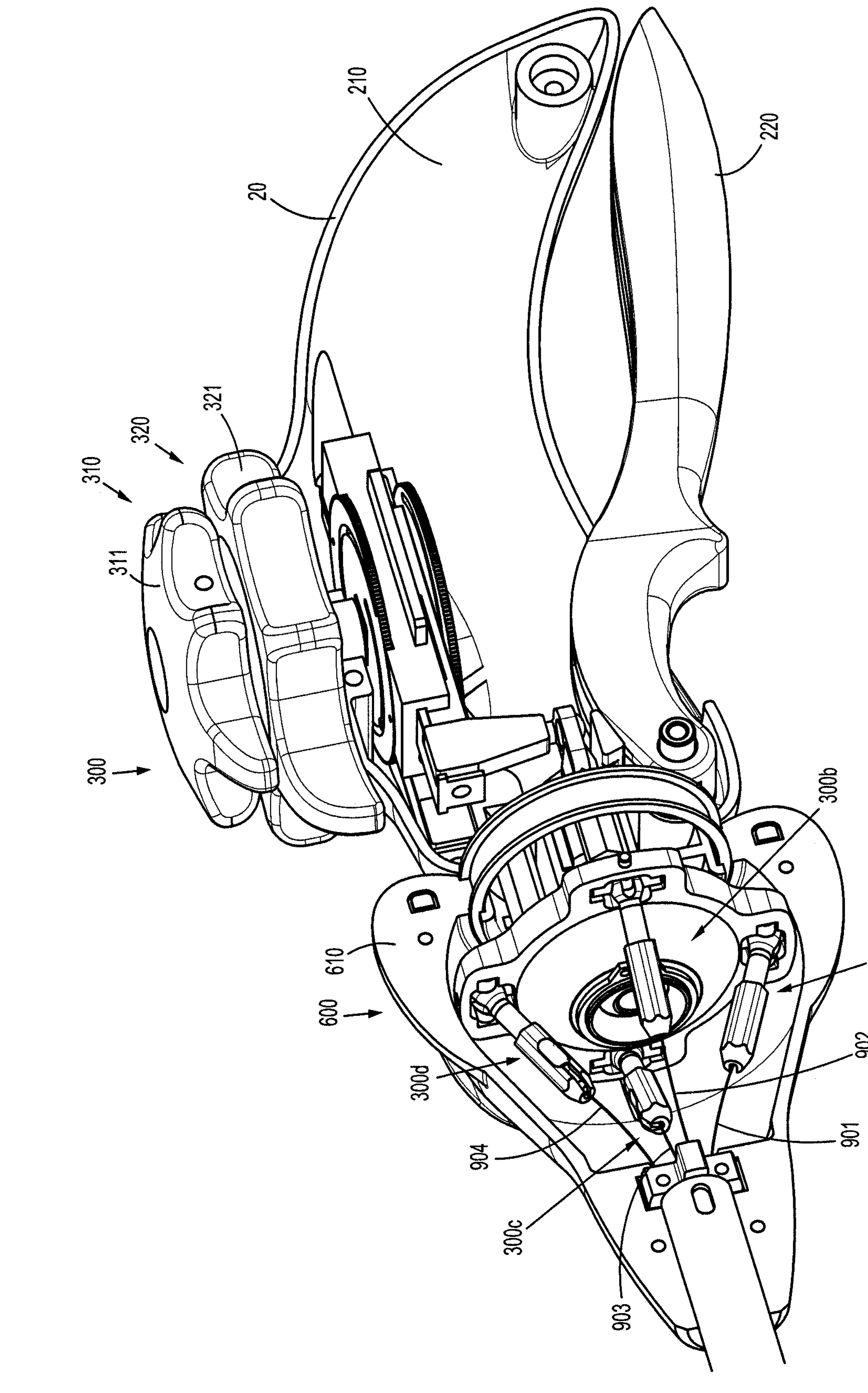
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FIG. 3

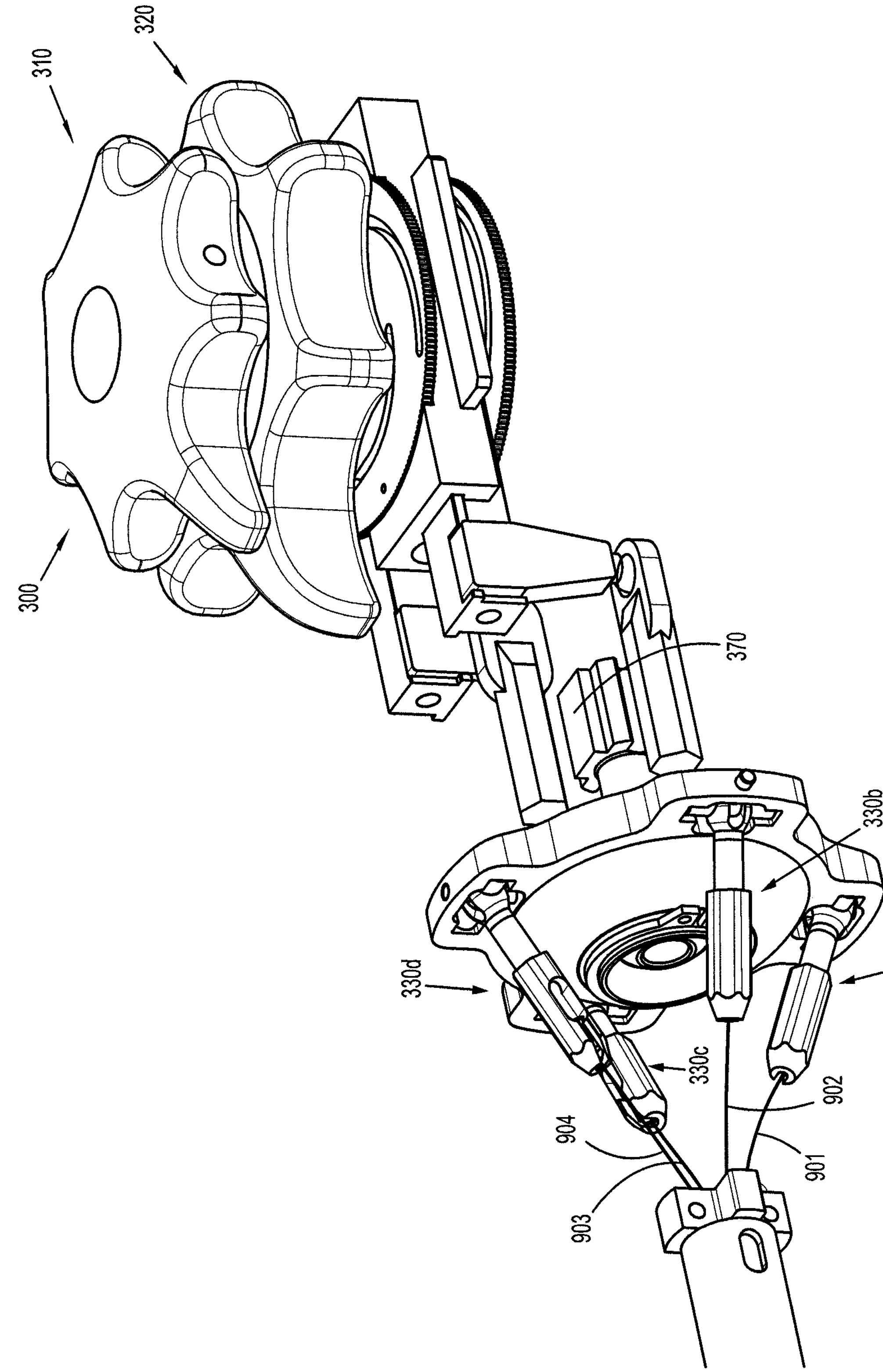

FIG. 4

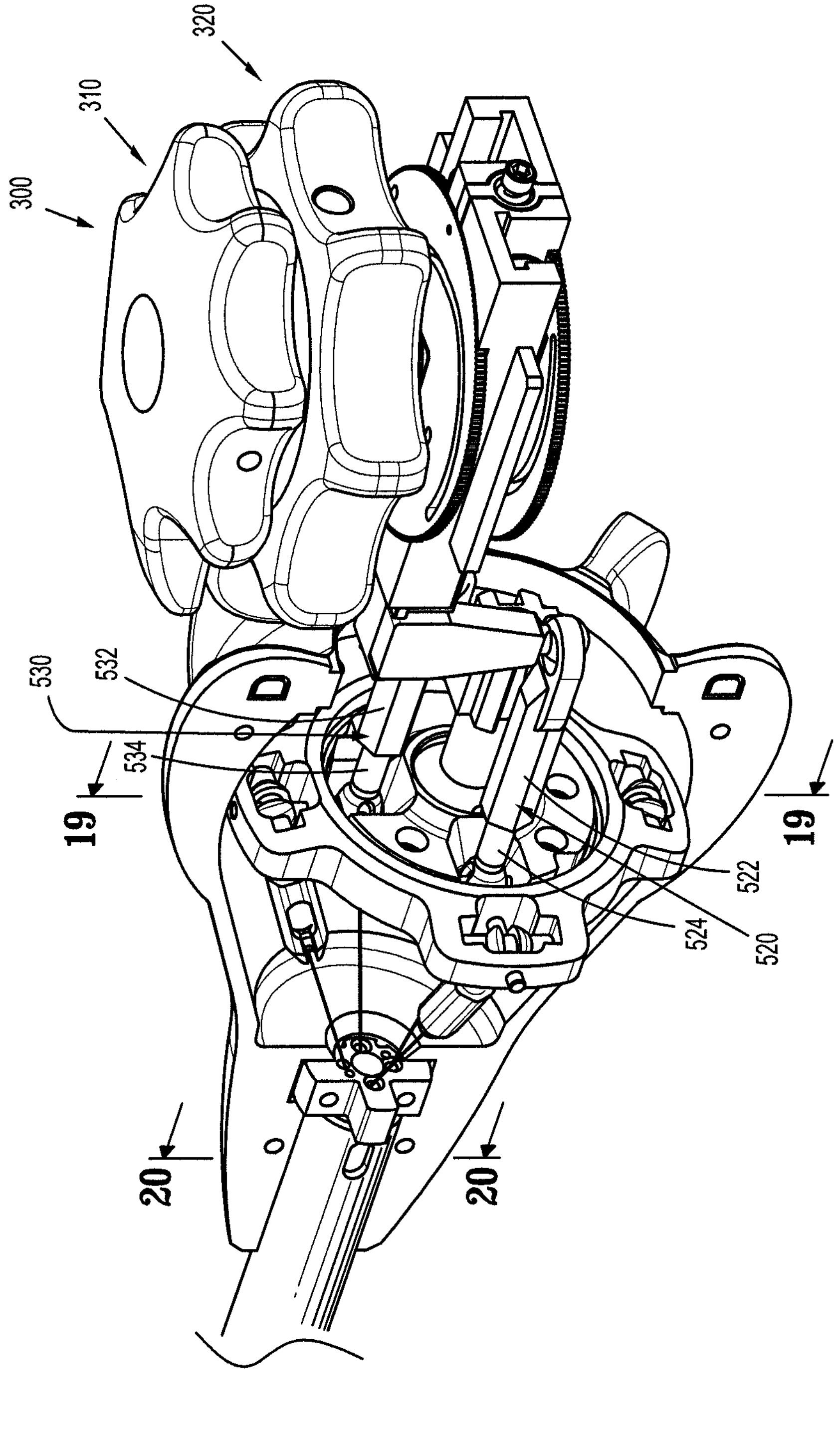

FIG. 5

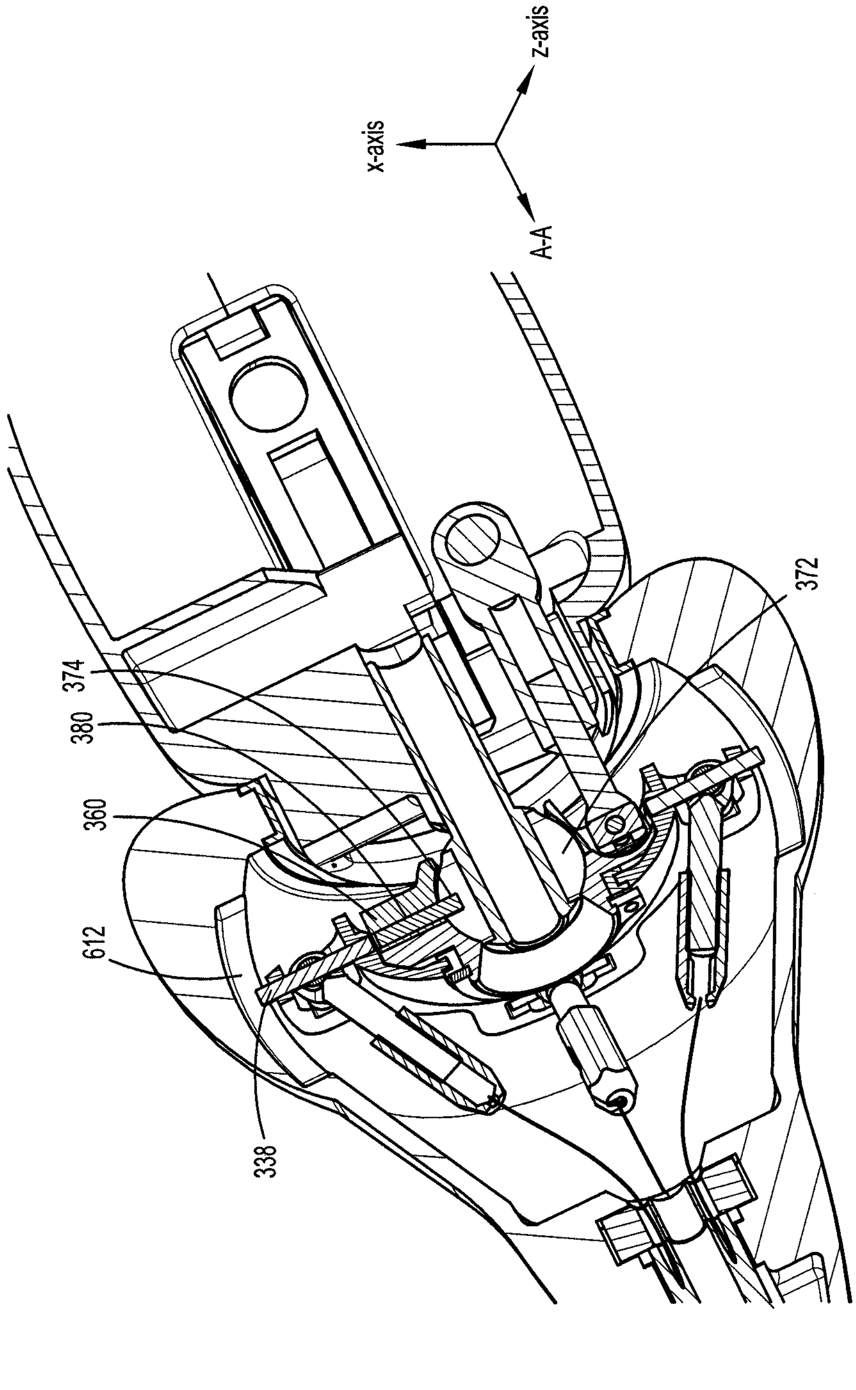

FIG. 6

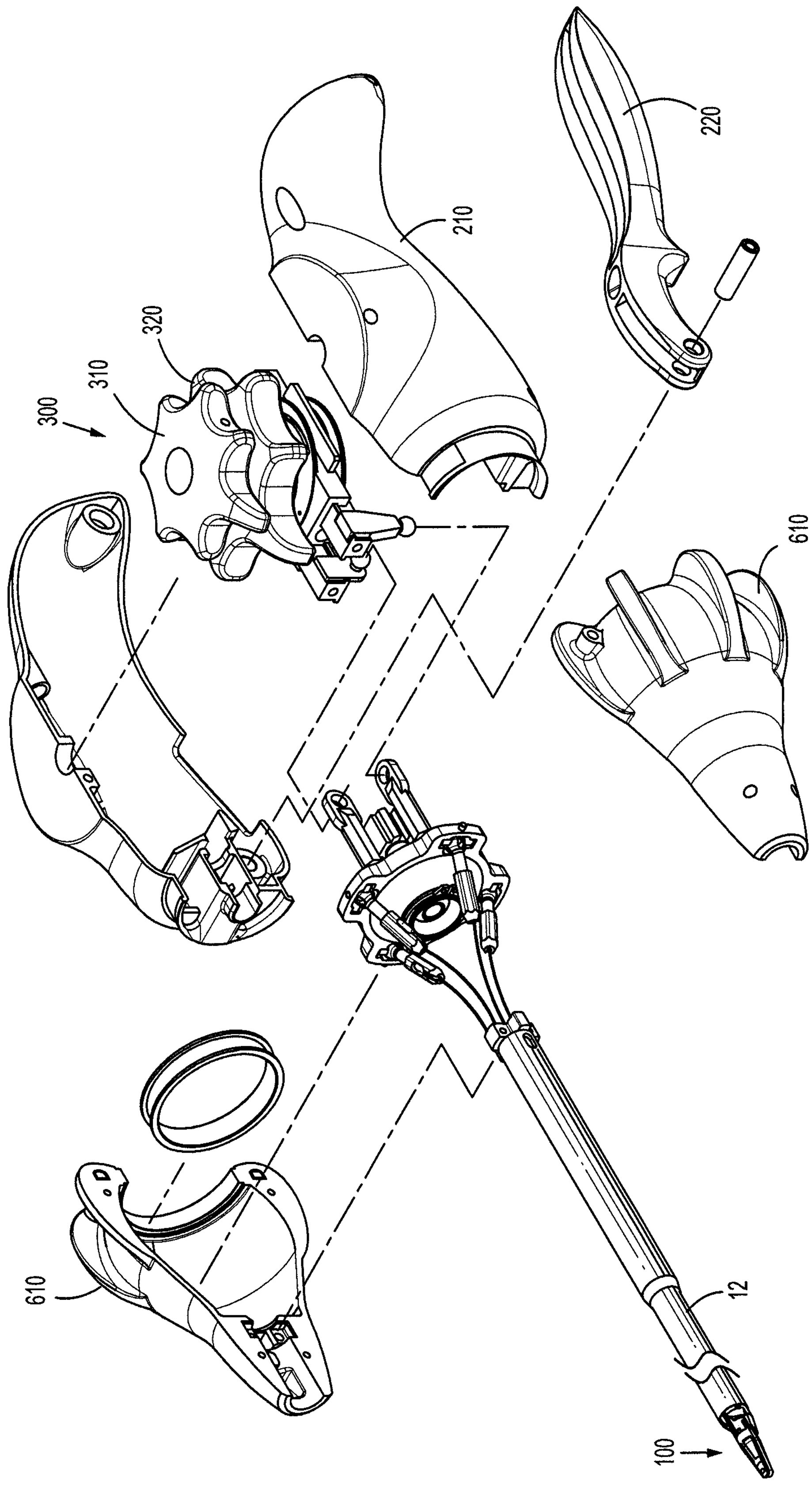

FIG. 7

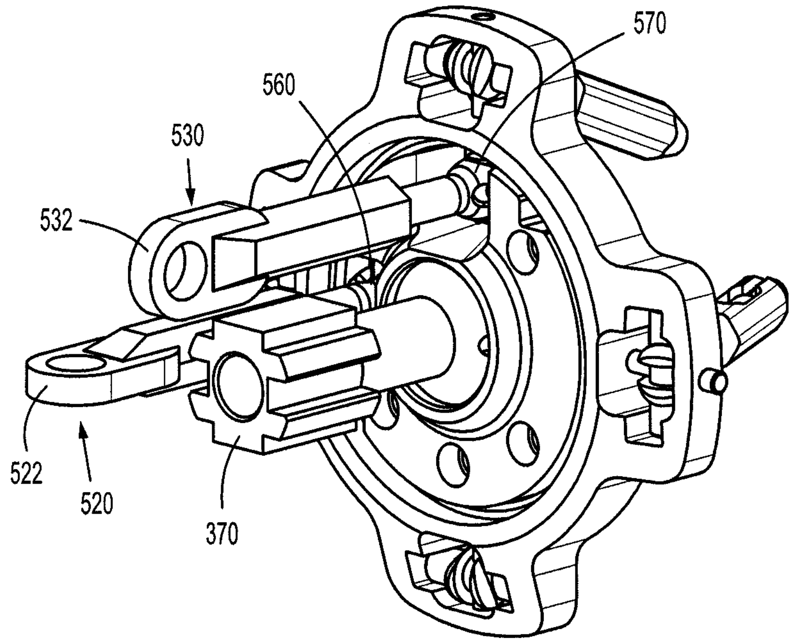

FIG. 8

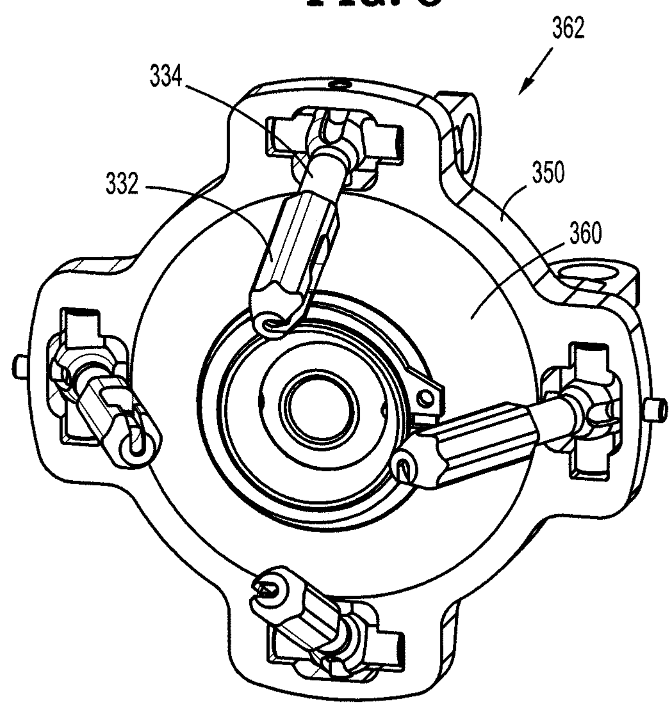

FIG. 9

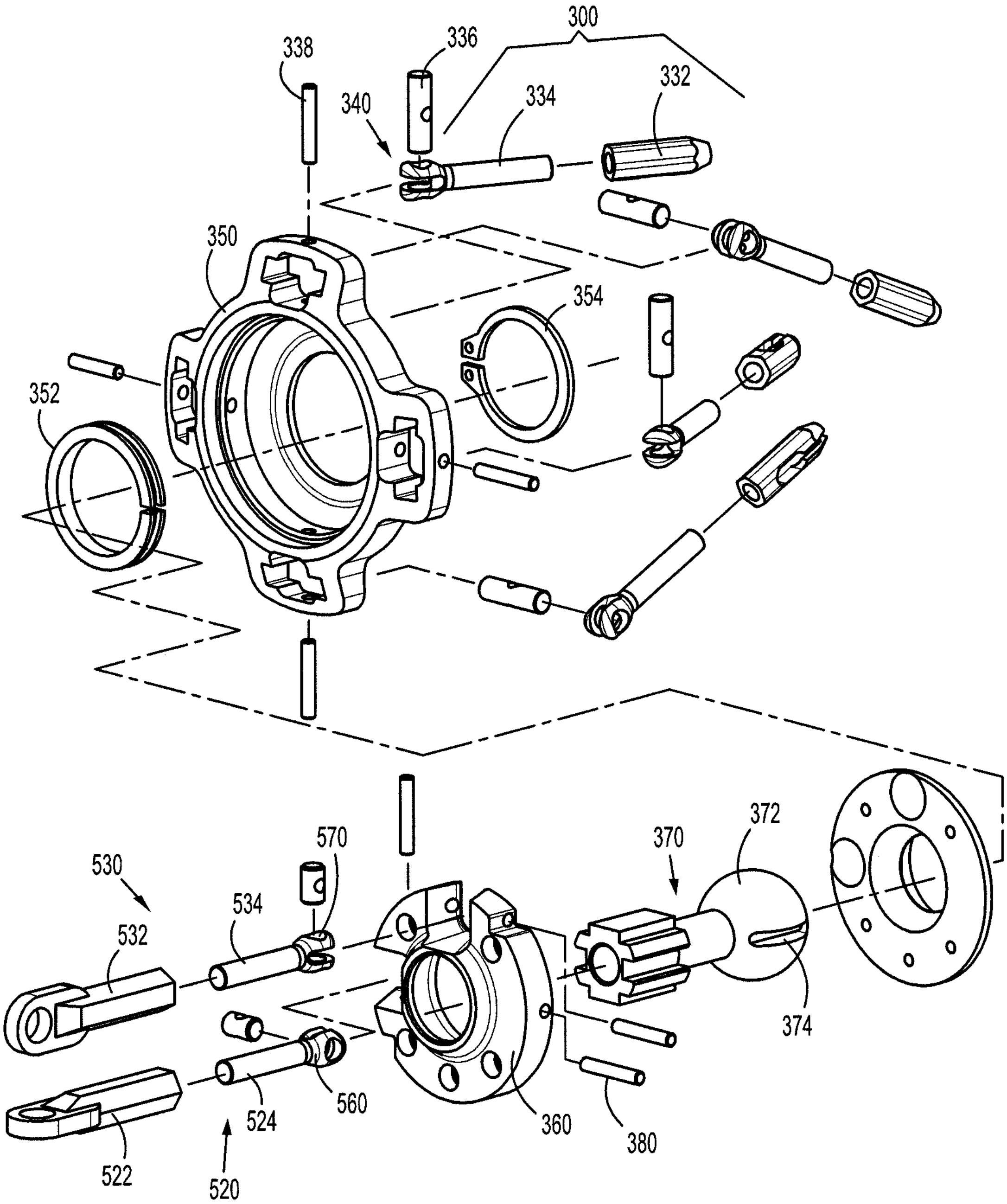
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FIG. 10

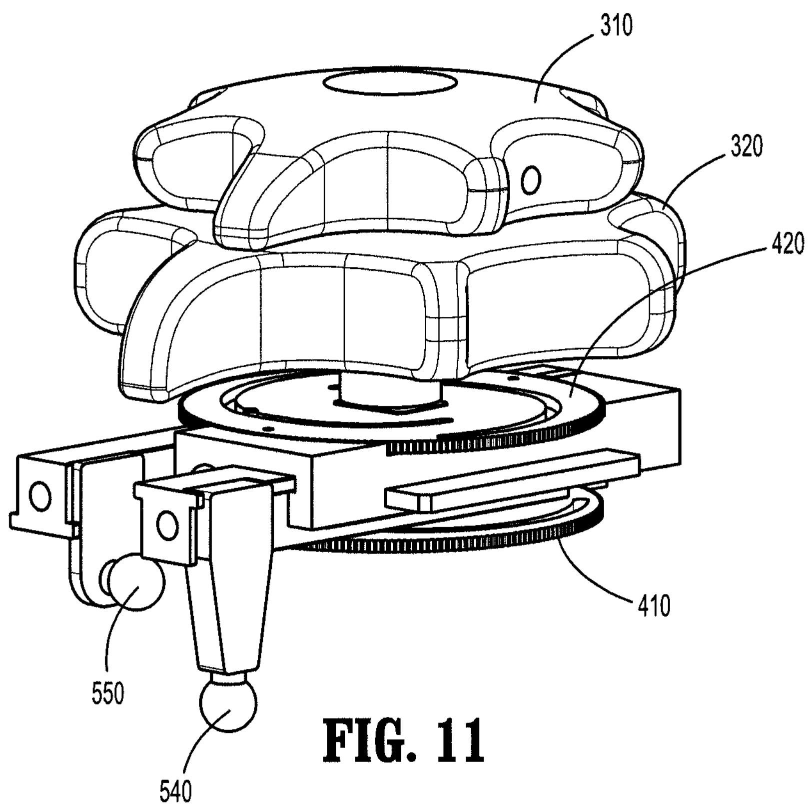


FIG. 11

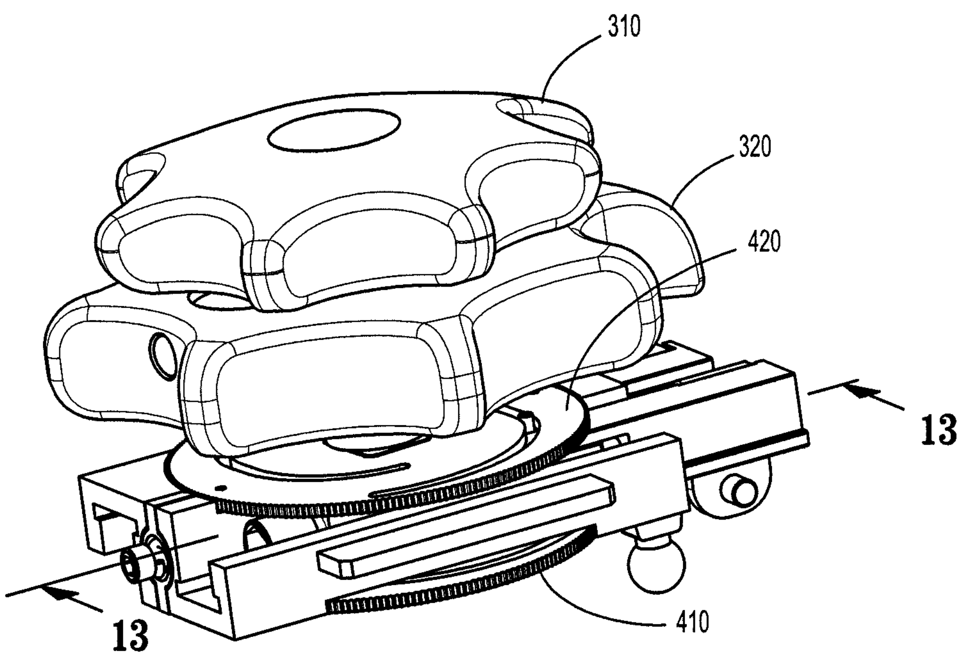


FIG. 12

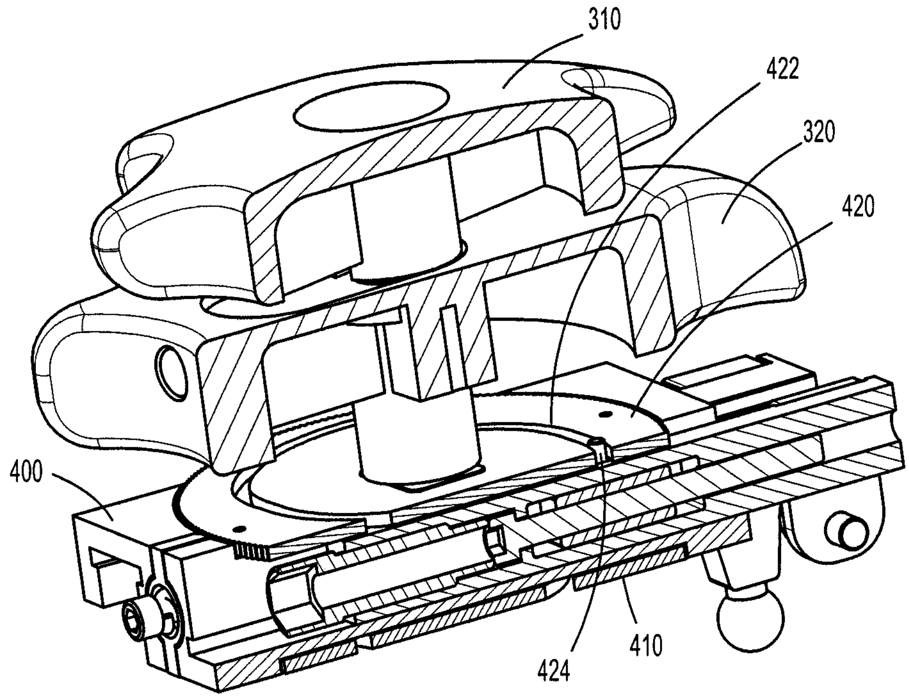


FIG. 13

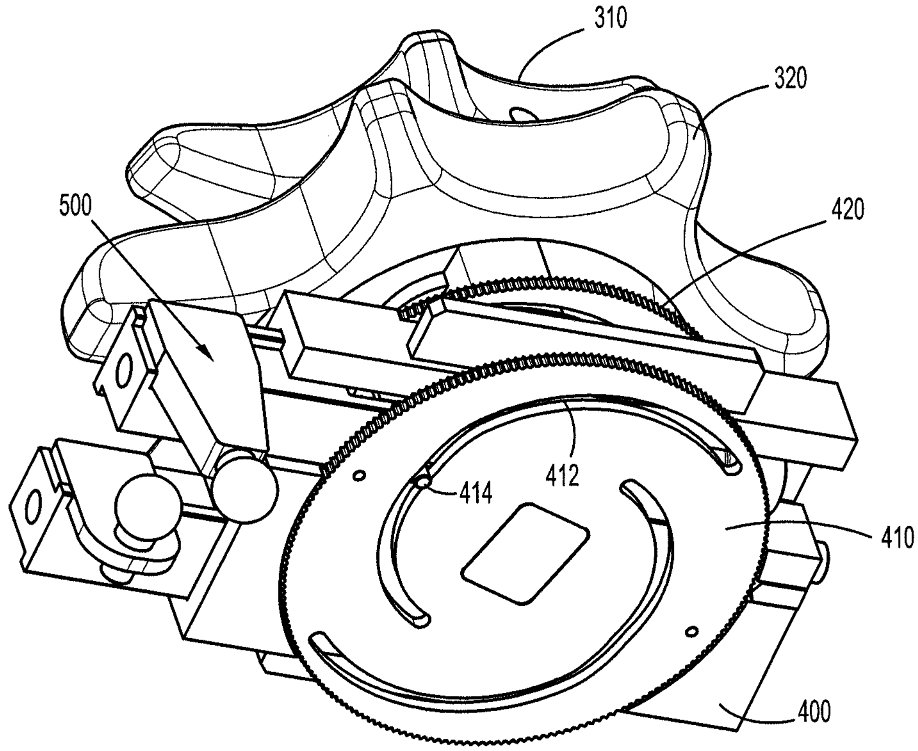


FIG. 14

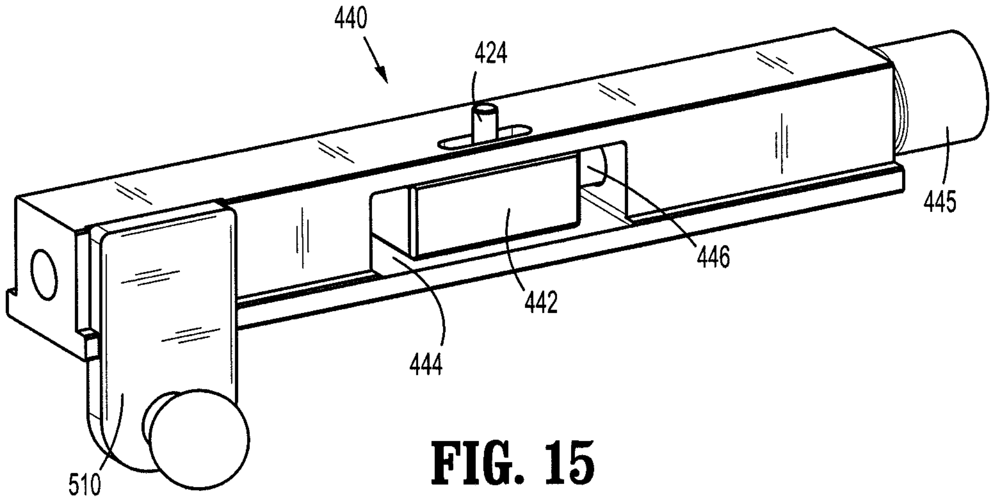
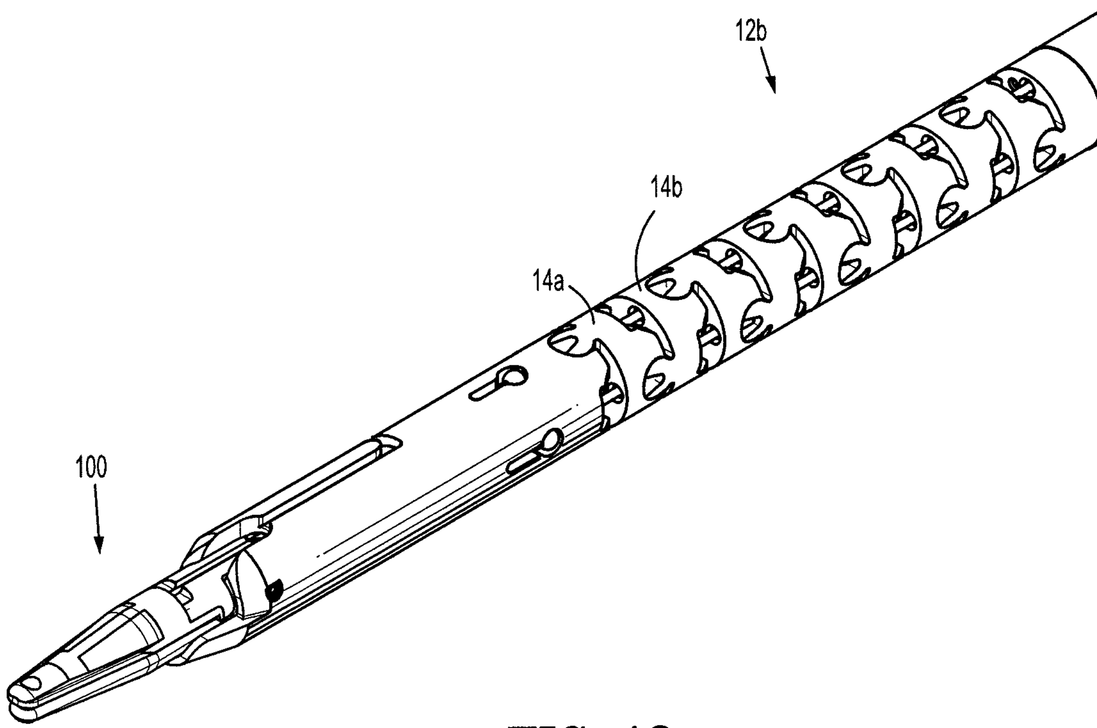


FIG. 15



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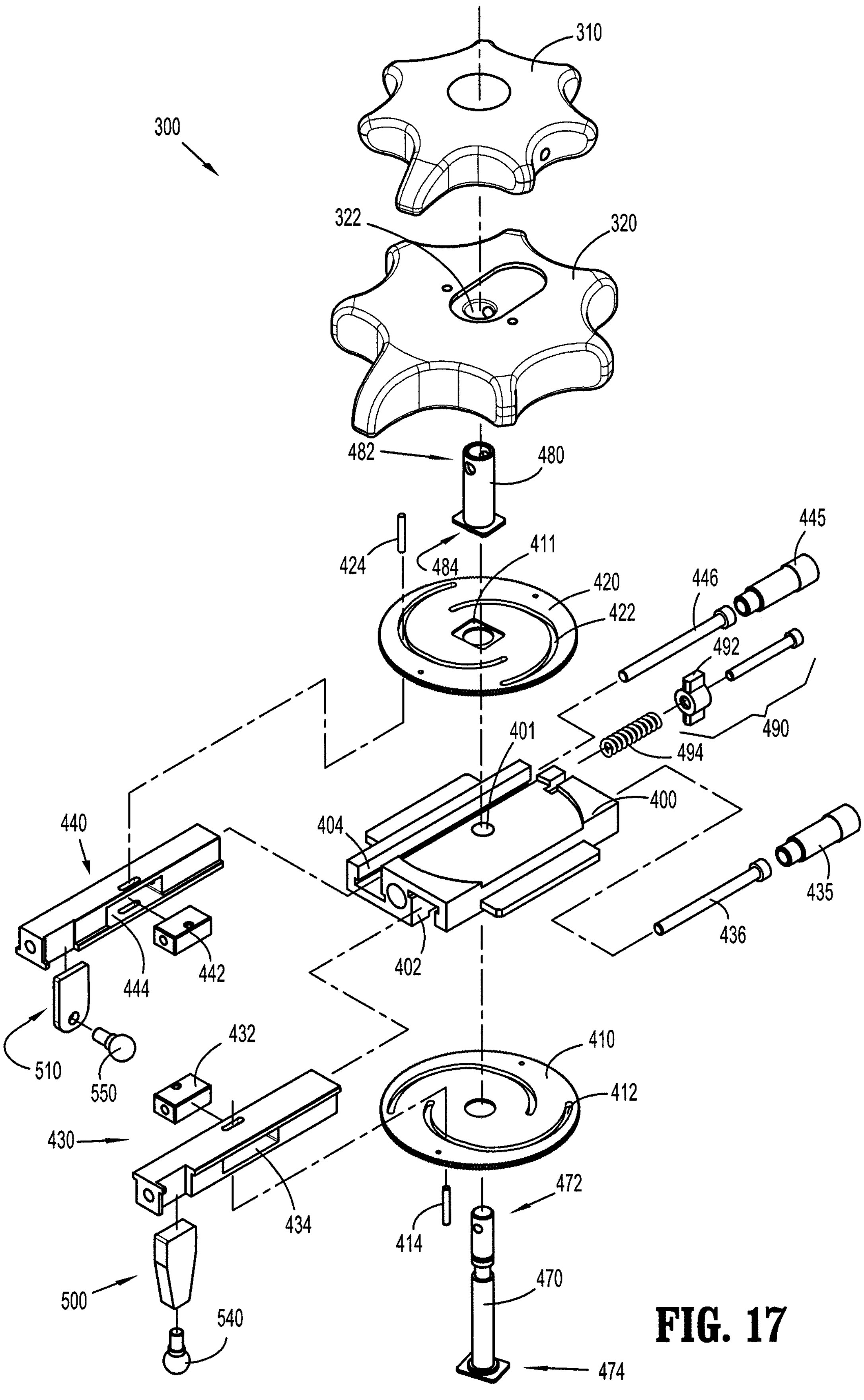
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480
424
484
411
420
422
446
445
492
490
401
494
400
404
440
402
436
435
444
442
510
550
432
410
412
430
434
414
472
470
500
540
474

FIG. 17

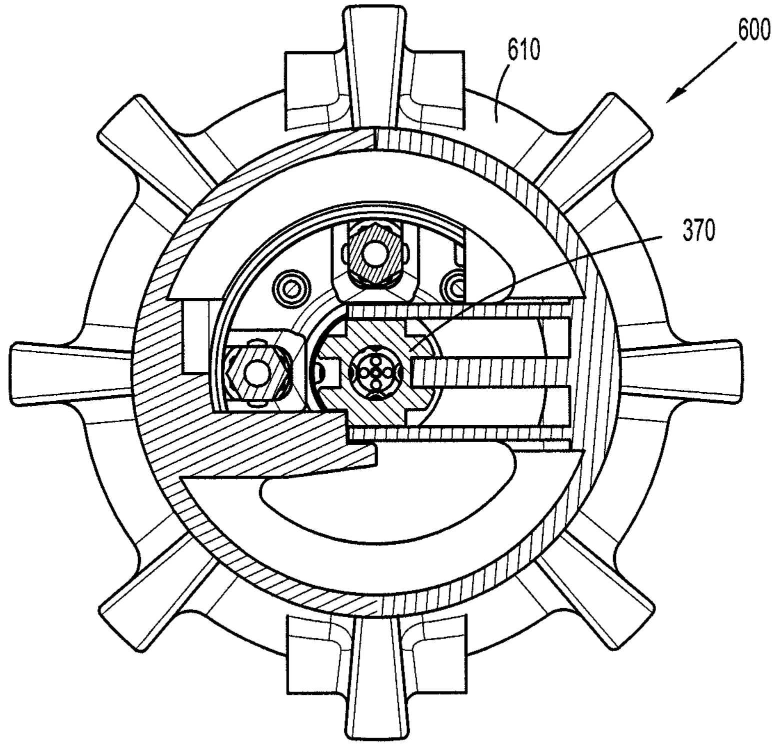

FIG. 18

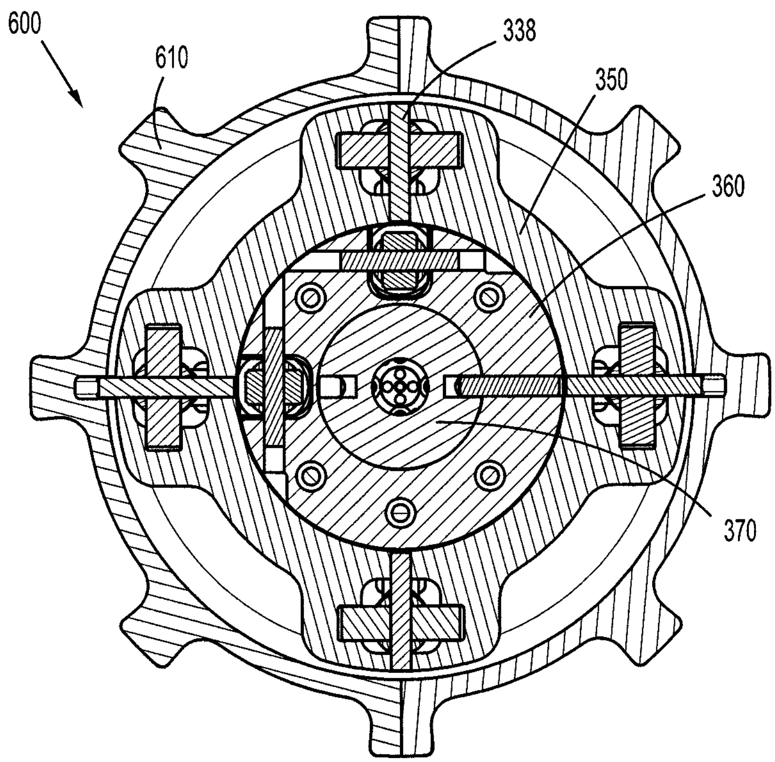

FIG. 19

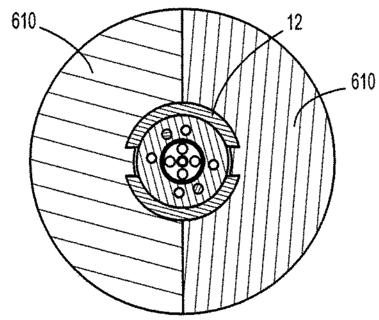

FIG. 20

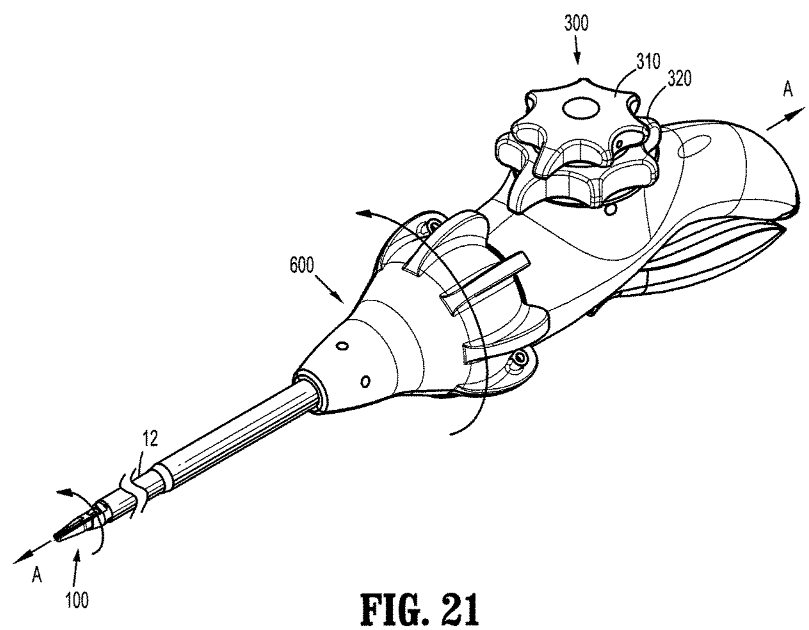

FIG. 21

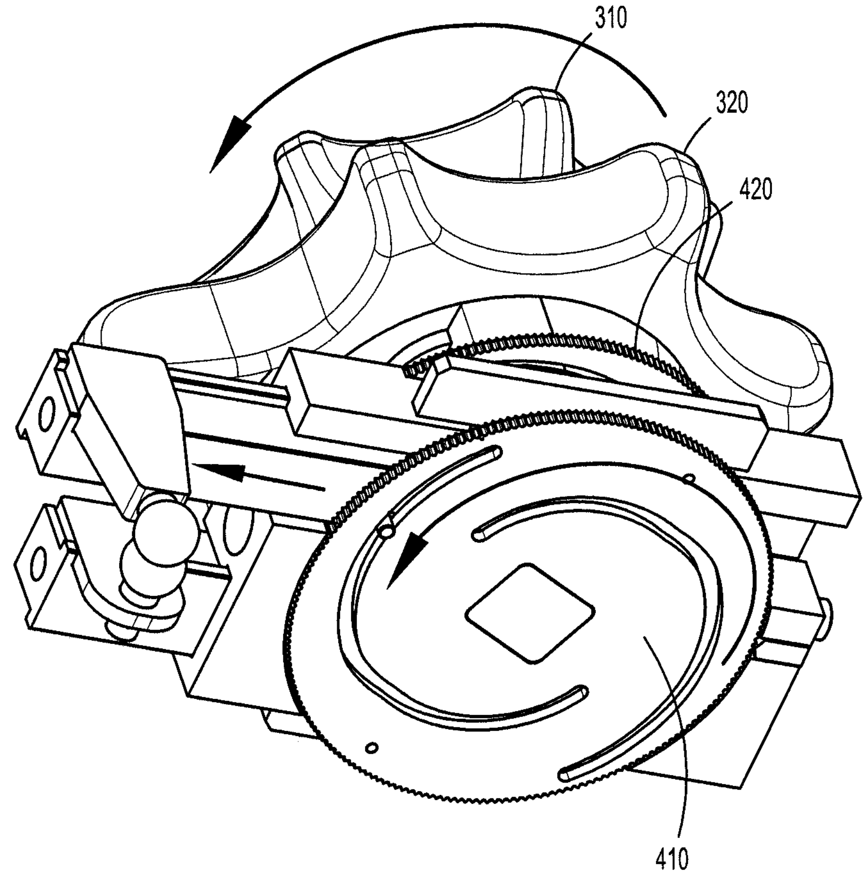

FIG. 22

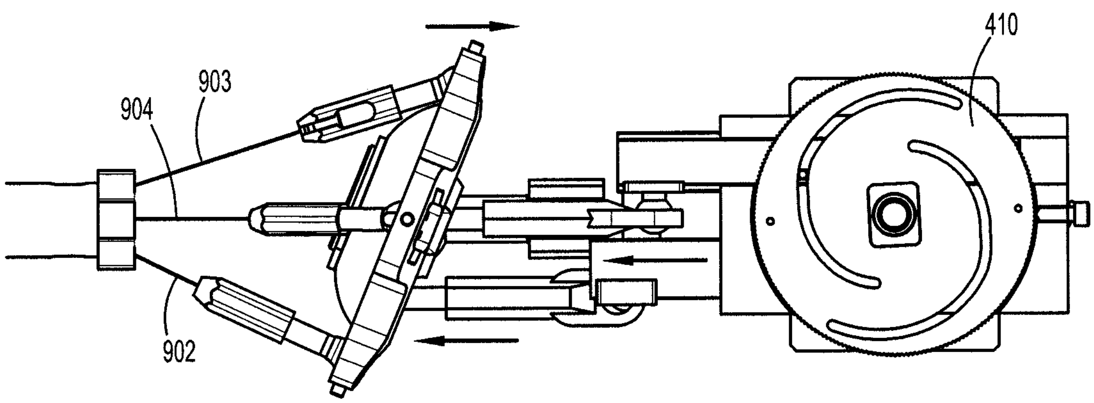

FIG. 23

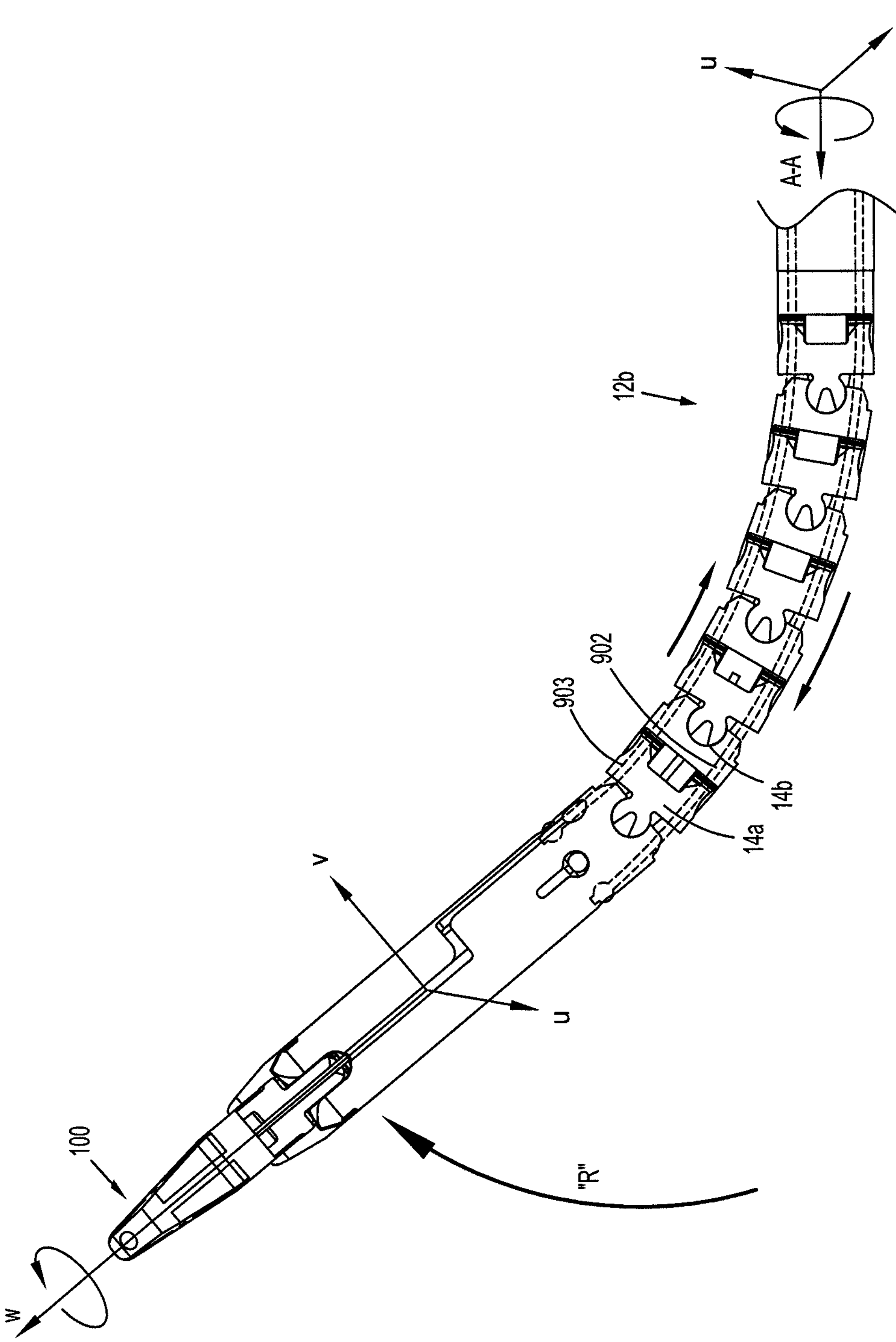

FIG. 24

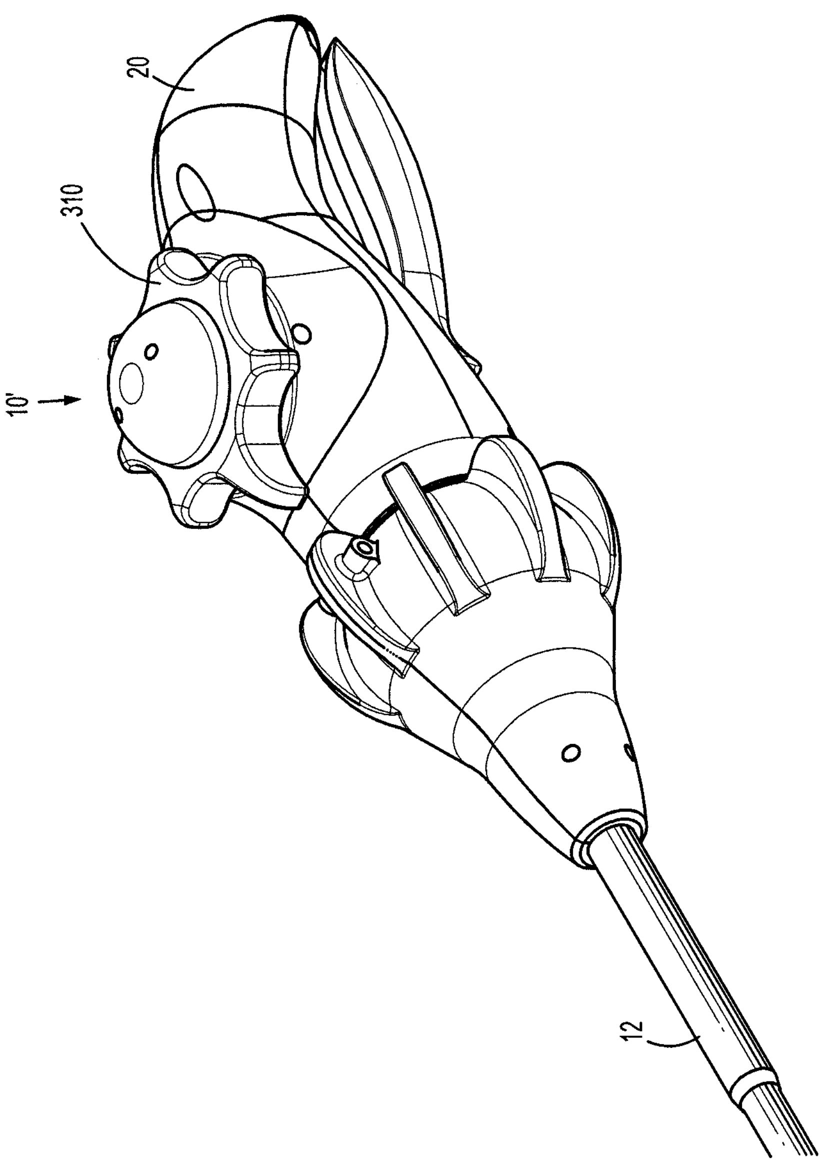

FIG. 25

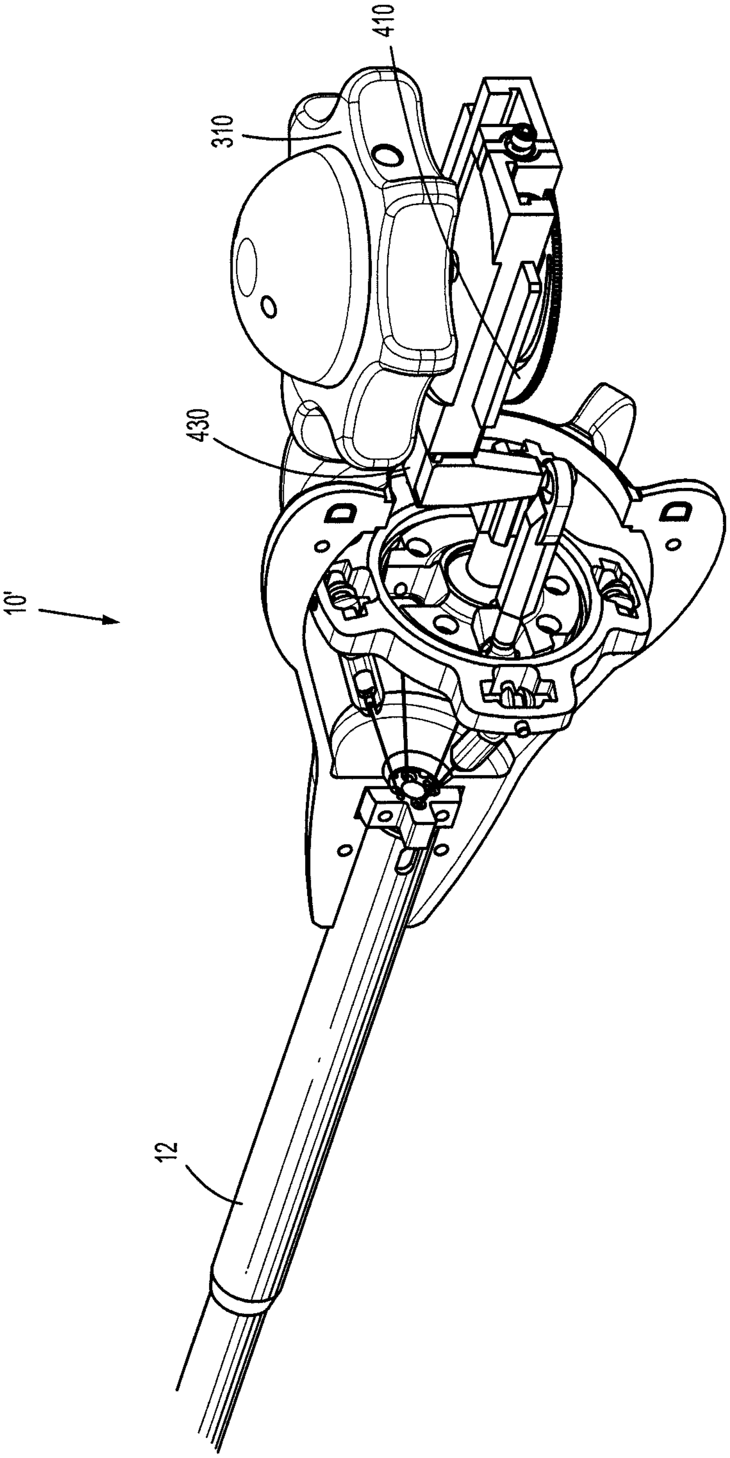

FIG. 26

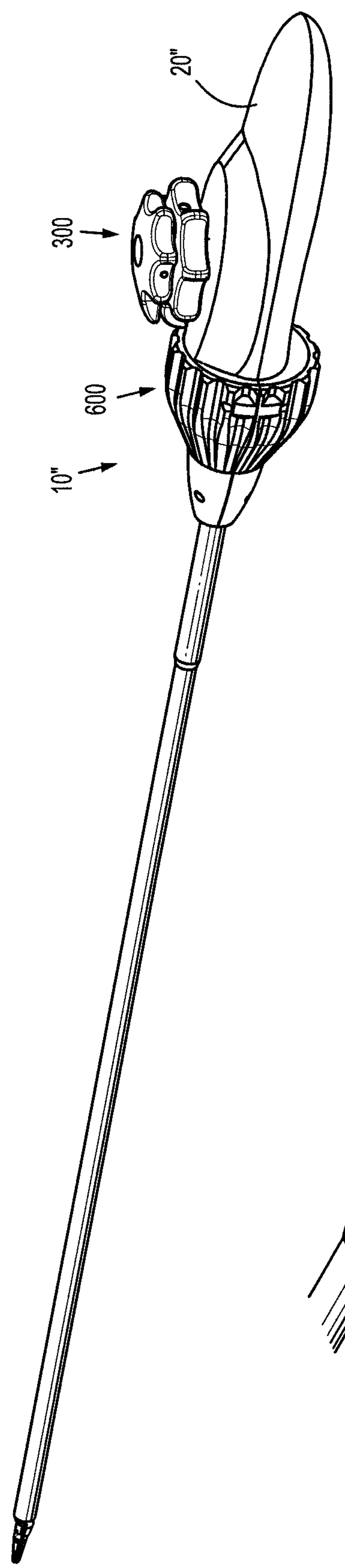

FIG. 27

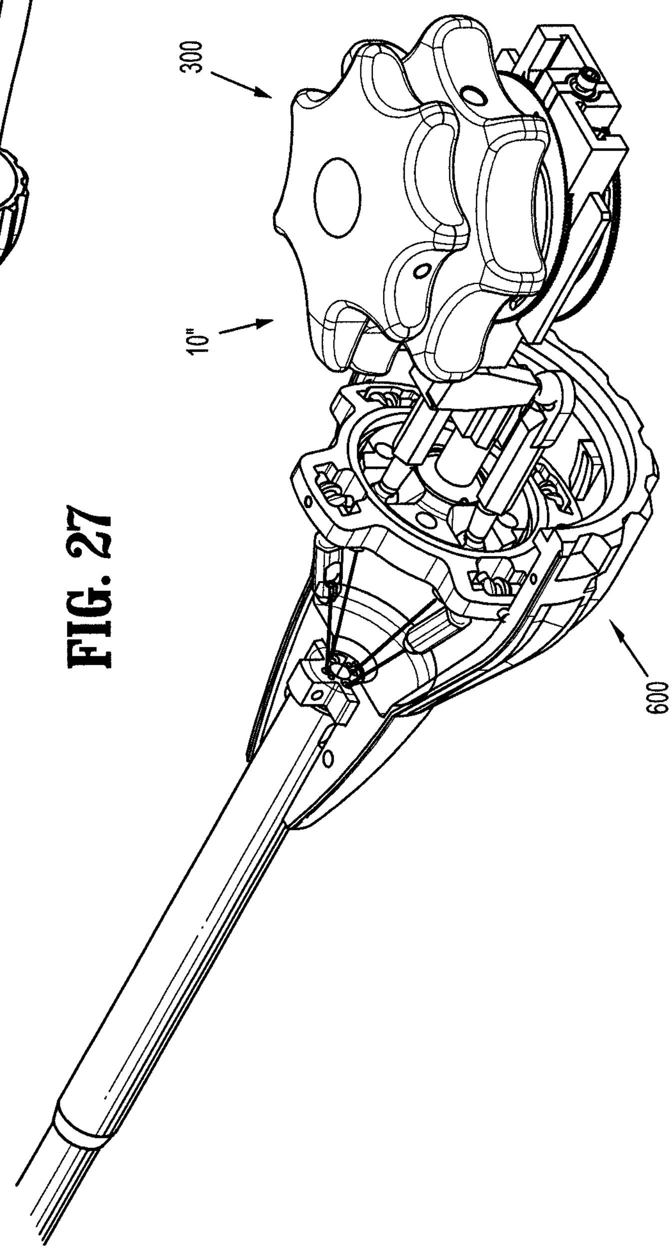

FIG. 28

SURGICAL DEVICE WITH ARTICULATION AND WRIST ROTATION

CROSS-REFERENCE TO RELATED APPLICATIONS

This present application is a divisional of U.S. patent application Ser. No. 15/422,636 filed Feb. 2, 2017, which issued as U.S. Pat. No. 10,448,964, which is a continuation of U.S. patent application Ser. No. 13/543,931 filed on Jul. 9, 2012, now abandoned, which claims benefit of and priority to U.S. Provisional Application No. 61/505,604, filed Jul. 8, 2011, and the disclosures of each of the above-identified applications are hereby incorporated by reference in their entirety.

BACKGROUND

The present disclosure relates to a device for surgically manipulating tissue. More particularly, the present disclosure relates to a device for surgically joining and/or cutting tissue utilizing an elongated, generally flexible and articulating shaft.

TECHNICAL FIELD

Various types of surgical instruments used to surgically join tissue are known in the art, and are commonly used, for example, for closure of tissue or organs in transection, resection, anastomoses, for occlusion of organs in thoracic and abdominal procedures, and for electrosurgically fusing or sealing tissue.

One example of such a surgical instrument is a surgical stapling instrument, which may include an anvil assembly, a cartridge assembly for supporting an array of surgical staples, an approximation mechanism for approximating the cartridge and anvil assemblies, and a firing mechanism for ejecting the surgical staples from the cartridge assembly.

Using a surgical stapling instrument, it is common for a surgeon to approximate the anvil and cartridge members. Next, the surgeon can fire the instrument to emplace staples in tissue. Additionally, the surgeon may use the same instrument or a separate instrument to cut the tissue adjacent or between the row(s) of staples.

Another example of a surgical instrument used to surgically join tissue is an electrosurgical forceps, which utilize both mechanical clamping action and electrical energy to effect hemostasis by heating the tissue and blood vessels to coagulate, cauterize and/or seal tissue. As an alternative to open forceps for use with open surgical procedures, many modern surgeons use endoscopes and endoscopic instruments for remotely accessing organs through smaller, puncture-like incisions. As a direct result thereof, patients tend to benefit from less scarring and reduced healing time.

SUMMARY

The present disclosure relates to a surgical instrument comprising a handle assembly, an elongated shaft, an end effector, a rotation mechanism, and an articulation mechanism. The rotation mechanism is disposed in mechanical cooperation with the handle assembly and effects rotation of the end effector about the second longitudinal axis. The articulation mechanism is disposed in mechanical cooperation with the handle assembly and effects movement of the end effector from a first position where the first longitudinal axis is substantially aligned with the second longitudinal axis to a second position where the second longitudinal axis is displaced from the first longitudinal axis. The articulation mechanism comprises a first articulation control disposed in mechanical cooperation with the handle assembly, a first cable and a second cable. Actuation of the first articulation control in a first direction causes the first cable to move distally and causes the second cable to move proximally.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of the presently disclosed surgical instrument are described herein with reference to the drawings wherein:

FIG. **1** is a perspective view of an endoscopic forceps depicting a handle assembly, a flexible shaft, an articulation assembly, a rotation assembly, and an end effector assembly according to the present disclosure;

FIG. **2** is a cross-sectional view of the handle assembly, the articulation assembly and a portion of the rotation assembly taken along line **2-2** of FIG. **1**;

FIG. **3** is a partial perspective, partial cross-sectional view of the features shown in FIG. **2**;

FIGS. **4** and **5** are perspective views of the articulation assembly of FIGS. **1-3**;

FIG. **6** is a perspective view of a portion of the articulation assembly and a portion of the rotation assembly taken along line **6-6** of FIG. **1**;

FIG. **7** is an assembly view of the forceps of FIG. **1**;

FIGS. **8** and **9** are perspective views of a portion of the articulation assembly of the present disclosure;

FIG. **10** is an assembly view of the portion of the articulation assembly of FIGS. **8** and **9**;

FIGS. **11-14** are perspective views of another portion of the articulation assembly;

FIG. **15** is a perspective view of a slider of the articulation mechanism of the present disclosure;

FIG. **16** is a perspective view of the area of detail illustrated in FIG. **1**;

FIG. **17** is an assembly view of a portion of the articulation assembly of the present disclosure;

FIGS. **18-20** are cross-sectional views of portions of the articulation assembly and the rotation assembly of the present disclosure;

FIG. **21** is a perspective view of the forceps of the present disclosure;

FIGS. **22** and **23** are views of a portion of the articulation assembly of the present disclosure;

FIG. **24** illustrates an articulated distal end of the forceps of the present disclosure;

FIG. **25** is a perspective view of a handle portion of a second embodiment of the disclosed forceps;

FIG. **26** is a perspective view of the handle portion of FIG. **25** with portions of the handle assembly removed;

FIG. **27** is a perspective view of forceps according to a third embodiment of the present disclosure; and

FIG. **28** is a perspective view of the handle portion of FIG. **27** with portions of the handle assembly removed.

DETAILED DESCRIPTION

Referring initially to FIG. **1**, one embodiment of an endoscopic vessel sealing forceps is depicted generally as **10**. In the drawings and in the descriptions which follow, the term "proximal," as is traditional, will refer to the end of the forceps **10** which is closer to the user, while the term "distal" will refer to the end which is farther from the user. The forceps **10** comprises a housing **20**, an end effector assembly

100 and an elongated shaft **12** extending therebetween to define a longitudinal axis A-A. A handle assembly **200**, an articulation assembly **300** including two articulation controls **310** and **320**, and a rotation assembly **600** are operable to control the end effector assembly **100** to grasp, seal and divide tubular vessels and vascular tissue. Although the forceps **10** is configured for use in connection with bipolar surgical procedures, various aspects of the present disclosure may also be employed for monopolar surgical procedures. Additionally, while the figures depict a certain type of a forceps, other types of forceps and other endoscopic surgical instruments are encompassed by the present disclosure. Further details of endoscopic forceps are described in commonly-owned U.S. Patent Publication No. 2010/0179540 to Marczyk et al., and U.S. patent application Ser. No. 12/718,143 to Marczyk et al., the entire contents of each of which are hereby incorporated by reference herein

Further details of an endoscopic surgical stapling instrument including surgical fasteners are described 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.

Generally, handle assembly **200** includes a fixed handle **210** and a movable handle **220**. The fixed handle **210** is integrally associated with the housing **20**, and the movable handle **220** is movable relative to fixed handle **210** to induce relative movement between a pair of jaw members of the end effector assembly **100**. The movable handle **220** is operatively coupled to the end effector assembly **100** via a drive rod or a flexible drive rod (not explicitly shown in the accompanying figures), which extends through the elongated shaft **12**, and reciprocates to induce movement in the jaw members. The movable handle **220** may be approximated with fixed handle **210** to move the jaw members from an open position wherein the jaw members are disposed in spaced relation relative to one another, to a clamping or approximated position wherein the jaw members cooperate to grasp tissue therebetween. Electrosurgical energy may be transmitted through tissue grasped between jaw members to effect a tissue seal. Further details of these components and various other components of the disclosed forceps are disclosed in the references that have incorporated in detail above.

Elongated shaft **12** of forceps **10** includes a distal end **16** dimensioned to mechanically engage the end effector assembly **100** and a proximal end **14**, which mechanically engages the housing **20**. The elongated shaft **12** includes two portions: a proximal portion **12***a* defining a proximal shaft axis B-B and a distal portion **12***b* defining a distal shaft axis C-C.

The proximal portion **12***a* of the shaft **12** may exhibit various constructions. For example, the proximal portion **12***a* may be formed from a substantially rigid tube, from flexible tubing (e.g., plastic), or the proximal portion **12***a* may be formed as a composite of a flexible tube and a rigidizing element, such as a tube of braided steel, to provide axial (e.g., compressional) and rotational strength. In other embodiments, the proximal portion **12***a* may be constructed from a plastically deformable material.

The distal portion **12***b* of shaft **12** includes an exterior casing or insulating material disposed over a plurality of links **14***a*, **14***b*, etc. (see FIGS. **16** and **24**; hereinafter "links **14**"). The links **14** are configured to pivot relative to one another to permit the distal portion **12***b* of the shaft **12** to articulate relative to the proximal shaft axis B-B. In one embodiment, the links **14** are nestingly engaged with one another to permit pivotal motion of the distal portion **12***b* in two orthogonal planes in response to movement of articulation controls **310** and **320**. The links **14** may be shaped to permit the distal portion **12***b* of the shaft **12** to be self-centering, or to have a tendency to return to an unarticulated configuration.

Articulation assembly **300** sits atop housing **20** and is operable via articulation controls **310** and **320** to move the end effector assembly **100** (and the articulating distal portion **12***b* of the shaft **12**) in the direction of arrows "U, D" and "R, L" relative to axis proximal shaft axis B-B as explained in more detail below.

The links **14** each include a central lumen extending longitudinally therethrough. The central lumen permits passage of various actuators, including a drive rod, a knife rod and four steering cables **901**, **902**, **903** and **904** (e.g., FIG. **4**) through the elongated shaft **12**.

The four steering cables **901-904** may be substantially elastic and slideably extend through elongated shaft **12**. A distal end of the each of the steering cables **901-904** is mechanically engaged with the end effector **100**. Proximal ends of the steering cables **901-904** are operatively coupled to the articulation controls **310**, **320** as described below.

Referring now to FIGS. **2-6** the articulation assembly **300** permits selective articulation of the end effector assembly **100** to facilitate the manipulation and grasping of tissue. More particularly, the two controls **310** and **320** include selectively rotatable wheels, **311** and **321**, respectively, that sit atop the housing **20**. Each wheel, e.g., wheel **311**, is independently moveable relative to the other wheel, e.g., **321**, and allows a user to selectively articulate the end effector assembly **100** in a given plane of articulation relative to the longitudinal axis A-A. For example, rotation of wheel **311** articulates the end effector assembly **100** along arrows R, L (or right-to-left articulation) by inducing a differential tension and a corresponding motion in steering cables **902** and **903**. Similarly, rotation of wheel **321** articulates the end effector assembly along arrows U, D (or up-and-down articulation) by inducing a differential tension and a corresponding motion in steering cables **901** and **904**.

The articulation assembly **300** and the rotation assembly **600**, comprise the articulating-rotating mechanism and include wheels **311** and **321**, and a rotation knob **610** to effect articulation and/or rotation of the end effector **100**. Details regarding the various components of the articulating-rotating mechanism are described in detail below.

Distal ends of cables **901-904** are disposed in mechanical engagement with end effector **100**, and travel proximally through shaft **12**, as described above. Proximal ends of cables **901-904** are disposed in mechanical cooperation with post assemblies **330***a***-300***d*, respectively. Each post assembly **330** includes a sleeve **332**, which is disposed at least partially around a post **334** (see FIGS. **9** and **10**). It is envisioned that the sleeves **332** and the posts **334** are threadably engaged with each other to allow the tension of the cables to be adjusted.

With particular reference to FIGS. **9** and **10**, an outer disc **350** and an inner disc **360** comprise a disc assembly **362**. Each post **334** is connected to outer disc **350** via pins **336**, **338** and a ball joint **340**. The interaction between the posts **334** and the outer disc **350** allow the posts **334** to swivel about pins **336**, **338** with respect to outer disc **350**. Outer disc **350** radially surrounds inner disc **360** and is rotatable around inner disc **360**. That is, a series of bearings **352** and clips **354** are disposed between inner disc **360** and outer disc **350** to enable outer disc **350** to rotate with respect to inner disc **360**. Additionally, as shown in FIG. **6**, an outer portion of pins **338** engages a groove **612** in rotation knob **610**. Thus, as rotation knob **610** rotates, outer disc **350**, post assemblies **330**, and cables **901-904** also rotate, which causes end effector **100** to rotate around longitudinal axis A-A (or around the w-axis as discussed below with reference to FIG. **24**).

The inner disc **360** is connected to housing **20** via a connector **370**. More particularly, inner disc **360** is connected to a distal portion of connector **370** via a ball-joint connection **372**, and connector **370** is stationary with respect to housing **20**. Additionally, connector **370** is hollow, such that portions of elongated mechanisms (e.g., firing rod, knife rod, etc.) can be advanced between housing **20** and shaft **12**. Such elongated mechanisms are not illustrated in the accompanying figures in the interest of visual clarity.

A pin **380** engages both ball-joint connection **372** and inner disc **360**. An outer portion of pin **380** engages inner disc **360**, and an inner portion of pin **380** engages a slot **374** within ball-joint connection **372** (see FIG. **6**). This connection results in inner disc **360** being able to rotate with respect to the X- and Z-axes, but unable to rotate with respect to the longitudinal axis A-A. The orientation of inner disc **360** and outer disc **350** results in outer disc **350** rotating with inner disc **360** around the X- and Z-axes. Additionally, as discussed above, outer disc **350** is also able to rotate around the longitudinal axis A-A when driven by rotation knob **610**.

Referring now to FIG. **17**, for example, articulation assembly **300** also includes a block **400**, a first disc **410**, a second disc **420**, a first slider **430**, and a second slider **440**. First articulation control **310** is connected to first disc **410** via a first post **470**; second articulation control **320** is connected to second disc **420** via a second post **480**. More particularly, an upper portion **472** of first post **470** is mechanically coupled to first articulation control **310** (e.g., via a pin), and a lower portion **474** of first post **470** is mechanically coupled to first disc **410**. An upper portion **482** of second post **480** is mechanically coupled to second articulation control **320** (e.g., via a pin), and a lower portion **484** of second post **480** is mechanically coupled to second disc **420**. As shown in FIG. **17**, lower portions **474**, **484** of posts **470**, **480** may include a polygonal-shape (e.g. a square) that is dimensioned to fit within a corresponding recess **411** in the corresponding disc **410**, **420** (the lower portion of first disc **410** is not shown). Additionally, an outer diameter of first post **470** is smaller than an inner diameter of second post **480**, thus enabling first post **470** to extend through second post **480**. First post **470** also extends through an opening **401** in block **400** and an opening **322** in first disc **320**. As such, rotation of first articulation control **310** causes rotation of first disc **410**, and rotation of second articulation control **320** causes rotation of second disc **420**.

Each disc **410**, **420** has at least one arcuate slot **412**, **422** therein. In the illustrated embodiments, discs **410**, **420** each include two slots. In this embodiment, discs **410**, **420** are identical to each other (and flipped about the Z-axis (FIG. **6**) with respect to each other), e.g., to facilitate manufacturing. Following pins **414**, **424** extend through respective slots **412**, **422**, and are coupled to respective sliders **430**, **440**. The location of following pins **414**, **424** can be adjusted within respective sliders **430**, **440** by the mechanisms illustrated in FIGS. **15** and **17**. More particularly, sliders **430**, **440** each include a slidable block **432**, **442** connected to respective pins **414**, **424**, and which are slidable within a cavity **434**, **444**. Proximal screws **435**, **445** threadably engage sliders **430**, **440**, and each abut a respective distal screw **436**, **446**. Distal screws **436**, **446** extend through and threadably engage respective slidable blocks **432**, **442**, such that rotation of proximal screws **435**, **445** causes translation of respective slidable blocks **432**, **442**, and thus pins **414**, **424**.

Additionally, sliders **430**, **440** slidingly engage longitudinal slots **402**, **404**, respectively, in block **400**. As such, rotation of articulation control **310** causes rotation of first disc **410**, which causes following pin **414** to move along arcuate slot **412**, which causes slider **430** to move longitudinally through longitudinal slot **402** in block **400**. Likewise, rotation of articulation control **320** causes longitudinal translation of slider **440** with respect to block **400**.

Sliders **430**, **440** are connected to inner disc **360** via a first connecting arms **500**, **510** and second connecting arms **520**, **530**. First connecting arms **500**, **510** downwardly depend from respective sliders **430**, **440** and are connected to second connecting arms **520**, **530**, respectively, via ball joints **540**, **550**. Second connecting arms **520**, **530** include proximal portions **522**, **532** and distal portions **524**, **534**, which are longitudinally translatable (e.g., threaded) with respect to one another to allow the length of second connecting arms **520**, **530** to be adjusted. Second connecting arms **520**, **530** are connected to inner disc **360** via ball joints **560**, **570**. The ball joint **560**, **570** connections allow three-dimensional movement (i.e., about the longitudinal axis A-A and the Y- and Z-axes) of disc assembly **362**. Additionally, as shown in FIG. **5**, for example, first connecting arm **520** is radially offset 90° from second connecting arm **530**. That is, in the illustrated embodiment, first connecting arm **520** engages inner disc **360** at a top portion thereof (i.e., in a **12**:**00** position in FIG. **5**), and second connecting arm **530** engages inner disc **360** at a lateral portion thereof (i.e., in a **9**:**00** position in FIG. **5**).

In use, rotation of first articulation control **310** causes first slider **430** to longitudinally translate, which causes a top portion of disc assembly **362** to move distally/proximally. Such movement by the top portion of disc assembly **362** causes upper cable **904** and lower cable **901** to in opposite directions from one another (i.e., one cable moves distally, the other cable moves proximally). When upper cable **904** is moved distally (i.e., produces slack) and lower cable **901** is moved proximally (i.e., produces tension), end effector **100** articulates downwardly, in the substantial direction of arrow "D" in FIG. **1**. When upper cable **904** is moved proximally and lower cable **901** is moved distally, end effector **100** articulates upwardly, in the substantial direction of arrow "U" in FIG. **1**. As can be appreciated, rotation of second articulation control **302** causes translation of cables **902**, **903** (see FIG. **23**), which causes end effector **100** to articulate in the directions of arrows "R" and "L" in FIG. **1**.

Further, with particular reference to FIG. **24**, when the end effector **100** is articulated in a particular direction and amount (e.g., "R" in FIG. **24**), and when coordinate system {u, v, w} is associated with the end effector **100**. FIG. **24** illustrates that rotation of rotation knob **610** about longitudinal axis A-A, causes the end effector **100** to rotate about axis "w"; end effector **100** does not rotate around longitudinal axis A-A. Thus, the end effector **100** maintains its articulation (i.e., its "R" position in FIG. **24**) while being able to rotate about the w-axis.

Additionally, in the illustrated embodiments, first disc **410** and second disc **420** include serrations along perimeters thereof. A member **490**, as shown in FIG. **17**, includes a distal end **492** that is biased into each disc **410**, **420** via a spring **494**, such that rotation of articulation control **310** and/or **320** causes distal end **492** of member **490** to contact successive serrations, which produces an audible sound to facilitate use.

Another forceps **10'** according to an embodiment of the present disclosure is illustrated in FIGS. **25** and **26**. This embodiment includes a single articulation control **310**, a single disc **410**, and a single slider **430**. In this embodiment, a user can rotate articulation control **310** in addition to the housing **20** for full articulation control of end effector **100**.

FIGS. **27** and **28** illustrate another embodiment of a forceps **10"** having housing **20'**, which is usable with the articulation assembly **300** and rotation assembly **600** of the present disclosure. As illustrated, housing **20'** lacks a movable handle. Here, it is envisioned that any type of actuation mechanism, including powered actuation, is usable with forceps **10"**.

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

What is claimed is:

1. A surgical instrument comprising:

a handle assembly;

an elongated shaft extending distally from the handle assembly and defining a first longitudinal axis;

an end effector disposed in mechanical cooperation with a distal portion of the elongated shaft, the end effector defining a second longitudinal axis and including a pair of jaw members;

a rotation mechanism disposed in mechanical cooperation with the handle assembly and configured to rotate the pair of jaw members of the end effector about the second longitudinal axis by a rotation of at least a portion of the rotation mechanism about the first longitudinal axis relative to the handle assembly;

an articulation mechanism disposed in mechanical cooperation with the handle assembly and configured to move the end effector from a first position where the first longitudinal axis is aligned with the second longitudinal axis to a second position where the second longitudinal axis is displaced from the first longitudinal axis, the articulation mechanism including:

a first articulation control disposed in mechanical cooperation with the handle assembly;

a second articulation control disposed in mechanical cooperation with the handle assembly, the first articulation control and the second articulation control are independently actuatable with respect to each other;

a first cable, a distal portion of the first cable disposed in mechanical cooperation with the end effector;

a second cable, a distal portion of the second cable disposed in mechanical cooperation with the end effector;

a third cable, a distal portion of the third cable disposed in mechanical cooperation with the end effector; and

a fourth cable, a distal portion of the fourth cable disposed in mechanical cooperation with the end effector;

wherein the first articulation control is actuatable in a first direction to cause the first cable to move distally with respect to the handle assembly and to cause the second cable to move proximally with respect to the handle assembly, and wherein the second articulation control is actuatable in a second direction to cause the third cable to move distally with respect to the handle assembly and to cause the fourth cable to move proximally with respect to the handle assembly;

a first disc;

a second disc; and

a link mechanism,

wherein proximal portions of the first cable, the second cable, the third cable and the fourth cable are coupled to the first disc, the first disc is rotatable about the first longitudinal axis relative to the handle assembly, and the link mechanism connects the first articulation control and the second articulation control to the second disc.

2. The surgical instrument according to claim **1**, wherein the rotation mechanism is configured to rotate the elongated shaft about the first longitudinal axis and relative to the handle assembly.

3. The surgical instrument according to claim **1**, wherein the rotation mechanism is configured to rotate the first cable and the second cable about the first longitudinal axis.

4. The surgical instrument according to claim **1**, wherein the articulation mechanism further includes a first slider, the second disc disposed in mechanical cooperation with the first articulation control and the first slider disposed in mechanical cooperation with the second disc such that actuation of the first articulation control causes longitudinal translation of the first slider, which causes longitudinal translation of the first cable and the second cable.

5. The surgical instrument according to claim **1**, wherein the second position of the end effector remains unchanged in response to actuation of the rotation mechanism.

6. The surgical instrument according to claim **1**, wherein the first articulation control includes a first wheel, the second articulation control includes a second wheel, and each of the first and second wheels is selectively and independently rotatable about a rotation axis which is disposed perpendicularly to the first longitudinal axis.

7. A surgical instrument comprising:

a handle assembly;

an elongated shaft extending distally from the handle assembly and defining a first longitudinal axis;

an end effector disposed in mechanical cooperation with a distal portion of the elongated shaft, the end effector defining a second longitudinal axis;

a rotation mechanism disposed in mechanical cooperation with the handle assembly and configured to rotate the end effector about the second longitudinal axis by a rotation of at least a portion of the rotation mechanism about the first longitudinal axis relative to the handle assembly; and

an articulation mechanism disposed in mechanical cooperation with the handle assembly and configured to move the end effector from a first position where the first longitudinal axis is aligned with the second longitudinal axis to a second position where the second longitudinal axis is displaced from the first longitudinal axis, the articulation mechanism having:

a first articulation control disposed in mechanical cooperation with the handle assembly;

a second articulation control disposed in mechanical cooperation with the handle assembly, the first articulation control and the second articulation control are independently actuatable with respect to each other;

a first cable, a distal portion of the first cable disposed in mechanical cooperation with the end effector, wherein a proximal portion of the first cable is coupled to a first disc, the first disc is rotatable about the first longitudinal axis relative to the handle assembly;

a second cable, a distal portion of the second cable disposed in mechanical cooperation with the end effector,

wherein the first articulation control is actuatable in a first direction to cause the first cable to move distally with respect to the handle assembly, and wherein the second articulation control is actuatable in a second direction to cause the second cable to move distally with respect to the handle assembly.

8. The surgical instrument according to claim **7**, wherein the first disc is rotatable about a second disc.

9. The surgical instrument according to claim **7**, wherein the first disc is rotatable with respect to a second disc and at least a portion of the first disc is disposed at the same longitudinal position along the first longitudinal axis as at least a portion of the second disc.

10. The surgical instrument according to claim **9**, wherein the second disc is rotationally fixed about the first longitudinal axis with respect to the handle assembly.

11. The surgical instrument according to claim **9**, wherein the second disc defines a passageway between the handle assembly and the elongated shaft.

12. The surgical instrument according to claim **9**, further including a link mechanism connecting the first articulation control to the second disc.

13. An articulation mechanism for use with a surgical instrument, the articulation mechanism comprising:

a first articulation control;

a second articulation control independently actuatable with respect to the first articulation control;

a first cable disposed in mechanical cooperation with the first articulation control;

a second cable disposed in mechanical cooperation with the first articulation control;

a third cable disposed in mechanical cooperation with the second articulation control;

a fourth cable disposed in mechanical cooperation with the second articulation control;

a disc defining a disc axis and disposed in mechanical cooperation with the first articulation control; and

a slider defining a slider axis and disposed in mechanical cooperation with the disc, the slider axis is parallel to the disc axis, and the disc is rotatable about the disc axis relative to the slider,

wherein the first articulation control is actuatable in a first direction to cause the first cable to move distally with respect to a portion of the first articulation control and to cause the second cable to move proximally with respect to the portion of the first articulation control, and wherein the second articulation control is actuatable in a second direction to cause the third cable to move distally with respect to a portion of the second articulation control and to cause the fourth cable to move proximally with respect to the portion of the second articulation control.

14. The articulation mechanism according to claim **13**, wherein the first articulation control is actuatable to cause longitudinal translation of the slider.

15. The articulation mechanism according to claim **14**, wherein the slider is longitudinally translatable to cause longitudinal translation of the first cable and the second cable.

16. The articulation mechanism according to claim **13**, wherein the first articulation control includes a first wheel, the second articulation control includes a second wheel, and each of the first and second wheels is selectively and independently rotatable about a rotation axis.

17. The articulation mechanism according to claim **16**, wherein the rotation axis is perpendicular to an axis defined by the first cable.

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