US012383247B2

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

(10) **Patent No.: US 12,383,247 B2**
(45) **Date of Patent: Aug. 12, 2025**

(54) **CLOSURE DEVICES AND METHODS**

(71) Applicant: **Abbott Vascular, Inc.**, Santa Clara, CA (US)

(72) Inventors: **Marc G. Gianotti**, Wiesendangen (CH); **Aaron M. Fortson**, Fremont, CA (US)

(73) Assignee: **Abbott Vascular, Inc.**, Santa Clara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 112 days.

(21) Appl. No.: **17/880,968**

(22) Filed: **Aug. 4, 2022**

(65) **Prior Publication Data**

US 2022/0370057 A1 Nov. 24, 2022

Related U.S. Application Data

(60) Continuation of application No. 16/737,604, filed on Jan. 8, 2020, now Pat. No. 11,439,378, which is a (Continued)

(51) **Int. Cl.**
A61B 17/00 (2006.01)
A61B 17/04 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 17/0057*** (2013.01); ***A61B 17/04*** (2013.01); ***A61B 17/0401*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC . A61B 17/0057; A61B 17/04; A61B 17/0401; A61B 17/0469; A61B 17/0482;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

287,046 A 10/1883 Norton
438,400 A 10/1890 Brennen
(Continued)

FOREIGN PATENT DOCUMENTS

AU 2003297432 A1 7/2004
CA 233960 A 9/1923
(Continued)

OTHER PUBLICATIONS

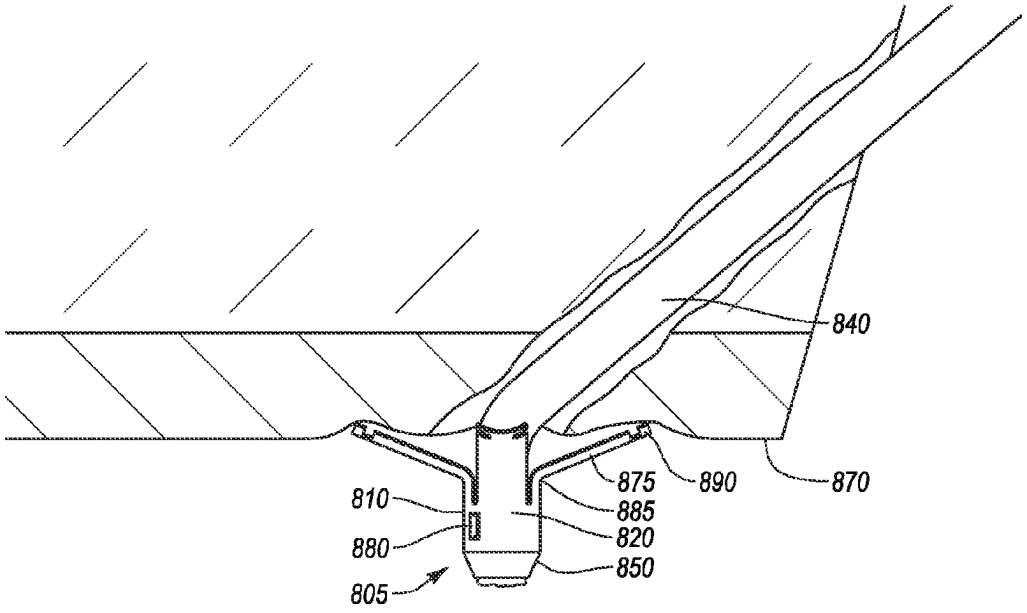
U.S. Appl. No. 11/508,656, filed Aug. 30, 2010, Office Action.
(Continued)

Primary Examiner — Julian W Woo
(74) *Attorney, Agent, or Firm* — Workman Nydegger

(57) **ABSTRACT**

A method for closing a puncture in tissue that includes advancing a guide member into proximity with the tissue, the guide member having a needle guide, positioning a distal end of the guide member with the needle guide toward the tissue to present an opening of the needle guide toward the tissue the needle guide cooperating with a suture securing device that is slidably coupled to the guide member and a suture attached to the suture securing device, deploying the suture securing device, the suture securing device comprising a body with an anchor point for the suture and features that allow the suture securing device to pierce the tissue and resist retraction through the tissue, and establishing tension in the suture to move the suture securing device toward another suture securing device to thereby close the puncture in the tissue.

19 Claims, 18 Drawing Sheets



Related U.S. Application Data

continuation of application No. 15/344,978, filed on Nov. 7, 2016, now Pat. No. 10,537,313, which is a division of application No. 13/112,618, filed on May 20, 2011, now Pat. No. 9,486,191, which is a continuation-in-part of application No. 12/684,470, filed on Jan. 8, 2010, now Pat. No. 9,414,820.

(60) Provisional application No. 61/143,751, filed on Jan. 9, 2009.

(52) **U.S. Cl.**
CPC ***A61B 17/0469*** (2013.01); *A61B 2017/00619* (2013.01); *A61B 2017/00623* (2013.01); *A61B 2017/00659* (2013.01); *A61B 2017/00663* (2013.01); *A61B 2017/00867* (2013.01); *A61B 2017/0409* (2013.01); *A61B 2017/0437* (2013.01); *A61B 2017/0464* (2013.01); *A61B 2017/0472* (2013.01); *A61B 17/0482* (2013.01); *A61B 17/0483* (2013.01); *A61B 17/0487* (2013.01)

(58) **Field of Classification Search**
CPC A61B 17/0483; A61B 17/0487; A61B 2017/00619; A61B 2017/00623; A61B 2017/00659; A61B 2017/00663; A61B 2017/0409
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

556,082	A	3/1896	Boeddinghaus
1,088,393	A	2/1914	Backus
1,123,290	A	1/1915	Von Herff
1,242,139	A	10/1917	Callahan
1,331,401	A	2/1920	Summers
1,426,111	A	8/1922	Sacker
1,480,935	A	1/1924	Gleason
1,516,990	A	11/1924	Silverman
1,596,004	A	8/1926	De Bengoa
1,647,958	A	11/1927	Ciarlante
1,847,347	A	3/1932	Maisto
1,852,098	A	4/1932	Anderson
1,880,569	A	10/1932	Weis
2,075,508	A	3/1937	Davidson
2,087,074	A	7/1937	Tucker
2,108,206	A	2/1938	Mecker
2,210,061	A	8/1940	Caminez
2,254,620	A	9/1941	Miller
2,316,297	A	4/1943	Southerland et al.
2,371,978	A	3/1945	Perham
2,453,227	A	11/1948	Janes
2,583,625	A	1/1952	Bergan
2,610,631	A	9/1952	Calicchio
2,684,070	A	7/1954	Kelsey
2,755,699	A	7/1956	Forster
2,756,748	A	7/1956	Ferguson
2,910,067	A	10/1959	White
2,944,311	A	7/1960	Schneckenberger
2,951,482	A	9/1960	Sullivan
2,969,887	A	1/1961	Darmstadt et al.
3,014,483	A	12/1961	Frank
3,015,403	A	1/1962	Fuller
3,029,754	A	4/1962	Doyle
3,113,379	A	12/1963	Frank
3,120,230	A	2/1964	Skold
3,142,878	A	8/1964	Santora
3,209,754	A	10/1965	Brown
3,209,784	A	10/1965	Schwartz
3,348,595	A	10/1967	Stevens, Jr.
3,357,070	A	12/1967	Soloan
3,482,428	A	12/1969	Kapitanov et al.
3,494,533	A	2/1970	Green et al.
3,494,553	A	2/1970	Nelson
3,495,586	A	2/1970	Regenbogen
3,510,923	A	5/1970	Blake
3,513,848	A	5/1970	Winston et al.
3,517,128	A	6/1970	Hines
3,523,351	A	8/1970	Filia
3,525,340	A	8/1970	Gilbert
3,557,794	A	1/1971	Van Patten
3,586,002	A	6/1971	Wood
3,604,425	A	9/1971	Le Roy
3,618,447	A	11/1971	Goins
3,664,345	A	5/1972	Dabbs et al.
3,677,243	A	7/1972	Nerz
3,682,180	A	8/1972	McFarlane
3,732,719	A	5/1973	Pallotta
3,750,650	A	8/1973	Ruttgers
3,753,438	A	8/1973	Wood et al.
3,757,629	A	9/1973	Schneider
3,799,172	A	3/1974	Szpur
3,805,337	A	4/1974	Branstetter
3,814,104	A	6/1974	Irnich et al.
3,823,719	A	7/1974	Cummings
3,828,791	A	8/1974	Santos
3,831,608	A	8/1974	Kletschka et al.
3,856,016	A	12/1974	Davis
3,874,388	A	4/1975	King et al.
3,908,662	A	9/1975	Razgulov et al.
3,926,194	A	12/1975	Greenberg et al.
3,931,821	A	1/1976	Kletschka et al.
3,939,820	A	2/1976	Grayzel
3,944,114	A	3/1976	Coppens
3,960,147	A	6/1976	Murray
3,976,079	A	8/1976	Samuels et al.
3,985,138	A	10/1976	Jarvik
4,007,743	A	2/1977	Blake
4,011,872	A	3/1977	Komiya
4,014,492	A	3/1977	Rothfuss
4,018,228	A	4/1977	Goosen
4,046,150	A	9/1977	Schwartz et al.
4,047,533	A	9/1977	Perciaccante et al.
4,064,881	A	12/1977	Meredith
4,112,944	A	9/1978	Williams
4,153,321	A	5/1979	Pombrol
4,162,673	A	7/1979	Patel
4,169,476	A	10/1979	Hiltebrandt
4,189,808	A	2/1980	Brown
4,192,315	A	3/1980	Hilzinger et al.
4,201,215	A	5/1980	Crossett et al.
4,204,541	A	5/1980	Kapitanov
4,207,870	A	6/1980	Eldridge
4,214,587	A	7/1980	Sakura, Jr.
4,215,699	A	8/1980	Patel
4,217,902	A	8/1980	March
4,267,995	A	5/1981	McMillan
4,273,129	A	6/1981	Boebel
4,274,415	A	6/1981	Kanamoto et al.
4,278,091	A	7/1981	Borzone
4,287,489	A	9/1981	Pinkham
4,291,698	A	9/1981	Fuchs et al.
4,317,445	A	3/1982	Robinson
4,317,451	A	3/1982	Cerwin et al.
4,318,401	A	3/1982	Zimmerman
4,327,485	A	5/1982	Rix
4,345,606	A	8/1982	Littleford
4,359,052	A	11/1982	Staub
4,368,736	A	1/1983	Kaster
4,387,489	A	6/1983	Dudek
4,396,139	A	8/1983	Hall et al.
4,400,879	A	8/1983	Hildreth
4,407,286	A	10/1983	Noiles et al.
4,411,654	A	10/1983	Boarini et al.
4,412,832	A	11/1983	Kling et al.
4,428,376	A	1/1984	Mericle
4,440,170	A	4/1984	Golden et al.
4,449,531	A	5/1984	Cerwin et al.
4,475,544	A	10/1984	Reis
4,480,356	A	11/1984	Martin
4,485,816	A	12/1984	Krumme

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,501,276 A 2/1985 Lombardi
RE31,855 E 3/1985 Osborne et al.
4,505,273 A 3/1985 Braun et al.
4,505,274 A 3/1985 Speelman
4,523,591 A 6/1985 Kaplan et al.
4,523,695 A 6/1985 Braun et al.
4,525,157 A 6/1985 Vaillancourt
4,526,174 A 7/1985 Froehlich
4,570,633 A 2/1986 Golden
4,577,635 A 3/1986 Meredith
4,586,503 A 5/1986 Kirsch et al.
4,592,498 A 6/1986 Braun et al.
4,595,559 A 6/1986 Planchamp
4,596,559 A 6/1986 Fleischhacker
4,607,638 A 8/1986 Crainich
4,610,251 A 9/1986 Kumar
4,610,252 A 9/1986 Catalano
4,635,634 A 1/1987 Santos
4,635,637 A 1/1987 Schreiber
4,644,956 A 2/1987 Morgenstern
4,651,737 A 3/1987 Deniega
4,664,305 A 5/1987 Blake et al.
4,665,906 A 5/1987 Jervis
4,667,675 A 5/1987 Davis
4,683,895 A 8/1987 Pohndorf
4,687,469 A 8/1987 Osypka
4,693,249 A 9/1987 Schenck et al.
4,697,312 A 10/1987 Freyer
4,719,917 A 1/1988 Barrows et al.
4,724,840 A 2/1988 McVay et al.
4,738,658 A 4/1988 Magro et al.
4,744,364 A 5/1988 Kensey
4,747,407 A 5/1988 Liu et al.
4,750,492 A 6/1988 Jacobs
4,759,364 A 7/1988 Boebel
4,771,782 A 9/1988 Millar
4,772,266 A 9/1988 Groshong
4,773,421 A 9/1988 Davis
4,777,950 A 10/1988 Kees, Jr.
4,789,090 A 12/1988 Blake, III
4,813,586 A 3/1989 Seifert
4,823,794 A 4/1989 Pierce
4,830,002 A 5/1989 Semm
4,832,688 A 5/1989 Sagae et al.
4,836,204 A 6/1989 Landymore et al.
4,852,568 A 8/1989 Kensey
4,860,746 A 8/1989 Yoon
4,865,026 A 9/1989 Barrett
4,866,818 A 9/1989 Thompson
4,874,122 A 10/1989 Froehlich et al.
4,878,915 A 11/1989 Brantigan
4,885,003 A 12/1989 Hillstead
4,886,067 A 12/1989 Palermo
4,887,601 A 12/1989 Richards
4,890,612 A 1/1990 Kensey
4,902,508 A 2/1990 Badylak et al.
4,917,087 A 4/1990 Walsh et al.
4,917,089 A 4/1990 Sideris
4,929,240 A 5/1990 Kirsch et al.
4,934,364 A 6/1990 Green
4,950,258 A 8/1990 Kawai et al.
4,957,499 A 9/1990 Lipatov et al.
4,961,729 A 10/1990 Vaillancourt
4,967,949 A 11/1990 Sandhaus
4,976,721 A 12/1990 Blasnik et al.
4,983,176 A 1/1991 Cushman et al.
4,997,436 A 3/1991 Oberlander
4,997,439 A 3/1991 Chen
4,997,736 A 3/1991 Kawamura et al.
5,002,562 A 3/1991 Oberlander
5,007,921 A 4/1991 Brown
5,009,663 A 4/1991 Broome
5,011,487 A 4/1991 Shichman
5,015,247 A 5/1991 Michelson
5,021,059 A 6/1991 Kensey et al.
5,026,390 A 6/1991 Brown
5,030,226 A 7/1991 Green et al.
5,032,127 A 7/1991 Frazee et al.
5,035,692 A 7/1991 Lyon et al.
5,041,129 A 8/1991 Hayhurst et al.
5,042,707 A 8/1991 Taheri
5,047,047 A 9/1991 Yoon
5,053,008 A 10/1991 Bajaj
5,059,201 A 10/1991 Asnis
5,061,274 A 10/1991 Kensey
5,061,283 A 10/1991 Silvestrini
5,071,430 A 12/1991 De et al.
5,074,871 A 12/1991 Groshong
5,078,731 A 1/1992 Hayhurst
5,092,941 A 3/1992 Miura
5,100,418 A 3/1992 Yoon et al.
5,100,422 A 3/1992 Berguer et al.
5,108,420 A 4/1992 Marks
5,108,421 A 4/1992 Fowler
5,114,032 A 5/1992 Laidlaw
5,114,065 A 5/1992 Storace
5,116,349 A 5/1992 Aranyi
5,122,122 A 6/1992 Allgood
5,122,156 A 6/1992 Granger et al.
5,131,379 A 7/1992 Sewell, Jr.
5,141,520 A 8/1992 Goble et al.
5,147,381 A 9/1992 Heimerl et al.
5,156,609 A 10/1992 Nakao et al.
5,158,566 A 10/1992 Pianetti
5,160,339 A 11/1992 Chen et al.
5,163,343 A 11/1992 Gish
5,167,634 A 12/1992 Corrigan et al.
5,167,643 A 12/1992 Lynn
5,171,249 A 12/1992 Stefanchik et al.
5,171,250 A 12/1992 Yoon
5,171,251 A 12/1992 Bregen et al.
5,171,259 A 12/1992 Inoue
5,176,648 A 1/1993 Holmes et al.
5,176,682 A 1/1993 Chow
5,176,691 A 1/1993 Pierce
5,192,287 A 3/1993 Fournier et al.
5,192,288 A 3/1993 Thompson et al.
5,192,300 A 3/1993 Fowler
5,192,301 A 3/1993 Kamiya et al.
5,192,302 A 3/1993 Kensey et al.
5,192,602 A 3/1993 Spencer et al.
5,193,533 A 3/1993 Body et al.
5,197,971 A 3/1993 Bonutti
5,203,787 A 4/1993 Noblitt et al.
5,207,697 A 5/1993 Carusillo et al.
5,209,756 A 5/1993 Seedhom et al.
5,211,651 A 5/1993 Reger et al.
5,217,024 A 6/1993 Dorsey et al.
5,217,471 A 6/1993 Burkhart
5,219,359 A 6/1993 McQuilkin et al.
5,222,971 A 6/1993 Willard et al.
5,222,974 A 6/1993 Kensey et al.
5,224,945 A 7/1993 Pannek
5,226,908 A 7/1993 Yoon
5,234,449 A 8/1993 Bruker et al.
5,236,435 A 8/1993 Sewell, Jr.
5,236,445 A 8/1993 Hayhurst et al.
5,237,996 A 8/1993 Waldman et al.
5,242,456 A 9/1993 Nash et al.
5,242,457 A 9/1993 Akopov et al.
5,242,459 A 9/1993 Buelna
5,243,857 A 9/1993 Janota
5,246,156 A 9/1993 Rothfuss et al.
5,246,443 A 9/1993 Mai
5,250,058 A 10/1993 Miller et al.
5,254,105 A 10/1993 Haaga
5,255,679 A 10/1993 Imran
5,258,015 A 11/1993 Li et al.
5,269,792 A 12/1993 Kloeckl et al.
5,275,610 A 1/1994 Eberbach
5,275,616 A 1/1994 Fowler
5,281,422 A 1/1994 Badylak et al.
5,282,808 A 2/1994 Kovac et al.
5,282,827 A 2/1994 Kensey et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,282,832 A 2/1994 Toso et al.
5,284,488 A 2/1994 Sideris
5,289,963 A 3/1994 McGarry et al.
5,290,243 A 3/1994 Chodorow et al.
5,290,310 A 3/1994 Makower et al.
5,292,309 A 3/1994 Van et al.
5,292,332 A 3/1994 Lee
5,300,046 A 4/1994 Scarfone et al.
5,304,183 A 4/1994 Gourlay et al.
5,304,184 A 4/1994 Hathaway et al.
5,304,204 A 4/1994 Bregen
5,306,254 A 4/1994 Nash et al.
5,306,280 A 4/1994 Bregen et al.
5,309,927 A 5/1994 Welch
5,318,542 A 6/1994 Hirsch et al.
5,320,639 A 6/1994 Rudnick
5,322,694 A 6/1994 Sixsmith
5,327,908 A 7/1994 Gerry
5,328,472 A 7/1994 Steinke et al.
5,330,442 A 7/1994 Green et al.
5,330,445 A 7/1994 Haaga
5,330,503 A 7/1994 Yoon
5,334,216 A 8/1994 Vidal et al.
5,334,217 A 8/1994 Das
5,335,680 A 8/1994 Moore
5,340,360 A 8/1994 Stefanchik
5,342,393 A 8/1994 Stack
5,344,439 A 9/1994 Otten
5,350,399 A 9/1994 Erlebacher et al.
5,352,229 A 10/1994 Goble et al.
5,354,279 A 10/1994 Berthold
5,364,406 A 11/1994 Sewell, Jr.
5,364,408 A 11/1994 Gordon
5,366,458 A 11/1994 Korthoff et al.
5,366,479 A 11/1994 McGarry et al.
5,376,101 A 12/1994 Green et al.
5,383,860 A 1/1995 Lau
5,383,896 A 1/1995 Gershony et al.
5,383,897 A 1/1995 Wholey
5,383,905 A 1/1995 Golds et al.
RE34,866 E 2/1995 Kensey et al.
5,391,173 A 2/1995 Wilk
5,391,174 A 2/1995 Weston
5,392,978 A 2/1995 Velez et al.
5,395,030 A 3/1995 Kuramoto et al.
5,397,355 A 3/1995 Marin et al.
5,403,330 A 4/1995 Tuason
5,403,331 A 4/1995 Chesterfield et al.
5,404,621 A 4/1995 Heinke
5,409,499 A 4/1995 Yi
5,411,520 A 5/1995 Nash et al.
5,413,571 A 5/1995 Katsaros et al.
5,413,584 A 5/1995 Schulze
5,416,584 A 5/1995 Kay
5,417,699 A 5/1995 Klein et al.
5,419,765 A 5/1995 Weldon et al.
5,419,777 A 5/1995 Hofling
5,421,832 A 6/1995 Lefebvre
5,423,857 A 6/1995 Rosenman et al.
5,425,489 A 6/1995 Shichman et al.
5,425,740 A 6/1995 Hutchinson, Jr.
5,431,639 A 7/1995 Shaw
5,431,667 A 7/1995 Thompson et al.
5,433,721 A 7/1995 Hooven et al.
5,437,631 A 8/1995 Janzen
5,439,479 A 8/1995 Shichman et al.
5,443,477 A 8/1995 Marin et al.
5,443,481 A 8/1995 Lee
5,445,167 A 8/1995 Yoon et al.
5,449,359 A 9/1995 Groiso
5,451,235 A 9/1995 Lock et al.
5,454,413 A 10/1995 Morelli
5,456,400 A 10/1995 Shichman et al.
5,462,558 A 10/1995 Kolesa et al.
5,462,561 A 10/1995 Voda
5,464,413 A 11/1995 Siska et al.
5,464,416 A 11/1995 Steckel
5,466,241 A 11/1995 Leroy et al.
5,470,010 A 11/1995 Rothfuss et al.
5,471,982 A 12/1995 Edwards et al.
5,474,557 A 12/1995 Mai
5,474,569 A 12/1995 Zinreich et al.
5,474,572 A 12/1995 Hayhurst
5,476,505 A 12/1995 Limon
5,478,352 A 12/1995 Fowler
5,478,353 A 12/1995 Yoon
5,478,354 A 12/1995 Tovey et al.
5,478,853 A 12/1995 Regnier et al.
5,484,420 A 1/1996 Russo
5,486,195 A 1/1996 Myers et al.
5,492,119 A 2/1996 Abrams
5,496,332 A 3/1996 Sierra et al.
5,497,933 A 3/1996 DeFonzo et al.
5,501,698 A 3/1996 Roth et al.
5,507,744 A 4/1996 Tay et al.
5,507,755 A 4/1996 Gresl et al.
5,510,115 A 4/1996 Breillatt et al.
5,514,159 A 5/1996 Matula et al.
5,521,184 A 5/1996 Zimmermann
5,522,840 A 6/1996 Krajicek
5,527,322 A 6/1996 Klein et al.
5,536,251 A 7/1996 Evard et al.
5,536,267 A 7/1996 Edwards et al.
5,540,712 A 7/1996 Kleshinski et al.
5,540,716 A 7/1996 Hlavacek
5,543,520 A 8/1996 Zimmermann
5,544,802 A 8/1996 Crainich
5,545,178 A 8/1996 Kensey et al.
5,547,474 A 8/1996 Kloeckl et al.
5,560,532 A 10/1996 Defonzo et al.
5,562,684 A 10/1996 Kammerer
5,571,120 A 11/1996 Yoon
5,573,540 A 11/1996 Yoon
5,573,784 A 11/1996 Badylak et al.
5,575,771 A 11/1996 Walinsky
5,582,616 A 12/1996 Bolduc et al.
5,584,879 A 12/1996 Reimold et al.
5,591,205 A 1/1997 Fowler
5,593,412 A 1/1997 Martinez et al.
5,593,422 A 1/1997 Muijs et al.
5,593,425 A 1/1997 Bonutti et al.
5,601,602 A 2/1997 Fowler
5,609,597 A 3/1997 Lehrer
5,611,986 A 3/1997 Datta et al.
5,613,974 A 3/1997 Andreas et al.
5,613,975 A 3/1997 Christy
5,618,291 A 4/1997 Thompson et al.
5,618,306 A 4/1997 Roth et al.
5,620,452 A 4/1997 Yoon
5,620,461 A 4/1997 Muijs et al.
5,626,614 A 5/1997 Hart
5,630,824 A 5/1997 Hart
5,634,936 A 6/1997 Linden et al.
5,643,318 A 7/1997 Tsukernik et al.
5,645,553 A 7/1997 Kolesa et al.
5,645,565 A 7/1997 Rudd et al.
5,645,566 A 7/1997 Brenneman et al.
5,645,567 A 7/1997 Crainich
5,647,372 A 7/1997 Tovey et al.
5,649,959 A 7/1997 Hannam et al.
D383,539 S 9/1997 Croley et al.
5,669,917 A 9/1997 Sauer et al.
5,669,935 A 9/1997 Rosenman et al.
5,672,174 A 9/1997 Gough et al.
5,674,231 A 10/1997 Green et al.
5,674,244 A 10/1997 Mathys
5,676,689 A 10/1997 Kensey et al.
5,676,974 A 10/1997 Valdes et al.
5,678,572 A 10/1997 Shaw et al.
5,681,280 A 10/1997 Rusk et al.
5,681,334 A 10/1997 Evans et al.
5,681,351 A 10/1997 Jamiolkowski et al.
5,683,405 A 11/1997 Yacoubian et al.
5,690,674 A 11/1997 Diaz

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,693,061 A 12/1997 Pierce et al.
5,695,504 A 12/1997 Gifford et al.
5,695,505 A 12/1997 Yoon
5,695,524 A 12/1997 Kelley et al.
5,697,943 A 12/1997 Sauer et al.
5,700,270 A 12/1997 Peyser et al.
5,700,273 A 12/1997 Buelna et al.
5,709,224 A 1/1998 Behl et al.
5,709,708 A 1/1998 Thal
5,713,899 A 2/1998 Marnay et al.
5,715,987 A 2/1998 Kelley et al.
5,716,375 A 2/1998 Fowler
5,720,755 A 2/1998 Dakov
5,720,765 A 2/1998 Thal
5,725,498 A 3/1998 Janzen et al.
5,725,552 A 3/1998 Kotula et al.
5,725,554 A 3/1998 Simon et al.
5,725,556 A 3/1998 Moser et al.
5,728,109 A 3/1998 Schulze et al.
5,728,110 A 3/1998 Vidal et al.
5,728,114 A 3/1998 Evans et al.
5,728,116 A 3/1998 Rosenman
5,728,122 A 3/1998 Leschinsky et al.
5,728,132 A 3/1998 Van et al.
5,728,133 A 3/1998 Kontos
5,728,143 A 3/1998 Gough et al.
5,732,872 A 3/1998 Bolduc et al.
5,735,736 A 4/1998 Volk
5,735,873 A 4/1998 MacLean
5,735,875 A 4/1998 Bonutti et al.
5,735,877 A 4/1998 Pagedas
5,746,753 A 5/1998 Sullivan et al.
5,749,826 A 5/1998 Faulkner
5,749,898 A 5/1998 Schulze et al.
5,752,966 A 5/1998 Chang
5,755,726 A 5/1998 Pratt et al.
5,755,727 A 5/1998 Kontos
5,755,778 A 5/1998 Kleshinski
5,759,189 A 6/1998 Ferragamo et al.
5,762,872 A 6/1998 Buehler et al.
5,766,217 A 6/1998 Christy
5,766,246 A 6/1998 Mulhauser et al.
5,769,862 A 6/1998 Kammerer et al.
5,769,870 A 6/1998 Salahieh et al.
5,776,147 A 7/1998 Dolendo
5,776,150 A 7/1998 Nolan et al.
5,779,707 A 7/1998 Bertholet et al.
5,780,807 A 7/1998 Saunders
5,782,844 A 7/1998 Yoon et al.
5,782,860 A 7/1998 Epstein et al.
5,782,861 A 7/1998 Cragg et al.
5,782,864 A 7/1998 Lizardi
5,795,958 A 8/1998 Rao et al.
5,797,928 A 8/1998 Kogasaka
5,797,929 A 8/1998 Andreas et al.
5,797,931 A 8/1998 Bito et al.
5,797,933 A 8/1998 Snow et al.
5,797,958 A 8/1998 Yoon
5,797,960 A 8/1998 Stevens et al.
5,810,776 A 9/1998 Bacich et al.
5,810,846 A 9/1998 Virnich et al.
5,810,851 A 9/1998 Yoon
5,810,877 A 9/1998 Roth et al.
5,814,069 A 9/1998 Schulze et al.
5,817,113 A 10/1998 Gifford et al.
5,820,631 A 10/1998 Nobles
5,823,189 A 10/1998 Kordis
5,827,298 A 10/1998 Hart et al.
5,830,125 A 11/1998 Scribner et al.
5,830,217 A 11/1998 Ryan
5,830,221 A 11/1998 Stein et al.
5,833,698 A 11/1998 Hinchliffe et al.
5,843,164 A 12/1998 Frantzen et al.
5,843,167 A 12/1998 Dwyer et al.
5,845,657 A 12/1998 Carberry et al.
5,846,254 A 12/1998 Schulze et al.
5,853,421 A 12/1998 Leschinsky et al.
5,853,422 A 12/1998 Huebsch et al.
5,855,312 A 1/1999 Toledano
5,855,576 A 1/1999 Leveen et al.
5,857,999 A 1/1999 Quick et al.
5,858,082 A 1/1999 Cruz et al.
5,860,991 A 1/1999 Klein et al.
5,861,003 A 1/1999 Latson et al.
5,861,005 A 1/1999 Kontos
5,865,791 A 2/1999 Whayne et al.
5,868,755 A 2/1999 Kanner et al.
5,868,762 A 2/1999 Cragg et al.
5,868,763 A 2/1999 Spence et al.
5,871,474 A 2/1999 Hermann et al.
5,871,490 A 2/1999 Schulze et al.
5,871,501 A 2/1999 Leschinsky et al.
5,871,525 A 2/1999 Edwards et al.
5,873,876 A 2/1999 Christy
5,873,891 A 2/1999 Sohn
5,879,366 A 3/1999 Shaw et al.
5,891,088 A 4/1999 Thompson et al.
5,893,592 A 4/1999 Schulze et al.
5,897,487 A 4/1999 Ouchi
5,902,310 A 5/1999 Foerster et al.
5,904,696 A 5/1999 Rosenman
5,904,697 A 5/1999 Gifford et al.
5,904,703 A 5/1999 Gilson
5,906,631 A 5/1999 Imran
5,907,893 A 6/1999 Zadno-Azizi et al.
5,908,149 A 6/1999 Welch et al.
5,910,155 A 6/1999 Ratcliff et al.
5,919,207 A 7/1999 Taheri
5,919,208 A 7/1999 Valenti
5,922,009 A 7/1999 Epstein et al.
5,928,208 A 7/1999 Chu et al.
5,928,231 A 7/1999 Klein et al.
5,928,251 A 7/1999 Aranyi et al.
5,928,260 A 7/1999 Chin et al.
5,935,147 A 8/1999 Kensey et al.
5,938,667 A 8/1999 Peyser et al.
5,941,890 A 8/1999 Voegele et al.
5,947,999 A 9/1999 Groiso
5,948,001 A 9/1999 Larsen
5,951,518 A 9/1999 Licata et al.
5,951,547 A 9/1999 Gough et al.
5,951,575 A 9/1999 Bolduc et al.
5,951,576 A 9/1999 Wakabayashi
5,951,589 A 9/1999 Epstein et al.
5,954,732 A 9/1999 Hart et al.
5,957,900 A 9/1999 Ouchi
5,957,936 A 9/1999 Yoon et al.
5,957,938 A 9/1999 Zhu et al.
5,957,940 A 9/1999 Tanner et al.
5,964,782 A 10/1999 Lafontaine et al.
5,972,023 A 10/1999 Tanner et al.
5,976,159 A 11/1999 Bolduc et al.
5,976,161 A 11/1999 Kirsch et al.
5,976,174 A 11/1999 Ruiz
5,980,517 A 11/1999 Gough
5,984,934 A 11/1999 Ashby et al.
5,984,948 A 11/1999 Hasson
5,984,949 A 11/1999 Levin
5,993,466 A 11/1999 Yoon
5,993,468 A 11/1999 Rygaard
5,993,476 A 11/1999 Groiso
6,001,110 A 12/1999 Adams
6,004,341 A 12/1999 Zhu et al.
6,007,563 A 12/1999 Nash et al.
6,007,574 A 12/1999 Pulnev et al.
6,009,877 A 1/2000 Edwards
6,010,517 A 1/2000 Baccaro
6,013,084 A 1/2000 Ken et al.
6,015,815 A 1/2000 Mollison
6,019,779 A 2/2000 Thorud et al.
6,022,372 A 2/2000 Kontos
6,024,747 A 2/2000 Kontos
6,024,750 A 2/2000 Mastri et al.
6,024,756 A 2/2000 Huebsch et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,024,758 A 2/2000 Thal
6,030,364 A 2/2000 Durgin et al.
6,030,413 A 2/2000 Lazarus
6,033,427 A 3/2000 Lee
6,036,703 A 3/2000 Evans et al.
6,036,720 A 3/2000 Abrams et al.
6,045,570 A 4/2000 Epstein et al.
6,048,358 A 4/2000 Barak
6,056,688 A 5/2000 Benderev et al.
6,056,744 A 5/2000 Edwards
6,056,768 A 5/2000 Cates et al.
6,056,769 A 5/2000 Epstein et al.
6,056,770 A 5/2000 Epstein et al.
6,059,800 A 5/2000 Hart et al.
6,059,825 A 5/2000 Hobbs et al.
6,063,085 A 5/2000 Tay et al.
6,063,114 A 5/2000 Nash et al.
6,066,160 A 5/2000 Colvin et al.
6,068,603 A 5/2000 Suzuki
6,071,300 A 6/2000 Brenneman et al.
6,074,395 A 6/2000 Trott et al.
6,074,409 A 6/2000 Goldfarb
6,077,281 A 6/2000 Das
6,077,291 A 6/2000 Das
6,080,182 A 6/2000 Shaw et al.
6,080,183 A 6/2000 Tsugita et al.
6,083,242 A 7/2000 Cook
6,086,608 A 7/2000 Ek et al.
6,090,130 A 7/2000 Nash et al.
6,092,561 A 7/2000 Schmid
6,095,155 A 8/2000 Criscuolo
6,099,553 A 8/2000 Hart et al.
6,102,271 A 8/2000 Longo et al.
6,105,217 A 8/2000 Caradine et al.
6,106,545 A 8/2000 Egan
6,110,184 A 8/2000 Weadock
6,113,610 A 9/2000 Poncet
6,113,611 A 9/2000 Allen et al.
6,113,612 A 9/2000 Swanson et al.
6,117,125 A 9/2000 Rothbarth et al.
6,117,144 A 9/2000 Nobles et al.
6,117,148 A 9/2000 Ravo et al.
6,117,157 A 9/2000 Tekulve
6,117,159 A 9/2000 Huebsch et al.
6,120,513 A 9/2000 Bailey et al.
6,120,524 A 9/2000 Taheri
6,126,675 A 10/2000 Shchervinsky et al.
6,126,677 A 10/2000 Ganaja et al.
6,136,010 A 10/2000 Modesitt et al.
6,143,004 A 11/2000 Davis et al.
6,143,017 A 11/2000 Thal
6,146,385 A 11/2000 Torrie et al.
6,149,660 A 11/2000 Laufer et al.
6,149,667 A 11/2000 Hovland et al.
6,152,144 A 11/2000 Lesh et al.
6,152,934 A 11/2000 Harper et al.
6,152,936 A 11/2000 Christy et al.
6,152,937 A 11/2000 Peterson et al.
6,159,234 A 12/2000 Bonutti et al.
6,161,263 A 12/2000 Anderson
6,165,204 A 12/2000 Levinson et al.
6,171,277 B1 1/2001 Ponzi
6,171,329 B1 1/2001 Shaw et al.
6,174,322 B1 1/2001 Schneidt
6,174,324 B1 1/2001 Egan et al.
6,179,849 B1 1/2001 Yencho et al.
6,179,860 B1 1/2001 Fulton et al.
6,183,775 B1 2/2001 Ventouras
6,193,708 B1 2/2001 Ken et al.
6,193,734 B1 2/2001 Bolduc et al.
6,197,042 B1 3/2001 Ginn et al.
6,198,974 B1 3/2001 Webster, Jr.
6,200,329 B1 3/2001 Fung et al.
6,200,330 B1 3/2001 Benderev et al.
6,203,565 B1 3/2001 Bonutti et al.
6,206,895 B1 3/2001 Levinson
6,206,913 B1 3/2001 Yencho et al.
6,206,931 B1 3/2001 Cook et al.
6,210,407 B1 4/2001 Webster
6,210,418 B1 4/2001 Storz et al.
6,217,554 B1 4/2001 Green
6,220,248 B1 4/2001 Voegele et al.
6,221,084 B1 4/2001 Fleenor
6,221,102 B1 4/2001 Baker et al.
6,231,561 B1 5/2001 Frazier et al.
6,231,592 B1 5/2001 Bonutti et al.
6,238,705 B1 5/2001 Liu et al.
6,241,740 B1 6/2001 Davis et al.
6,245,079 B1 6/2001 Nobles et al.
6,248,124 B1 6/2001 Pedros et al.
6,254,615 B1 7/2001 Bolduc et al.
6,254,617 B1 7/2001 Spence et al.
6,254,642 B1 7/2001 Taylor
6,258,115 B1 7/2001 Dubrul
6,267,773 B1 7/2001 Gadberry et al.
6,273,903 B1 8/2001 Wilk
6,276,704 B1 8/2001 Suiter
6,277,140 B2 8/2001 Ginn et al.
6,280,460 B1 8/2001 Bolduc et al.
6,287,322 B1 9/2001 Zhu et al.
6,287,335 B1 9/2001 Drasler et al.
6,290,674 B1 9/2001 Roue et al.
6,296,657 B1 10/2001 Brucker
6,302,870 B1 10/2001 Jacobsen et al.
6,302,898 B1 10/2001 Edwards et al.
6,305,891 B1 10/2001 Burlingame
6,306,081 B1 10/2001 Ishikawa et al.
6,309,416 B1 10/2001 Swanson et al.
6,319,258 B1 11/2001 McAllen et al.
6,322,580 B1 11/2001 Kanner
6,328,727 B1 12/2001 Frazier et al.
6,329,386 B1 12/2001 Mollison
6,334,865 B1 1/2002 Redmond et al.
6,348,064 B1 2/2002 Kanner
6,355,052 B1 3/2002 Neuss et al.
6,355,061 B1 3/2002 Quiachon et al.
6,358,258 B1 3/2002 Arcia et al.
6,375,671 B1 4/2002 Kobayashi et al.
D457,958 S 5/2002 Dycus et al.
6,383,208 B1 5/2002 Sancoff et al.
6,391,048 B1 5/2002 Ginn et al.
6,395,015 B1 5/2002 Borst et al.
6,397,110 B1 5/2002 Kuzma
6,398,752 B1 6/2002 Sweezer et al.
6,402,765 B1 6/2002 Monassevitch et al.
6,409,739 B1 6/2002 Nobles et al.
6,419,669 B1 7/2002 Frazier et al.
6,421,899 B1 7/2002 Zitnay
6,423,054 B1 7/2002 Ouchi
6,425,911 B1 7/2002 Akerfeldt et al.
6,428,472 B1 8/2002 Haas
6,428,548 B1 8/2002 Durgin et al.
6,443,158 B1 9/2002 LaFontaine et al.
6,443,963 B1 9/2002 Baldwin et al.
6,447,540 B1 9/2002 Fontaine et al.
6,450,391 B1 9/2002 Kayan et al.
6,455,053 B1 9/2002 Okada et al.
6,458,130 B1 10/2002 Frazier et al.
6,461,327 B1 10/2002 Addis et al.
6,461,364 B1 10/2002 Ginn et al.
6,461,366 B1 10/2002 Seguin
6,482,224 B1 11/2002 Michler et al.
6,485,504 B1 11/2002 Johnson et al.
6,488,692 B1 12/2002 Spence et al.
6,494,848 B1 12/2002 Sommercorn et al.
6,500,115 B2 12/2002 Krattiger et al.
6,505,210 B1 1/2003 Frey et al.
6,506,210 B1 1/2003 Kanner
6,508,828 B1 1/2003 Akerfeldt et al.
6,514,280 B1 2/2003 Gilson
6,517,498 B1 2/2003 Burbank et al.
6,517,555 B1 2/2003 Caro
6,517,569 B2 2/2003 Mikus et al.
6,527,737 B2 3/2003 Kaneshige

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,533,762 B2 3/2003 Kanner et al.
6,533,812 B2 3/2003 Swanson et al.
6,537,288 B2 3/2003 Vargas et al.
6,544,230 B1 4/2003 Flaherty et al.
6,547,806 B1 4/2003 Ding
6,551,319 B2 4/2003 Lieberman
6,558,349 B1 5/2003 Kirkman
6,569,159 B1 5/2003 Edwards et al.
6,569,173 B1 5/2003 Blatter et al.
6,569,185 B2 5/2003 Ungs
6,572,629 B2 6/2003 Kalloo et al.
6,578,585 B1 6/2003 Stachowski et al.
6,582,452 B2 6/2003 Coleman et al.
6,582,482 B2 6/2003 Gillman et al.
6,596,012 B2 7/2003 Akerfeldt et al.
6,596,013 B2 7/2003 Yang et al.
6,599,303 B1 7/2003 Peterson et al.
6,599,311 B1 7/2003 Biggs et al.
6,602,263 B1 8/2003 Swanson et al.
6,610,072 B1 8/2003 Christy et al.
6,613,059 B2 9/2003 Schaller et al.
6,613,060 B2 9/2003 Adams et al.
6,616,686 B2 9/2003 Coleman et al.
6,620,165 B2 9/2003 Wellisz
6,623,509 B2 9/2003 Ginn
6,623,510 B2 9/2003 Carley et al.
6,626,918 B1 9/2003 Ginn et al.
6,626,919 B1 9/2003 Swanstrom
6,626,920 B2 9/2003 Whayne
6,626,930 B1 9/2003 Allen et al.
6,632,197 B2 10/2003 Lyon
6,632,238 B2 10/2003 Ginn et al.
6,634,537 B2 10/2003 Chen
6,645,205 B2 11/2003 Ginn
6,645,225 B1 11/2003 Atkinson
6,645,255 B2 11/2003 Sanduja et al.
6,652,538 B2 11/2003 Kayan et al.
6,652,556 B1 11/2003 Vantassel et al.
6,663,633 B1 12/2003 Pierson, III
6,663,655 B2 12/2003 Ginn et al.
6,665,906 B2 12/2003 Li
6,669,714 B2 12/2003 Coleman et al.
6,673,083 B1 1/2004 Kayan et al.
6,676,665 B2 1/2004 Foley et al.
6,676,671 B2 1/2004 Robertson et al.
6,676,685 B2 1/2004 Pedros et al.
6,679,894 B2 1/2004 Damarati
6,679,904 B2 1/2004 Gleeson et al.
6,685,707 B2 2/2004 Roman et al.
6,689,147 B1 2/2004 Koster, Jr.
6,695,867 B2 2/2004 Ginn et al.
6,699,256 B1 3/2004 Logan et al.
6,702,826 B2 3/2004 Liddicoat et al.
6,712,836 B1 3/2004 Berg et al.
6,712,837 B2 3/2004 Aakerfeldt et al.
6,719,777 B2 4/2004 Ginn et al.
6,726,704 B1 4/2004 Loshakove et al.
6,736,822 B2 5/2004 McClellan et al.
6,743,195 B2 6/2004 Zucker
6,743,243 B1 6/2004 Roy et al.
6,743,259 B2 6/2004 Ginn
6,745,079 B2 6/2004 King
6,746,457 B2 6/2004 Dana et al.
6,746,472 B2 6/2004 Frazier et al.
6,749,621 B2 6/2004 Pantages et al.
6,749,622 B2 6/2004 McGuckin et al.
6,752,813 B2 6/2004 Goldfarb et al.
6,755,842 B2 6/2004 Kanner et al.
6,758,855 B2 7/2004 Fulton et al.
6,767,356 B2 7/2004 Kanner et al.
6,776,784 B2 8/2004 Ginn
6,776,785 B1 8/2004 Yencho et al.
6,780,185 B2 8/2004 Frei et al.
6,780,197 B2 8/2004 Roe et al.
6,786,915 B2 9/2004 Akerfeldt et al.
6,790,218 B2 9/2004 Jayaraman
6,790,220 B2 9/2004 Morris et al.
6,837,893 B2 1/2005 Miller
6,837,906 B2 1/2005 Ginn
6,846,319 B2 1/2005 Ginn et al.
6,849,078 B2 2/2005 Durgin et al.
6,860,895 B1 3/2005 Akerfeldt et al.
6,890,343 B2 5/2005 Ginn et al.
6,896,687 B2 5/2005 Dakov
6,896,692 B2 5/2005 Ginn et al.
6,904,647 B2 6/2005 Byers, Jr.
6,913,607 B2 7/2005 Ainsworth et al.
6,926,723 B1 8/2005 Mulhauser et al.
6,926,731 B2 8/2005 Coleman et al.
6,929,634 B2 8/2005 Dorros et al.
6,942,641 B2 9/2005 Seddon
6,942,674 B2 9/2005 Belef et al.
6,942,691 B1 9/2005 Chuter
6,964,668 B2 11/2005 Modesitt et al.
6,969,391 B1 11/2005 Gazzani
6,969,397 B2 11/2005 Ginn
6,984,238 B2 1/2006 Gifford et al.
6,989,003 B2 1/2006 Wing et al.
6,989,016 B2 1/2006 Tallarida et al.
7,001,398 B2 2/2006 Carley et al.
7,001,400 B1 2/2006 Modesitt et al.
7,008,435 B2 3/2006 Cummins
7,008,439 B1 3/2006 Janzen et al.
7,025,776 B1 4/2006 Houser et al.
7,033,379 B2 4/2006 Peterson
7,048,747 B2 5/2006 Arcia et al.
7,060,084 B1 6/2006 Loshakove et al.
7,063,711 B1 6/2006 Loshakove et al.
7,074,232 B2 7/2006 Kanner et al.
7,076,305 B2 7/2006 Imran et al.
7,083,635 B2 8/2006 Ginn
7,087,064 B1 8/2006 Hyde
7,087,088 B2 8/2006 Berg et al.
7,094,245 B2 8/2006 Adams et al.
7,108,709 B2 9/2006 Cummins
7,108,710 B2 9/2006 Anderson
7,111,768 B2 9/2006 Cummins et al.
7,112,225 B2 9/2006 Ginn
7,122,002 B2 10/2006 Okada
7,144,411 B2 12/2006 Ginn et al.
7,147,646 B2 12/2006 Dana et al.
7,163,551 B2 1/2007 Anthony et al.
7,169,158 B2 1/2007 Sniffin et al.
7,169,164 B2 1/2007 Borillo et al.
7,175,646 B2 2/2007 Brenneman et al.
7,211,101 B2 5/2007 Carley et al.
7,220,268 B2 5/2007 Blatter
7,229,452 B2 6/2007 Kayan
7,261,716 B2 8/2007 Strobel et al.
7,270,672 B1 9/2007 Singer
7,306,614 B2 12/2007 Weller et al.
7,311,720 B2 12/2007 Mueller et al.
7,316,704 B2 1/2008 Bagaoisan et al.
7,316,706 B2 1/2008 Bloom et al.
7,322,995 B2 1/2008 Buckman et al.
7,326,230 B2 2/2008 Ravikumar
7,331,979 B2 2/2008 Khosravi et al.
7,335,220 B2 2/2008 Khosravi et al.
D566,272 S 4/2008 Walburg et al.
7,361,178 B2 4/2008 Hearn et al.
7,361,183 B2 4/2008 Ginn
7,361,185 B2 4/2008 O'Malley et al.
7,393,363 B2 7/2008 Ginn
7,396,359 B1 7/2008 Derowe et al.
7,431,727 B2 10/2008 Cole et al.
7,431,729 B2 10/2008 Chanduszko
7,445,596 B2 11/2008 Kucklick et al.
7,449,011 B2 11/2008 Wenchell et al.
7,452,327 B2 11/2008 Durgin et al.
7,462,188 B2 12/2008 McIntosh
7,465,286 B2 12/2008 Patterson et al.
7,507,200 B2 3/2009 Okada
7,533,790 B1 5/2009 Knodel et al.
7,556,632 B2 7/2009 Zadno

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,582,103	B2	9/2009	Young et al.	
7,582,104	B2	9/2009	Corcoran et al.	
7,597,706	B2	10/2009	Kanner et al.	
7,618,427	B2	11/2009	Ortiz et al.	
7,622,628	B2	11/2009	Bergin et al.	
7,632,287	B2	12/2009	Baker et al.	
7,645,285	B2	1/2010	Cosgrove et al.	
D611,144	S	3/2010	Reynolds et al.	
7,678,135	B2	3/2010	Maahs et al.	
7,727,249	B2	6/2010	Rahmani	
7,731,655	B2	6/2010	Smith et al.	
7,749,249	B2	7/2010	Gelbart et al.	
7,780,696	B2	8/2010	Daniel et al.	
7,799,042	B2	9/2010	Williamson et al.	
7,806,904	B2	10/2010	Carley et al.	
7,819,895	B2	10/2010	Ginn et al.	
7,824,419	B2	11/2010	Boraiah	
7,841,502	B2	11/2010	Walberg et al.	
7,842,068	B2	11/2010	Ginn	
7,850,709	B2	12/2010	Cummins et al.	
7,850,797	B2	12/2010	Carley et al.	
7,854,810	B2	12/2010	Carley et al.	
7,857,828	B2	12/2010	Jabba et al.	
7,867,249	B2	1/2011	Palermo et al.	
7,875,054	B2	1/2011	LaFontaine	
7,879,071	B2	2/2011	Carley et al.	
7,887,555	B2	2/2011	Carley et al.	
7,887,563	B2	2/2011	Cummins	
7,901,428	B2	3/2011	Ginn et al.	
7,905,900	B2	3/2011	Palermo et al.	
7,918,873	B2	4/2011	Cummins	
7,931,669	B2	4/2011	Ginn et al.	
7,931,671	B2	4/2011	Tenerz	
7,967,842	B2	6/2011	Bakos	
8,007,512	B2	8/2011	Ginn et al.	
8,038,688	B2	10/2011	Modesitt et al.	
8,048,108	B2 *	11/2011	Sibbitt, Jr.	A61B 17/0643 606/213
8,083,768	B2	12/2011	Ginn et al.	
8,103,327	B2	1/2012	Harlev et al.	
8,105,352	B2	1/2012	Egneloev	
8,128,644	B2	3/2012	Carley et al.	
8,172,749	B2	5/2012	Melsheimer	
8,182,497	B2	5/2012	Carley et al.	
8,192,459	B2	6/2012	Cummins et al.	
8,202,283	B2	6/2012	Carley et al.	
8,202,293	B2	6/2012	Ellingwood et al.	
8,202,294	B2	6/2012	Jabba et al.	
8,211,122	B2	7/2012	Mcintosh	
8,216,260	B2	7/2012	Lam et al.	
8,226,666	B2	7/2012	Zarbatany et al.	
8,226,681	B2	7/2012	Clark et al.	
8,236,026	B2	8/2012	Carley et al.	
8,257,390	B2	9/2012	Carley et al.	
8,303,624	B2	11/2012	Fortson	
8,313,497	B2	11/2012	Walberg et al.	
8,323,312	B2	12/2012	Clark	
8,398,656	B2	3/2013	Palermo et al.	
8,398,676	B2	3/2013	Roorda et al.	
8,403,929	B2	3/2013	Weisshaupt et al.	
8,409,228	B2	4/2013	Blatter et al.	
8,469,995	B2	6/2013	Cummins et al.	
8,475,468	B2	7/2013	Leckrone et al.	
8,486,092	B2	7/2013	Carley et al.	
8,486,108	B2	7/2013	Carley et al.	
8,491,609	B2	7/2013	Stone	
8,518,057	B2	8/2013	Walberg et al.	
8,529,587	B2	9/2013	Ellingwood et al.	
8,556,930	B2	10/2013	Ellingwood	
8,562,630	B2	10/2013	Campbell	
8,574,244	B2	11/2013	Reynolds	
8,579,932	B2	11/2013	Pantages et al.	
8,579,933	B2	11/2013	Chen et al.	
8,585,836	B2	11/2013	Carley et al.	
8,590,760	B2	11/2013	Cummins et al.	
8,597,325	B2	12/2013	Ginn	
8,603,116	B2	12/2013	Roorda	
8,603,136	B2	12/2013	Ginn	
8,617,184	B2	12/2013	Oepen	
8,657,852	B2	2/2014	Roorda et al.	
8,672,953	B2	3/2014	Reyes et al.	
8,690,910	B2	4/2014	Carley et al.	
8,728,119	B2	5/2014	Cummins	
8,758,396	B2	6/2014	Ginn et al.	
8,758,398	B2	6/2014	Carley	
8,758,399	B2	6/2014	Fortson et al.	
8,758,400	B2	6/2014	Ginn et al.	
8,784,447	B2	7/2014	Coleman et al.	
8,808,310	B2	8/2014	Jones et al.	
8,820,602	B2	9/2014	Walberg et al.	
8,821,534	B2	9/2014	Voss	
8,834,494	B2	9/2014	Schorr et al.	
8,858,594	B2	10/2014	Clark	
8,893,947	B2	11/2014	Reynolds et al.	
8,905,937	B2	12/2014	Ellingwood et al.	
8,926,633	B2	1/2015	Carly	
8,926,656	B2	1/2015	Palermo et al.	
8,956,388	B2	2/2015	Ginn et al.	
8,992,549	B2	3/2015	Bennett, III	
9,050,068	B2	6/2015	Walberg et al.	
9,050,087	B2	6/2015	Ginn et al.	
9,060,769	B2	6/2015	Coleman et al.	
9,089,311	B2	7/2015	Fortson et al.	
9,089,674	B2	7/2015	Ginn et al.	
9,149,276	B2	10/2015	Voss	
9,173,644	B2	11/2015	Voss	
9,241,696	B2	1/2016	Mehl	
9,271,707	B2	3/2016	Palermo et al.	
9,282,965	B2	3/2016	Kokish	
9,295,469	B2	3/2016	Cummins et al.	
9,314,230	B2	4/2016	Roorda et al.	
9,320,522	B2	4/2016	Carley et al.	
9,332,976	B2	5/2016	Yribarren	
9,345,460	B2	5/2016	Houser et al.	
9,364,209	B2	6/2016	Voss	
9,398,914	B2	7/2016	Ellingwood et al.	
9,402,625	B2	8/2016	Coleman et al.	
9,414,820	B2	8/2016	Voss et al.	
9,414,824	B2	8/2016	Fortson et al.	
9,486,191	B2	11/2016	Gianotti et al.	
9,498,196	B2	11/2016	Pantages et al.	
9,554,786	B2	1/2017	Carley et al.	
9,579,091	B2	2/2017	Ginn et al.	
9,585,646	B2	3/2017	Carley et al.	
9,585,647	B2	3/2017	Clark	
9,962,144	B2	5/2018	Ellingwood	
9,980,728	B2	5/2018	Cummins et al.	
10,085,753	B2	10/2018	Walberg et al.	
10,111,664	B2	10/2018	Ginn et al.	
10,201,340	B2	2/2019	Pantages et al.	
10,245,013	B2	4/2019	Carley et al.	
11,399,815	B2	8/2022	Yassinzadeh et al.	
11,439,378	B2 *	9/2022	Gianotti	A61B 17/04
2001/0021855	A1	9/2001	Levinson	
2001/0031973	A1	10/2001	Nobles et al.	
2001/0044639	A1	11/2001	Levinson	
2001/0046518	A1	11/2001	Sawhney	
2001/0047180	A1	11/2001	Grudem et al.	
2002/0022822	A1	2/2002	Cragg et al.	
2002/0026215	A1	2/2002	Redmond et al.	
2002/0026216	A1	2/2002	Grimes	
2002/0029050	A1	3/2002	Gifford et al.	
2002/0038127	A1	3/2002	Blatter et al.	
2002/0049427	A1	4/2002	Wiener et al.	
2002/0049453	A1	4/2002	Nobles et al.	
2002/0056460	A1	5/2002	Boyd et al.	
2002/0058960	A1	5/2002	Hudson et al.	
2002/0062104	A1	5/2002	Ashby et al.	
2002/0095164	A1	7/2002	Andreas et al.	
2002/0095181	A1	7/2002	Beyar	
2002/0099389	A1	7/2002	Michler et al.	
2002/0106409	A1	8/2002	Sawhney et al.	
2002/0151963	A1	10/2002	Brown et al.	
2002/0169475	A1	11/2002	Gainor et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2002/0183786 A1 12/2002 Girton
2002/0183787 A1 12/2002 Wahr et al.
2002/0188275 A1 12/2002 McGuckin
2002/0198589 A1 12/2002 Leong
2003/0004543 A1 1/2003 Gleeson et al.
2003/0009180 A1 1/2003 Hinchliffe et al.
2003/0018358 A1 1/2003 Saadat
2003/0023248 A1 1/2003 Parodi
2003/0033006 A1 2/2003 Phillips et al.
2003/0060846 A1 3/2003 Egnelov et al.
2003/0065358 A1 4/2003 Frecker et al.
2003/0083679 A1 5/2003 Grudem et al.
2003/0088269 A1 5/2003 Ashby
2003/0093108 A1 5/2003 Avellanet et al.
2003/0097140 A1 5/2003 Kanner
2003/0109890 A1 6/2003 Kanner et al.
2003/0125766 A1 7/2003 Ding
2003/0139819 A1 7/2003 Beer et al.
2003/0144695 A1 7/2003 McGuckin et al.
2003/0167063 A1 9/2003 Kerr
2003/0195504 A1 10/2003 Tallarida et al.
2003/0208211 A1 11/2003 Kortenbach
2003/0233095 A1 12/2003 Urbanski et al.
2004/0002763 A1 1/2004 Phillips et al.
2004/0009205 A1 1/2004 Sawhney
2004/0044350 A1 3/2004 Martin et al.
2004/0049224 A1 3/2004 Buehlmann et al.
2004/0059376 A1 3/2004 Breuniger
2004/0068273 A1 4/2004 Fariss et al.
2004/0078053 A1 4/2004 Berg et al.
2004/0087985 A1 5/2004 Loshakove et al.
2004/0092962 A1 5/2004 Thornton et al.
2004/0092964 A1 5/2004 Modesitt et al.
2004/0092968 A1 5/2004 Caro et al.
2004/0092973 A1 5/2004 Chanduszko et al.
2004/0093024 A1 5/2004 Lousararian et al.
2004/0093027 A1 5/2004 Fabisiak et al.
2004/0097978 A1 5/2004 Modesitt et al.
2004/0106980 A1 6/2004 Solovay et al.
2004/0127940 A1 7/2004 Ginn et al.
2004/0143261 A1 7/2004 Hartley et al.
2004/0143290 A1 7/2004 Brightbill
2004/0143291 A1 7/2004 Corcoran et al.
2004/0147957 A1 7/2004 Pierson
2004/0158287 A1 8/2004 Cragg et al.
2004/0158309 A1 8/2004 Wachter et al.
2004/0167511 A1 8/2004 Buehlmann et al.
2004/0191277 A1 9/2004 Sawhney et al.
2004/0215232 A1 10/2004 Belhe et al.
2004/0225301 A1 11/2004 Roop et al.
2004/0243216 A1 12/2004 Gregorich
2004/0249412 A1 12/2004 Snow et al.
2004/0254591 A1 12/2004 Kanner et al.
2004/0267193 A1 12/2004 Bagaoisan et al.
2004/0267308 A1 12/2004 Bagaoisan et al.
2005/0033326 A1 2/2005 Briganti et al.
2005/0038460 A1 2/2005 Jayaraman
2005/0038500 A1 2/2005 Boylan et al.
2005/0059982 A1 3/2005 Zung et al.
2005/0075654 A1 4/2005 Kelleher
2005/0075665 A1 4/2005 Brenzel et al.
2005/0085851 A1 4/2005 Fiehler et al.
2005/0085854 A1 4/2005 Ginn
2005/0085855 A1 4/2005 Forsberg
2005/0119695 A1 6/2005 Carley et al.
2005/0121042 A1 6/2005 Belhe et al.
2005/0148818 A1 7/2005 Mesallum
2005/0149066 A1 7/2005 Stafford
2005/0149117 A1 7/2005 Khosravi et al.
2005/0152949 A1 7/2005 Hotchkiss et al.
2005/0154401 A1 7/2005 Weldon et al.
2005/0165357 A1 7/2005 McGuckin et al.
2005/0169974 A1 8/2005 Tenerz et al.
2005/0177189 A1 8/2005 Ginn et al.
2005/0187564 A1 8/2005 Jayaraman
2005/0203552 A1 9/2005 Laufer et al.
2005/0222614 A1 10/2005 Ginn et al.
2005/0228405 A1 10/2005 Maruyama et al.
2005/0228443 A1 10/2005 Yassinzadeh
2005/0245876 A1 11/2005 Khosravi et al.
2005/0251202 A1 11/2005 Ewers et al.
2005/0256532 A1 11/2005 Nayak et al.
2005/0267495 A1 12/2005 Ginn et al.
2005/0267524 A1 12/2005 Chanduszko
2005/0273136 A1 12/2005 Belef et al.
2005/0273137 A1 12/2005 Ginn
2005/0283188 A1 12/2005 Loshakove et al.
2006/0034930 A1 2/2006 Khosravi et al.
2006/0047313 A1 3/2006 Khanna et al.
2006/0058844 A1 3/2006 White et al.
2006/0064115 A1 3/2006 Allen et al.
2006/0069397 A1 3/2006 Nobles et al.
2006/0089635 A1 4/2006 Young et al.
2006/0095029 A1 5/2006 Young et al.
2006/0100664 A1 5/2006 Pai et al.
2006/0106418 A1 5/2006 Seibold et al.
2006/0142784 A1 6/2006 Kontos
2006/0162509 A1 7/2006 Wang
2006/0190014 A1 8/2006 Ginn et al.
2006/0190036 A1 8/2006 Wendel et al.
2006/0190037 A1 8/2006 Ginn et al.
2006/0195125 A1 8/2006 Sakakine et al.
2006/0217744 A1 9/2006 Bender et al.
2006/0229553 A1 10/2006 Hammack et al.
2006/0253037 A1 11/2006 Ginn et al.
2006/0253072 A1 11/2006 Pai et al.
2006/0259049 A1 11/2006 Harada et al.
2006/0265012 A1 11/2006 Anderson
2006/0287673 A1 12/2006 Brett et al.
2006/0293698 A1 12/2006 Douk
2007/0005093 A1 1/2007 Cox
2007/0010851 A1 1/2007 Chanduszko et al.
2007/0027476 A1 2/2007 Harris et al.
2007/0027525 A1 2/2007 Ben-Muvhar
2007/0049668 A1 3/2007 Garner
2007/0049967 A1 3/2007 Sibbitt et al.
2007/0049968 A1 3/2007 Sibbitt et al.
2007/0049970 A1 3/2007 Belef et al.
2007/0060858 A1 3/2007 Sogard et al.
2007/0060895 A1 3/2007 Sibbitt et al.
2007/0060950 A1 3/2007 Khosravi et al.
2007/0060951 A1 3/2007 Shannon
2007/0073337 A1 3/2007 Abbott et al.
2007/0078302 A1 4/2007 Ortiz et al.
2007/0083230 A1 4/2007 Javois
2007/0083231 A1 4/2007 Lee
2007/0093869 A1 4/2007 Bloom et al.
2007/0112304 A1 5/2007 Voss
2007/0112365 A1 5/2007 Hilal et al.
2007/0112385 A1 5/2007 Conlon
2007/0123816 A1 5/2007 Zhu et al.
2007/0123817 A1 5/2007 Khosravi et al.
2007/0123936 A1 5/2007 Goldin et al.
2007/0149996 A1 6/2007 Coughlin
2007/0167981 A1 7/2007 Opolski et al.
2007/0172430 A1 7/2007 Brito et al.
2007/0179527 A1 8/2007 Eskuri et al.
2007/0185529 A1 8/2007 Coleman et al.
2007/0185530 A1 8/2007 Chin-Chen et al.
2007/0203506 A1 8/2007 Sibbitt et al.
2007/0203507 A1 8/2007 McLaughlin et al.
2007/0208376 A1 9/2007 Meng
2007/0213747 A1 9/2007 Monassevitch et al.
2007/0225755 A1 9/2007 Preinitz et al.
2007/0225756 A1 9/2007 Preinitz et al.
2007/0225757 A1 9/2007 Preinitz et al.
2007/0225758 A1 9/2007 Preinitz et al.
2007/0239209 A1 10/2007 Fallman
2007/0265658 A1 11/2007 Nelson et al.
2007/0275036 A1 11/2007 Green et al.
2007/0276488 A1 11/2007 Wachter et al.
2007/0282373 A1 12/2007 Ashby et al.
2008/0009794 A1 1/2008 Bagaoisan et al.
2008/0033459 A1 2/2008 Shafi et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0045979 A1 2/2008 Ma
2008/0058839 A1 3/2008 Nobles et al.
2008/0065151 A1 3/2008 Ginn
2008/0082123 A1 4/2008 Forsberg et al.
2008/0086075 A1 4/2008 Isik et al.
2008/0091235 A1 4/2008 Sirota
2008/0093414 A1 4/2008 Bender et al.
2008/0097509 A1 4/2008 Beyar et al.
2008/0114378 A1 5/2008 Matsushita
2008/0114395 A1 5/2008 Mathisen et al.
2008/0177288 A1 7/2008 Carlson
2008/0208225 A1 8/2008 Seibold et al.
2008/0215089 A1 9/2008 Williams et al.
2008/0215090 A1 9/2008 Gonzales et al.
2008/0243148 A1 10/2008 Mikkaichi et al.
2008/0243182 A1 10/2008 Bates et al.
2008/0249504 A1 10/2008 Lattouf et al.
2008/0262541 A1 10/2008 Sater et al.
2008/0269801 A1 10/2008 Coleman et al.
2008/0287967 A1 11/2008 Andreas et al.
2008/0287988 A1 11/2008 Smith et al.
2008/0294001 A1 11/2008 Surti
2008/0300628 A1 12/2008 Ellingwood
2008/0312667 A1 12/2008 Drasler et al.
2008/0312686 A1 12/2008 Ellingwood
2008/0312740 A1 12/2008 Wachter et al.
2009/0054912 A1 2/2009 Heanue et al.
2009/0062846 A1 3/2009 Ken
2009/0105728 A1 4/2009 Noda et al.
2009/0112306 A1 4/2009 Bonsignore et al.
2009/0132031 A1 5/2009 Cook et al.
2009/0137900 A1 5/2009 Bonner et al.
2009/0157101 A1 6/2009 Reyes et al.
2009/0171388 A1 7/2009 Dave et al.
2009/0187215 A1 7/2009 Mackiewicz et al.
2009/0216267 A1 8/2009 Willard et al.
2009/0221960 A1 9/2009 Albrecht et al.
2009/0227938 A1 9/2009 Fasching et al.
2009/0230168 A1 9/2009 Coleman et al.
2009/0254119 A1 10/2009 Sibbitt et al.
2009/0259233 A1 10/2009 Bogart et al.
2009/0281555 A1 11/2009 Stone
2009/0312789 A1 12/2009 Kassab et al.
2010/0042118 A1 2/2010 Garrison et al.
2010/0042144 A1 2/2010 Bennett
2010/0114119 A1 5/2010 Mclawhorn et al.
2010/0130965 A1 5/2010 Sibbitt et al.
2010/0179567 A1 7/2010 Voss et al.
2010/0179589 A1 7/2010 Roorda et al.
2010/0185216 A1 7/2010 Garrison et al.
2010/0185234 A1 7/2010 Fortson et al.
2010/0249828 A1 9/2010 Mavani et al.
2010/0262166 A1 10/2010 Boraiah et al.
2011/0054492 A1 3/2011 Clark
2011/0066163 A1 3/2011 Cho et al.
2011/0082495 A1 4/2011 Ruiz
2011/0137340 A1 6/2011 Cummins
2011/0178548 A1 7/2011 Tenerz
2011/0190793 A1 8/2011 Nobles et al.
2011/0218568 A1 9/2011 Voss
2011/0270282 A1 11/2011 Lemke
2012/0101520 A1 4/2012 Ginn et al.
2012/0245623 A1 9/2012 Kariniemi et al.
2013/0053792 A1 2/2013 Fischell et al.
2013/0165956 A1 6/2013 Sherts et al.
2013/0178872 A1 7/2013 Shriver
2013/0310853 A1 11/2013 Zaugg et al.
2014/0039549 A1 2/2014 Belsky et al.
2014/0081318 A1 3/2014 Houser et al.
2015/0080914 A1 3/2015 Roundy et al.
2015/0190071 A1 7/2015 Ellingwood et al.
2016/0000417 A1 1/2016 Voss
2016/0120546 A1 5/2016 Roundy et al.
2016/0151057 A1 6/2016 Voss
2016/0213357 A1 7/2016 Mehl
2017/0020496 A1 1/2017 Yribarren
2017/0020517 A1 1/2017 Coleman et al.
2018/0256166 A1 9/2018 Cummins et al.
2018/0325506 A1 11/2018 Ellingwood
2019/0117205 A1 4/2019 Kokish
2019/0117207 A1 4/2019 Carley et al.
2019/0350569 A1 11/2019 Palermo et al.
2020/0138423 A1 5/2020 Voss
2020/0138424 A1 5/2020 Gianotti et al.

FOREIGN PATENT DOCUMENTS

CA 2339060 A1 2/2000
DE 19711288 A1 10/1998
DE 29723736 U1 2/1999
DE 19859952 A1 2/2000
DE 102006056283 A1 6/2008
EP 0386361 A1 9/1990
EP 0534696 A1 3/1993
EP 0621032 A1 10/1994
EP 0744237 A1 11/1996
EP 0756851 A2 2/1997
EP 0774237 A2 5/1997
EP 0858776 A2 8/1998
EP 0941697 A1 9/1999
EP 1867287 A2 12/2007
FR 2443238 A1 7/1980
FR 2715290 A1 7/1995
FR 2722975 A1 2/1996
FR 2768324 A1 3/1999
GB 1358466 A 7/1974
GB 2075144 A 11/1981
GB 2397240 A 7/2004
IE 58-181006 U 12/1983
IE 2000/0722 10/2001
IE 2000/0724 10/2001
IE 2001/0547 7/2002
IE 2001/0815 7/2002
IE 2001/0748 8/2002
IE 2001/0749 8/2002
IE 2002/0452 12/2002
IE 2002/0664 2/2003
IE 2002/0665 2/2003
IE 2002/0451 7/2003
IE 2002/0552 7/2003
IE 2003/0424 12/2003
IE 2003/0490 1/2004
IE 2004/0368 11/2005
IE 2005/0342 11/2005
JP 01-274750 A 11/1989
JP 01-275750 A 11/1989
JP 09-218875 A 8/1997
JP 11-500642 A 1/1999
JP 2000-102546 A 4/2000
NL 9302140 A 7/1995
PL 171425 B1 4/1997
RU 2086192 C1 8/1997
SU 0197801 6/1967
SU 0495067 A1 12/1975
SU 0912155 A1 3/1982
SU 1243708 A1 7/1986
SU 1324650 A1 7/1987
SU 1405828 A1 6/1988
SU 1456109 A1 2/1989
SU 1560133 A1 4/1990
WO 95/21573 A1 8/1995
WO 96/24291 A1 8/1996
WO 97/00046 A1 1/1997
WO 97/07741 A1 3/1997
WO 97/20505 A1 6/1997
WO 97/27897 A1 8/1997
WO 97/28745 A1 8/1997
WO 98/06346 A1 2/1998
WO 98/06448 A1 2/1998
WO 98/16161 A1 4/1998
WO 98/17179 A1 4/1998
WO 98/18389 A1 5/1998
WO 98/24374 A1 6/1998
WO 98/25508 A2 6/1998

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	98/58591	A1	12/1998
WO	99/21491	A1	5/1999
WO	99/40849	A1	8/1999
WO	99/60941	A1	12/1999
WO	99/62408	A1	12/1999
WO	99/62415	A1	12/1999
WO	00/06029	A1	2/2000
WO	00/07505	A1	2/2000
WO	00/07640	A2	2/2000
WO	00/27311	A1	5/2000
WO	00/27313	A2	5/2000
WO	00/56223	A1	9/2000
WO	00/56227	A1	9/2000
WO	00/56228	A1	9/2000
WO	00/71032	A2	11/2000
WO	01/21058	A2	3/2001
WO	01/35832	A2	5/2001
WO	01/47594	A1	7/2001
WO	01/49186	A2	7/2001
WO	01/91628	A2	12/2001
WO	02/19915	A1	3/2002
WO	02/19920	A1	3/2002
WO	02/19922	A1	3/2002
WO	02/19924	A1	3/2002
WO	02/28286	A1	4/2002
WO	02/38055	A2	5/2002
WO	02/45593	A2	6/2002
WO	02/45594	A2	6/2002
WO	02/62234	A2	8/2002
WO	02/98302	A1	12/2002
WO	03/13363	A1	2/2003
WO	03/13364	A1	2/2003
WO	03/47434	A1	6/2003
WO	03/71955	A2	9/2003
WO	03/71956	A2	9/2003
WO	03/71957	A2	9/2003
WO	03/94748	A1	11/2003
WO	2003/101310	A1	12/2003
WO	2004/004578	A1	1/2004
WO	2004/012602	A2	2/2004
WO	2004/060169	A2	7/2004
WO	2004/069054	A2	8/2004
WO	2005/000126	A2	1/2005
WO	2005/006990	A2	1/2005
WO	2005/041782	A2	5/2005
WO	2005/063129	A2	7/2005
WO	2005/082256	A1	9/2005
WO	2005/092204	A2	10/2005
WO	2005/110240	A1	11/2005
WO	2005/112782	A1	12/2005
WO	2005/115251	A1	12/2005
WO	2005/115521	A1	12/2005
WO	2006/000514	A1	1/2006
WO	2006/026116	A1	3/2006
WO	2006/052611	A1	5/2006
WO	2006/052612	A1	5/2006
WO	2006/078578	A2	7/2006
WO	2006/083889	A1	8/2006
WO	2006/115901	A1	11/2006
WO	2006/115904	A2	11/2006
WO	2006/118877	A2	11/2006
WO	2007/005585	A2	1/2007
WO	2007/025014	A2	3/2007
WO	2007/025017	A2	3/2007
WO	2007/025018	A2	3/2007
WO	2007/025019	A2	3/2007
WO	2007/081836	A1	7/2007
WO	2007/088069	A1	8/2007
WO	2008/031102	A1	3/2008
WO	2008/036384	A2	3/2008
WO	2008/074027	A1	6/2008
WO	2008/150915	A1	12/2008
WO	2009/079091	A1	6/2009
WO	2010/031050	A1	3/2010
WO	2010/062693	A2	6/2010
WO	2010/081101	A2	7/2010
WO	2010/081102	A2	7/2010
WO	2010/081103	A1	7/2010
WO	2010/081106	A1	7/2010
ZA	200100527		1/2001
ZA	200100528		1/2001

OTHER PUBLICATIONS

U.S. Appl. No. 11/508,656, mail date Mar. 25, 2010, Office Action.
U.S. Appl. No. 11/508,662, mail date Apr. 14, 2010, Office Action.
U.S. Appl. No. 11/508,662, filed Oct. 26, 2010, Office Action.
U.S. Appl. No. 11/891,358, filed Apr. 26, 2010, Office Action.
U.S. Appl. No. 12/684,470, filed Jan. 21, 2016, Office Action.
U.S. Appl. No. 12/684,470, filed Jun. 4, 2014, Office Action.
U.S. Appl. No. 12/684,470, Mail Date Aug. 26, 2015, Office Action.
U.S. Appl. No. 13/052,634, filed Apr. 22, 2013, Office Action.
U.S. Appl. No. 13/052,634, filed Feb. 8, 2013, Office Action.
U.S. Appl. No. 13/052,634, filed Nov. 8, 2013, Office Action.
U.S. Appl. No. 13/308,227, filed Dec. 2, 2013, Interview Summary.
U.S. Appl. No. 13/615,547, filed Apr. 12, 2013, Notice of Allowance.
U.S. Appl. No. 29/230,479, Notices of Allowance, Mail Date Aug. 24, 2006.
U.S. Application filed Apr. 30, 2008, by Ginn et al., U.S. Appl. No. 12/113,092.
U.S. Application filed Jan. 31, 2011, by Carley et al., U.S. Appl. No. 13/017,636.
U.S. Patent Application filed Apr. 18, 2016, by Roorda et al., U.S. Appl. No. 15/131,786.
U.S. Provisional Application filed Apr. 20, 2006, by Jones et al., U.S. Appl. No. 60/793,444.
U.S. Provisional Application filed Aug. 24, 2005, by Sibbitt Jr. et al., U.S. Appl. No. 60/711,279.
U.S. Provisional Application filed Dec. 19, 2007, by Mackiewicz et al., U.S. Appl. No. 61/015,144.
U.S. Provisional Application filed Dec. 22, 2008, by Clark, U.S. Appl. No. 61/139,995.
U.S. Provisional Application filed Dec. 30, 2008, by Clark, U.S. Appl. No. 61/141,597.
U.S. Provisional Application filed Jan. 9, 2009, by Mehl et al., U.S. Appl. No. 61/143,748.
U.S. Provisional Application filed Jan. 9, 2009, by Voss et al., U.S. Appl. No. 61/143,751.
U.S. Provisional Application filed Jan. 16, 2009, by Fortson, et al., U.S. Appl. No. 61/145,468.
U.S. Provisional Application filed Jul. 1, 2005, by Pantages et al., U.S. Appl. No. 60/696,069.
U.S. Provisional Application filed Jun. 24, 2005, by Carly, U.S. Appl. No. 60/693,531.
U.S. Provisional Application filed Jun. 25, 2007, by Ellingwood et al., U.S. Appl. No. 60/946,042.
U.S. Provisional Application filed Jun. 25, 2007, by Ellingwood, U.S. Appl. No. 60/946,026.
U.S. Provisional Application filed Jun. 25, 2007, by Voss et al., U.S. Appl. No. 60/946,030.
U.S. Provisional Application filed May 25, 2001 by Ginn., U.S. Appl. No. 09/866,551.
U.S. Provisional Application filed Oct. 14, 2005, by Sibbitt Jr. et al., U.S. Appl. No. 60/726,985.
U.S. Provisional Application filed Oct. 30, 2008, by Mehl et al., U.S. Appl. No. 61/109,822.
U.S. Provisional Application filed Sep. 15, 2008, by Sibbitt Jr. et al., U.S. Appl. No. 61/097,072.
Ut Aker et al., Immediate arterial hemostasis after cardiac catheterization: initial experience with a new puncture closure device, Cathet Cardiovasc Diagn, Mar. 1994, pp. 228-232, vol. 33—No. 3, Missouri Baptist Medical Center, St. Louis.
Watelet et al., Percutaneous repair of aortic aneurysms: a prospective study of suture-mediated closure devices, European journal of vascular and endovascular surgery, vol. 32, No. 3, 2006, p. 261-265.
Wei Qu et al., An absorbable pinned-ring device for microvascular anastomosis of vein grafts: Experimental studies, Microsurgery

(56) **References Cited**

OTHER PUBLICATIONS

1999, Mar. 1999, pp. 128-134, vol. 19—No. 3, Department of Orthopaedic Surgery, Hiroshima University School of Medicine, Hiroshima, Japan.

William G. Kussmaul III MD, et al., Rapid arterial hemostasis and decreased access site complications after cardiac catheterization and angioplasty: Results of a randomized trial of a novel hemostatic device, Journal of the American College of Cardiology, Jun. 1995, pp. 1685-1692, vol. 25—No. 7.

Office Action received for U.S. Appl. No. 14/077,007, filed Jan. 29, 2016.

Office Action received for U.S. Appl. No. 14/077,007, filed Jul. 27, 2015.

Office Action received for U.S. Appl. No. 14/246,926, filed Aug. 5, 2015.

Office Action received for U.S. Appl. No. 14/246,926, filed Jun. 15, 2016.

Office Action received for U.S. Appl. No. 14/246,926, filed Nov. 23, 2015.

Office Action received for U.S. Appl. No. 14/246,973, filed Aug. 3, 2015.

Office Action received for U.S. Appl. No. 14/246,973, filed Jul. 7, 2016.

Office Action received for U.S. Appl. No. 14/246,973, filed Nov. 24, 2015.

Office Action received for U.S. Appl. No. 14/312,339, filed Aug. 28, 2017.

Office Action received for U.S. Appl. No. 14/312,339, filed Dec. 28, 2017.

Office Action received for U.S. Appl. No. 14/312,339, filed Jan. 22, 2016.

Office Action received for U.S. Appl. No. 14/312,339, filed Jan. 31, 2017.

Office Action received for U.S. Appl. No. 14/312,339, filed May 3, 2016.

Office Action received for U.S. Appl. No. 14/312,339, filed May 23, 2017.

Office Action received for U.S. Appl. No. 14/323,753, mailed on Nov. 3, 2015.

Office Action received for U.S. Appl. No. 14/466,576, mailed on Jul. 8, 2015.

Office Action received for U.S. Appl. No. 14/539,830, filed Jan. 29, 2016.

Office Action received for U.S. Appl. No. 14/539,830, filed Jul. 26, 2016.

Office Action received for U.S. Appl. No. 14/732,977, filed Sep. 26, 2017.

Office Action received for U.S. Appl. No. 14/839,658, filed May 30, 2017.

Office Action received for U.S. Appl. No. 14/839,658, filed Sep. 19, 2017.

Office Action received for U.S. Appl. No. 14/855,080, filed Apr. 2, 2018.

Office Action received for U.S. Appl. No. 14/855,080, filed Apr. 15, 2019.

Office Action received for U.S. Appl. No. 14/855,080, filed Sep. 21, 2018.

Office Action received for U.S. Appl. No. 14/928,950, filed Mar. 30, 2018.

Office Action received for U.S. Appl. No. 14/928,950, filed Sep. 26, 2017.

Office Action received for U.S. Appl. No. 15/056,281, filed Feb. 5, 2018.

Office Action received for U.S. Appl. No. 15/056,281, filed Jan. 14, 2019.

Office Action received for U.S. Appl. No. 15/056,281, filed Jun. 13, 2018.

Office Action received for U.S. Appl. No. 15/056,281, filed Sep. 19, 2018.

Office Action received for U.S. Appl. No. 15/069,230, filed Aug. 7, 2018.

Office Action received for U.S. Appl. No. 15/069,230, filed Feb. 15, 2018.

Office Action received for U.S. Appl. No. 15/069,230, filed Mar. 19, 2019.

Office Action received for U.S. Appl. No. 15/142,106, filed Feb. 13, 2019.

Office Action received for U.S. Appl. No. 15/142,106, filed Sep. 7, 2018.

Office Action received for U.S. Appl. No. 15/142,106, mailed on Jun. 13, 2019.

Office Action received for U.S. Appl. No. 15/149,784, mailed on May 11, 2017.

Office Action received for U.S. Appl. No. 15/222,397, mailed on Jan. 23, 2017.

Office Action received for U.S. Appl. No. 15/344,978, filed Dec. 10, 2018.

Office Action received for U.S. Appl. No. 15/356,028, filed Aug. 29, 2018.

Office Action received for U.S. Appl. No. 15/356,028, filed Feb. 22, 2018.

Office Action received for U.S. Appl. No. 15/419,335, filed Aug. 13, 2018.

Office Action received for U.S. Appl. No. 15/946,071, mailed on Mar. 25, 2020.

Office Action received for U.S. Appl. No. 15/976,425, mailed on Jun. 22, 2020.

Office Action received for U.S. Appl. No. 15/976,425, mailed on Mar. 6, 2020.

Office Action received for U.S. Appl. No. 29/296,370, mailed on Aug. 18, 2008.

Office Action received for U.S. Pat. No. 6,632,238, mailed on Feb. 26, 2003.

Office Action received for U.S. Appl. No. 10/240,183, mailed on Dec. 17, 2004.

Office Action received for U.S. Appl. No. 10/682,459, mailed on Oct. 12, 2010.

Advisory Action received for U.S. Appl. No. 09/732,178, mailed on Jun. 10, 2003.

Advisory Action received for U.S. Appl. No. 12/106,928, filed Mar. 25, 2014.

Advisory Action received for U.S. Appl. No. 12/961,331, mailed on Sep. 20, 2013.

Advisory Action received for U.S. Appl. No. 15/056,281, filed Aug. 27, 2018.

Advisory Action received for U.S. Appl. No. 15/069,230, mailed on Oct. 22, 2018.

Amir Loshakove, et al., "Vascular Closure Device", PCT Publication No. WO 00/56223, Sep. 28, 2000.

Carpenter et al, Midterm results of the multicenter trial of the Powerlink bifurcated system for endovascular aortic aneurysm repair, Journal of Vascular Surgery, vol. 40, No. 5, Nov. 2004, p. 849-859.e5.

Database WPI; Section PQ, Week 200120; Derwent Publications Ltd., London GB; AN 2001-203165; XP002199926 & ZA 200 100 528 A (Anthony T), Feb. 28, 2001 (Feb. 28, 2001) abstract.

Deepak Mital et al, Renal Transplantation Without Sutures Using The Vascular Clipping System For Renal Artery and Vein Anastomosis—A New Technique, Transplantation Issue, Oct. 1996, pp. 1171-1173, vol. 62—No. 8, Section of Transplantation Surgery, Department of General Surgery, Rush-Presbyterian/St. Luke's Medical Center, Chiqaqo, IL.

DL Wessel et al, Outpatient closure of the patent ductus arteriosus, Circulation, May 1988, pp. 1068-1071, vol. 77—No. 5, Department of Anesthesia, Children's Hospital, Boston, MA.

E Pikoulis et al, Arterial reconstruction with vascular clips is safe and quicker than sutured repair, Cardiovascular Surgery, Dec. 1998, pp. 573-578(6), vol. 6—No. 6, Department of Surgery, Uniformed Services University of the Health Sciences, Bethesda, MD.

Eisenack et al, Percutaneous Endovascular Aortic Aneurysm Repair: A Prospective Evaluation of Safety, Efficiency, and Risk Factors, Journal of Endovascular Ther., 2009, vol. 16, p. 708-713.

(56) **References Cited**

OTHER PUBLICATIONS

Examiner's Amendment received for U.S. Appl. No. 10/435,104, mailed on Jan. 3, 2006.
G Gershony et al, Novel vascular sealing device for closure of percutaneous vascular access sites, Cathet. Cardiovasc. Diagn., Jan. 1998, pp. 82-88, vol. 45.
Greenhalgh et al, Endovascular versus open repair of abdominal aortic aneurysm, The New England journal of medicine, vol. 362, No. 20, 2010, p. 1863-1871.
Grossman, W., Cardiac Catheterization and Angiography, 3rd Ed., Lea & Febiger, Philadelphia, pp. 1-49, 52-247. 1986.
H De Swart et al, A new hemostatic puncture closure device for the immediate sealing of arterial puncture sites, American journal of cardiology, Aug. 1993, pp. 445-449, vol. 72—No. 5, Department of Cardiology, Academic Hospital Maastricht, The Netherlands.
Hand tool for forming telephone connections—comprises pliers with reciprocably driven ram crimping clip around conductors against anvil, Derwent-ACC-No. 1978-B8090A. (Jan. 10, 1978).
Harrith M. Hasson M.D. , Laparoscopic Cannula Cone with Means for Cannula Stabilization and Wound Closure, The Journal of the American Association of Gynecologic Laparoscopists, May 1998, pp. 183-185, vol. 5—No. 2, Division of Obstetrics and Gynecology, University of Chicago, Chigago, IL.
Howell et al, Percutaneous Repair of Abdominal Aortic Aneurysms Using the aneuRx Stent Graft and the Percutaneous Vascular Surgery Device, Catheterization and cardiovascular interventions, vol. 55, No. 3, 2002, p. 281-287.
https://www.thefreedictionary.com/flex, retrieved Sep. 2, 2018, definition of the term flex.
https://www.thefreedictionary.com/integral, retrieved Aug. 20, 2018, definition of the term integral.
Inlet Medical Inc. Brochure, pp. 1-2, referencing Om Elashry et al., Comparative clinical study of port-closure techniques following laparoscopic surgery, Depatiment of Surgery, Mallickrodt Institute of Radiography, J Am Coll Surg., Oct. 1996, pp. 335-344, vol. 183—No. 4.
Interview Summary received for U.S. Appl. No. 12/724,304, filed Mar. 13, 2012.
Interview Summary received for U.S. Appl. No. 14/928,950, mailed on Jun. 4, 2018.
Interview Summary received for U.S. Appl. No. 15/069,230, filed May 1, 2019.
Interview Summary received for U.S. Appl. No. 15/419,335, filed Oct. 1, 2018.
J. Findlay et al, Carotid Arteriotomy Closure Using a Vascular Clip System, Neurosurgery, Mar. 1998, pp. 550-554, vol. 42—No. 3, Division of Neurosurgery, University of Alberta, Edmonton, Canada.
Jean-Baptiste et al., Percutaneous closure devices for endovascular repair of infrarenal abdominal aortic aneurysms: a prospective, non-randomized comparative study, European Journal of Vascular and Endovascular Surgery, vol. 35, No. 4, 2008, p. 422-428.
Jeremy L Gilbert PhD, Wound Closure Biomaterials and Devices, Shock., Mar. 1999, p. 226, vol. 11—No. 3, Institution Northwestern University (editorial review).
Jochen T. Cremer, MD, et al., Different approaches for minimally invasive closure of atrial septal defects, Ann. Thorac. Surg., Nov. 1998, pp. 1648-1652, vol. 67, a Division of Thoracic and Cardiovascular Surgery, Surgical Center, Hannover Medical School. Hannover, Germany.
K Narayanan et al., Simultaneous primary closure of four fasciotomy wounds in a single setting using the Sure-Closure device, Injury, Jul. 1996, pp. 449-451, vol. 27—No. 6, Department of Surgery, Mercy Hospital of Pittsburgh, PA.
Krajcer and Gregoric, Totally percutaneous aortic aneurysm repair: methods and outcomes using the fully integrated IntuiTrak endovascular system, The Journal of cardiovascular surgery, vol. 51, No. 4, 2010, p. 493-501.
Lederle et al, Outcomes foilowing endovascular vs open repair of abdominal aortic aneurysm: a randomized trial, Jama, vol. 302, No. 14, 2009, p. 1535-1542.
Lee et al, Total percutaneous access for endovascular aortic aneurysm repair ("Preclose" technique), Journal of vascular surgery, vol. 45, No. 6, 2007, p. 1095-1101.
Malkawi et al, Percutaneous access for endovascular aneurysm repair: a systematic review, European Journal of Vascular and Endovascular Surgery, vol. 39, No. 6, 2010, p. 676-682.
Marshall, AC. & Lock, J.E.; "Structural and compliant anatomy of the patent foramen ovale in patients undergoing transcatheter closure", Am. Heart Journ., 140(2):303-307, Aug. 2000.
McCarthy, et al., "Tension (Stay) Suture Bridge", J. of International College of Surgeons, 34(5), pp. 613-614 (Nov. 1960).
MD Gonze et al, Complications associated with percutaneous closure devices, Conference: Annual Meeting of the Society for Clinical Vascular Surgery, The American journal of surgery, Mar. 1999, pp. 209-211, vol. 178, No. 3, Department of Surgery, Section of Vascular Surgery, Ochsner Medical Institutions, New Orleans, LA.
MD Hellinger et al, Effective peritoneal and fascial closure of abdominal trocar sites utilizing the Endo-Judge, J Laparoendosc Surg., Oct. 1996, pp. 329-332, vol. 6—No. 5, Orlando Regional Medical Center, FL.
Michael Gianturco, A Play on Catheterization, Forbes, Dec. 1996, p. 146, vol. 158—No. 15.
Morasch et al., Percutaneous repair of abdominal aortic aneurysm, Journal of vascular surgery, vol. 40, No. 1, 2004, p. 12-16.
Nakamura, S. et al., Techniques for Palmaz-Schatz Stent Deployment in Lesions With a Large Side Branch, Catherterization and Cardiovascular Diagnosis, 34: 353-361, 1995.
Notice of Allowance received for U.S. Appl. No. 09/478,179, mailed on Nov. 6, 2000.
Notice of Allowance received for U.S. Appl. No. 09/546,998, mailed on May 6, 2002.
Notice of Allowance received for U.S. Appl. No. 09/610,238, mailed on Feb. 11, 2002.
Notice of Allowance received for U.S. Appl. No. 09/610,238, mailed on Mar. 26, 2001.
Notice of Allowance received for U.S. Appl. No. 09/680,837, mailed on Jun. 16, 2003.
Notice of Allowance received for U.S. Appl. No. 09/732,178, mailed on Nov. 17, 2003.
Notice of Allowance received for U.S. Appl. No. 09/732,835, mailed on Mar. 17, 2004.
Thomas P. Baum RPA-C et al, Delayed Primary Closure Using Silastic Vessel and Skin Staples: Description of Technique and Case Reports, Annals of Plastic and Reconstructive Surgery, Albert Einstein College of Medicine and Montefiore Medical Center, Bronx, NY, Mar. 1999.
Thomas P. Baum RPA-C et al, Delayed Primary Closure Using Silastic Vessel Loops and Skin Staples: Description of the Technique and Case Reports, Annals of Plastic Surgery, Mar. 1999, pp. 337-340, vol. 42—No. 3, Institution Department of Plastic and Reconstructive Surgery, Albert Einstein College of Medicine and Montefiore Medical Center, Bronx, NY.
Tomoaki Hinohara, Percutaneous vascular surgery (Prostar® Plus and Techstar® for femoral artery site closure), Interventional Cardiology Newsletter, May-Jul. 1997, pp. 19-22, pp. 24-28, vol. 5—No. 3-4.
Torsello et al, Endovascular suture versus cutdown for endovascular aneurysm repair: a prospective randomized pilot study, Journal of vascular surgery, vol. 38, No. 1, 2003, p. 78-82.
Traul et al., Percutaneous endovascular repair of infrarenal abdominal aortic aneurysms: a feasibility study, Journal of vascular surgery, vol. 32, No. 4, 2000, p. 770-776.
Turn-macmillandictionary.com/dictionary.american/turn.
U.S. Appl. filed Dec. 30, 2008, Clark., U.S. Appl. No. 61/481,377.
U.S. Appl. filed Jan. 21, 2011, Von Oepen et al., U.S. Appl. No. 13/011,850.
U.S. Appl. filed Jul. 1, 2005, Pantages et al., U.S. Appl. No. 60/696,096.
U.S. Appl. filed Jul. 5, 2000, Kerievsky., U.S. Appl. No. 09/610,128.
U.S. Appl. filed Jun. 18, 2012, Carley et al., U.S. Appl. No. 13/525,718.

(56) **References Cited**

OTHER PUBLICATIONS

Office Action received for U.S. Appl. No. 10/240,183, mailed on Jul. 27, 2004.
Office Action received for U.S. Appl. No. 10/264,306, mailed on Aug. 13, 2009.
Office Action received for U.S. Appl. No. 10/264,306, mailed on Feb. 9, 2005.
Office Action received for U.S. Appl. No. 10/264,306, mailed on Feb. 26, 2009.
Office Action received for U.S. Appl. No. 10/264,306, mailed on Jan. 27, 2010.
Office Action received for U.S. Appl. No. 10/264,306, mailed on Jun. 15, 2010.
Office Action received for U.S. Appl. No. 10/264,306, mailed on Jun. 27, 2008.
Office Action received for U.S. Appl. No. 10/264,306, mailed on Oct. 4, 2005.
Office Action received for U.S. Appl. No. 10/335,075, mailed on Apr. 21, 2006.
Office Action received for U.S. Appl. No. 10/335,075, mailed on Aug. 10, 2005.
Office Action received for U.S. Appl. No. 10/335,075, mailed on Dec. 19, 2005.
Office Action received for U.S. Appl. No. 10/356,214, mailed on Apr. 29, 2009.
Office Action received for U.S. Appl. No. 10/356,214, mailed on Aug. 23, 2006.
Office Action received for U.S. Appl. No. 10/356,214, mailed on Feb. 13, 2007.
Office Action received for U.S. Appl. No. 10/356,214, mailed on Mar. 6, 2008.
Office Action received for U.S. Appl. No. 10/356,214, mailed on Nov. 4, 2008.
Office Action received for U.S. Appl. No. 10/356,214, mailed on Nov. 30, 2005.
Office Action received for U.S. Appl. No. 10/356,214, mailed on Sep. 12, 2007.
Office Action received for U.S. Appl. No. 10/435,104, mailed on Jun. 2, 2010.
Office Action received for U.S. Appl. No. 10/435,104, mailed on Jun. 10, 2004.
Office Action received for U.S. Appl. No. 10/435,104, mailed on May 16, 2006.
Office Action received for U.S. Appl. No. 10/455,768, mailed on Nov. 16, 2004.
Office Action received for U.S. Appl. No. 10/486,067, mailed on Jan. 10, 2006.
Office Action received for U.S. Appl. No. 10/486,070, mailed on Apr. 20, 2005.
Office Action received for U.S. Appl. No. 10/486,070, mailed on Aug. 10, 2005.
Office Action received for U.S. Appl. No. 10/517,004, mailed on Aug. 13, 2007.
Office Action received for U.S. Appl. No. 10/517,004, mailed on Jan. 30, 2008.
Office Action received for U.S. Appl. No. 10/519,778, mailed on Feb. 23, 2006.
Office Action received for U.S. Appl. No. 10/541,083, mailed on May 5, 2008.
Office Action received for U.S. Appl. No. 10/541,083, mailed on Oct. 16, 2007.
Office Action received for U.S. Appl. No. 10/541,083, mailed on Oct. 31, 2007.
Office Action received for U.S. Appl. No. 10/616,832, mailed on Jan. 22, 2008.
Office Action received for U.S. Appl. No. 10/616,832, mailed on Jul. 21, 2009.
Office Action received for U.S. Appl. No. 10/616,832, mailed on Jun. 30, 2006.
Office Action received for U.S. Appl. No. 10/616,832, mailed on May 29, 2007.
Office Action received for U.S. Appl. No. 10/616,832, mailed on Oct. 20, 2006.
Office Action received for U.S. Appl. No. 10/616,832, mailed on Sep. 17, 2008.
Office Action received for U.S. Appl. No. 10/617,090, mailed on Mar. 22, 2005.
Office Action received for U.S. Appl. No. 10/638,115, mailed on Feb. 7, 2008.
Office Action received for U.S. Appl. No. 10/638,115, mailed on Jan. 31, 2007.
Office Action received for U.S. Appl. No. 10/638,115, mailed on Oct. 29, 2008.
Office Action received for U.S. Appl. No. 10/638,115, mailed on Sep. 18, 2007.
Office Action received for U.S. Appl. No. 10/667,144, mailed on Dec. 5, 2007.
Office Action received for U.S. Appl. No. 10/667,144, mailed on Jun. 6, 2011.
Office Action received for U.S. Appl. No. 10/667,144, mailed on Jun. 22, 2010.
Office Action received for U.S. Appl. No. 10/667,144, mailed on Mar. 24, 2009.
Office Action received for U.S. Appl. No. 10/667,144, mailed on May 2, 2007.
Office Action received for U.S. Appl. No. 10/667,144, mailed on May 12, 2008.
Office Action received for U.S. Appl. No. 10/667,144, mailed on Nov. 19, 2007.
Office Action received for U.S. Appl. No. 10/667,144, mailed on Nov. 23, 2009.
Office Action received for U.S. Appl. No. 10/667,144, mailed on Sep. 19, 2006.
Office Action received for U.S. Appl. No. 10/669,313, mailed on Oct. 31, 2005.
Office Action received for U.S. Appl. No. 10/682,459, mailed on Apr. 2, 2008.
Office Action received for U.S. Appl. No. 10/682,459, mailed on Apr. 28, 2010.
Office Action received for U.S. Appl. No. 10/682,459, mailed on Dec. 4, 2008.
Office Action received for U.S. Appl. No. 10/682,459, mailed on Dec. 23, 2009.
Office Action received for U.S. Appl. No. 10/682,459, mailed on Jun. 10, 2009.
Office Action received for U.S. Appl. No. 10/786,444, mailed on Apr. 17, 2007.
Office Action received for U.S. Appl. No. 10/786,444, mailed on Aug. 31, 2007.
Office Action received for U.S. Appl. No. 10/786,444, mailed on Jan. 14, 2010.
Office Action received for U.S. Appl. No. 10/786,444, mailed on Jun. 18, 2009.
Office Action received for U.S. Appl. No. 10/786,444, mailed on Oct. 17, 2008.
Office Action received for U.S. Appl. No. 10/786,444, mailed on Oct. 30, 2006.
Office Action received for U.S. Appl. No. 10/787,073, mailed on Aug. 13, 2009.
Office Action received for U.S. Appl. No. 10/787,073, mailed on Feb. 22, 2008.
Office Action received for U.S. Appl. No. 10/787,073, mailed on Nov. 12, 2008.
Office Action received for U.S. Appl. No. 10/787,073, mailed on Nov. 30, 2006.
Office Action received for U.S. Appl. No. 10/787,073, mailed on Sep. 5, 2007.
Office Action received for U.S. Appl. No. 10/908,721, filed Jan. 25, 2008.
Office Action received for U.S. Appl. No. 10/908,721, mailed on Aug. 10, 2007.

(56) **References Cited**

OTHER PUBLICATIONS

Office Action received for U.S. Appl. No. 10/908,721, mailed on Feb. 2, 2010.
Office Action received for U.S. Appl. No. 10/908,721, mailed on Jun. 23, 2009.
Office Action received for U.S. Appl. No. 10/908,721, mailed on Nov. 25, 2008.
Office Action received for U.S. Appl. No. 10/908,721, mailed on Oct. 19, 2006.
Office Action received for U.S. Appl. No. 11/048,503, mailed on Jun. 26, 2009.
Office Action received for U.S. Appl. No. 11/048,503, mailed on Mar. 13, 2009.
Office Action received for U.S. Appl. No. 11/113,549, mailed on Apr. 16, 2008.
Office Action received for U.S. Appl. No. 11/113,549, mailed on Feb. 6, 2007.
Office Action received for U.S. Appl. No. 11/113,549, mailed on Jan. 4, 2011.
Office Action received for U.S. Appl. No. 11/113,549, mailed on Jul. 6, 2010.
Office Action received for U.S. Appl. No. 11/113,549, mailed on Jul. 21, 2009.
Office Action received for U.S. Appl. No. 11/113,549, mailed on May 30, 2007.
Office Action received for U.S. Appl. No. 11/113,549, mailed on Nov. 9, 2007.
Office Action received for U.S. Appl. No. 11/152,562, mailed on Feb. 13, 2009.
Office Action received for U.S. Appl. No. 11/152,562, mailed on Jul. 6, 2009.
Office Action received for U.S. Appl. No. 11/152,562, mailed on Mar. 31, 2010.
Office Action received for U.S. Appl. No. 11/152,562, mailed on May 13, 2008.
Office Action received for U.S. Appl. No. 11/198,811, filed Apr. 6, 2009.
Office Action received for U.S. Appl. No. 11/198,811, mailed on Aug. 26, 2008.
Office Action received for U.S. Appl. No. 11/198,811, mailed on Sep. 22, 2009.
Office Action received for U.S. Appl. No. 11/344,793, filed Jan. 22, 2009.
Office Action received for U.S. Appl. No. 11/344,868, filed Mar. 25, 2009.
Office Action received for U.S. Appl. No. 11/344,891, filed Apr. 29, 2008.
Office Action received for U.S. Appl. No. 11/344,891, filed Dec. 8, 2008.
Office Action received for U.S. Appl. No. 11/344,891, mailed on Feb. 26, 2009.
Office Action received for U.S. Appl. No. 11/344,891, mailed on May 7, 2010.
Office Action received for U.S. Appl. No. 11/344,891, mailed on Oct. 7, 2009.
Office Action received for U.S. Appl. No. 11/390,586, mailed on Jul. 6, 2010.
Office Action received for U.S. Appl. No. 11/390,586, mailed on Jun. 24, 2009.
Office Action received for U.S. Appl. No. 12/122,603, mailed on Nov. 20, 2013.
Office Action received for U.S. Appl. No. 12/122,603, mailed on Sep. 23, 2011.
Office Action received for U.S. Appl. No. 12/135,858, filed Feb. 16, 2012.
Office Action received for U.S. Appl. No. 12/135,858, filed Jul. 13, 2011.
Office Action received for U.S. Appl. No. 12/143,020, mailed on Aug. 31, 2011.
Office Action received for U.S. Appl. No. 12/143,020, mailed on May 11, 2011.
Office Action received for U.S. Appl. No. 12/338,977, filed Jun. 19, 2013.
Office Action received for U.S. Appl. No. 12/338,977, filed Nov. 28, 2012.
Office Action received for U.S. Appl. No. 12/338,977, mailed on Jan. 19, 2012.
Office Action received for U.S. Appl. No. 12/338,977, mailed on Jul. 11, 2012.
Office Action received for U.S. Appl. No. 12/365,397, mailed on Sep. 13, 2010.
Office Action received for U.S. Appl. No. 12/393,877, filed Dec. 13, 2011.
Office Action received for U.S. Appl. No. 12/393,877, filed May 21, 2012.
Office Action received for U.S. Appl. No. 12/393,877, mailed on Sep. 29, 2011.
Office Action received for U.S. Appl. No. 12/402,398, mailed on Jan. 24, 2011.
Office Action received for U.S. Appl. No. 12/402,398, mailed on Mar. 9, 2010.
Office Action received for U.S. Appl. No. 12/402,398, mailed on May 20, 2010.
Office Action received for U.S. Appl. No. 12/402,398, mailed on Sep. 20, 2012.
Office Action received for U.S. Appl. No. 12/403,256, mailed on Dec. 16, 2009.
Office Action received for U.S. Appl. No. 12/403,256, mailed on Mar. 30, 2010.
Office Action received for U.S. Appl. No. 12/403,277, filed Nov. 5, 2012.
Office Action received for U.S. Appl. No. 12/403,277, mailed on Apr. 3, 2012.
Office Action received for U.S. Appl. No. 12/403,277, mailed on Aug. 15, 2014.
Office Action received for U.S. Appl. No. 12/403,277, mailed on Jan. 27, 2014.
Office Action received for U.S. Appl. No. 12/403,277, mailed on Jul. 8, 2010.
Office Action received for U.S. Appl. No. 12/403,277, mailed on Mar. 31, 2011.
Office Action received for U.S. Appl. No. 12/403,277, mailed on Oct. 12, 2010.
Office Action received for U.S. Appl. No. 12/481,377, filed Jan. 3, 2012.
Office Action received for U.S. Appl. No. 12/481,377, mailed on Apr. 28, 2011.
Office Action received for U.S. Appl. No. 12/481,377, mailed on Jun. 21, 2011.
Office Action received for U.S. Appl. No. 12/548,274, filed Aug. 14, 2014.
Office Action received for U.S. Appl. No. 12/548,274, filed Sep. 10, 2012.
Office Action received for U.S. Appl. No. 12/548,274, mailed on Dec. 28, 2011.
Office Action received for U.S. Appl. No. 12/548,274, mailed on Mar. 2, 2012.
Office Action received for U.S. Appl. No. 12/608,769, filed Feb. 10, 2012.
Office Action received for U.S. Appl. No. 12/608,769, mailed on Aug. 22, 2012.
Office Action received for U.S. Appl. No. 12/608,773, filed Jul. 17, 2014.
Office Action received for U.S. Appl. No. 12/608,773, filed Jul. 20, 2012.
Office Action received for U.S. Appl. No. 12/608,773, filed Jun. 7, 2012.
Office Action received for U.S. Appl. No. 12/608,773, filed Mar. 12, 2015.
Office Action received for U.S. Appl. No. 12/608,773, mailed on Jan. 7, 2013.

(56) **References Cited**

OTHER PUBLICATIONS

Office Action received for U.S. Appl. No. 12/642,319, filed Aug. 28, 2012.
Office Action received for U.S. Appl. No. 12/642,319, filed Feb. 27, 2012.
Office Action received for U.S. Appl. No. 12/642,319, mailed on Dec. 16, 2013.
Office Action received for U.S. Appl. No. 12/684,400, filed Feb. 13, 2012.
Office Action received for U.S. Appl. No. 12/684,400, filed Feb. 23, 2015.
Office Action received for U.S. Appl. No. 12/684,400, filed May 9, 2012.
Office Action received for U.S. Appl. No. 12/684,400, filed Oct. 16, 2012.
Office Action received for U.S. Appl. No. 12/684,470, filed Aug. 26, 2015.
Office Action received for U.S. Appl. No. 12/684,470, filed Aug. 30, 2012.
Notice of Allowance received for U.S. Appl. No. 09/764,813, mailed on Jun. 4, 2001.
Notice of Allowance received for U.S. Appl. No. 09/933,299, mailed on Jun. 16, 2003.
Notice of Allowance received for U.S. Appl. No. 09/948,813, mailed on Jan. 31, 2003.
Notice of Allowance received for U.S. Appl. No. 09/949,398, mailed on Jul. 28, 2003.
Notice of Allowance received for U.S. Appl. No. 09/949,438, mailed on Apr. 21, 2003.
Notice of Allowance received for U.S. Appl. No. 10/006,400, mailed on Apr. 27, 2010.
Notice of Allowance received for U.S. Appl. No. 10/006,400, mailed on Aug. 2, 2010.
Notice of Allowance received for U.S. Appl. No. 10/006,400, mailed on Jan. 13, 2010.
Notice of Allowance received for U.S. Appl. No. 10/006,400, mailed on Jul. 9, 2009.
Notice of Allowance received for U.S. Appl. No. 10/081,717, mailed on Sep. 29, 2003.
Notice of Allowance received for U.S. Appl. No. 10/081,723, mailed on May 13, 2005.
Notice of Allowance received for U.S. Appl. No. 10/081,725, mailed on Feb. 9, 2004.
Notice of Allowance received for U.S. Appl. No. 10/081,726, mailed on Apr. 11, 2003.
Notice of Allowance received for U.S. Appl. No. 10/081,726, mailed on Jun. 9, 2003.
Notice of Allowance received for U.S. Appl. No. 10/147,774, mailed on Apr. 18, 2007.
Notice of Allowance received for U.S. Appl. No. 10/147,774, mailed on Dec. 2, 2010.
Notice of Allowance received for U.S. Appl. No. 10/147,774, mailed on Sep. 27, 2007.
Notice of Allowance received for U.S. Appl. No. 10/240,183, mailed on Mar. 9, 2005.
Notice of Allowance received for U.S. Appl. No. 10/264,306, mailed on Feb. 4, 2008.
Notice of Allowance received for U.S. Appl. No. 10/264,306, mailed on Jul. 2, 2007.
Notice of Allowance received for U.S. Appl. No. 10/264,306, mailed on May 10, 2006.
Notice of Allowance received for U.S. Appl. No. 10/264,306, mailed on Oct. 29, 2010.
Notice of Allowance received for U.S. Appl. No. 10/335,075, mailed on Dec. 27, 2006.
Notice of Allowance received for U.S. Appl. No. 10/356,214, mailed on Jan. 13, 2010.
Notice of Allowance received for U.S. Appl. No. 10/356,214, mailed on May 13, 2010.
Notice of Allowance received for U.S. Appl. No. 10/356,214, mailed on Sep. 3, 2010.
Notice of Allowance received for U.S. Appl. No. 10/435,104, mailed on Apr. 4, 2008.
Notice of Allowance received for U.S. Appl. No. 10/435,104, mailed on Aug. 2, 2007.
Notice of Allowance received for U.S. Appl. No. 10/435,104, mailed on Dec. 22, 2008.
Notice of Allowance received for U.S. Appl. No. 10/435,104, mailed on Dec. 28, 2006.
Notice of Allowance received for U.S. Appl. No. 10/435,104, mailed on Jan. 20, 2010.
Notice of Allowance received for U.S. Appl. No. 10/435,104, mailed on Jul. 10, 2007.
Notice of Allowance received for U.S. Appl. No. 10/435,104, mailed on Jul. 23, 2009.
Notice of Allowance received for U.S. Appl. No. 10/435,104, mailed on Nov. 14, 2007.
Notice of Allowance received for U.S. Appl. No. 10/435,104, mailed on Oct. 5, 2010.
Notice of Allowance received for U.S. Appl. No. 10/435,104, mailed on Oct. 26, 2007.
Notice of Allowance received for U.S. Appl. No. 10/435,104, mailed on Sep. 21, 2004.
Notice of Allowance received for U.S. Appl. No. 10/435,104, mailed on Sep. 26, 2008.
Notice of Allowance received for U.S. Appl. No. 10/455,768, mailed on Apr. 6, 2005.
Notice of Allowance received for U.S. Appl. No. 10/486,067, mailed on Sep. 20, 2006.
Notice of Allowance received for U.S. Appl. No. 10/486,070, mailed on Oct. 18, 2005.
Notice of Allowance received for U.S. Appl. No. 10/517,004, mailed on Apr. 23, 2010.
Notice of Allowance received for U.S. Appl. No. 10/517,004, mailed on Aug. 3, 2010.
Notice of Allowance received for U.S. Appl. No. 10/517,004, mailed on Aug. 13, 2008.
Notice of Allowance received for U.S. Appl. No. 10/517,004, mailed on Feb. 10, 2009.
Notice of Allowance received for U.S. Appl. No. 10/517,004, mailed on Jan. 11, 2010.
Notice of Allowance received for U.S. Appl. No. 10/517,004, mailed on Jun. 26, 2009.
Notice of Allowance received for U.S. Appl. No. 10/517,004, mailed on Mar. 24, 2009.
Notice of Allowance received for U.S. Appl. No. 10/519,778, mailed on May 31, 2006.
Notice of Allowance received for U.S. Appl. No. 10/541,083, mailed on Apr. 16, 2009.
Notice of Allowance received for U.S. Appl. No. 10/541,083, mailed on Aug. 17, 2010.
Notice of Allowance received for U.S. Appl. No. 10/541,083, mailed on Dec. 29, 2008.
Notice of Allowance received for U.S. Appl. No. 10/541,083, mailed on Feb. 5, 2010.
Notice of Allowance received for U.S. Appl. No. 10/541,083, mailed on May 10, 2010.
Notice of Allowance received for U.S. Appl. No. 10/541,083, mailed on Sep. 19, 2008.
Notice of Allowance received for U.S. Appl. No. 10/541,083, mailed on Sep. 30, 2009.
Notice of Allowance received for U.S. Appl. No. 10/616,832, mailed on Jan. 11, 2010.
Notice of Allowance received for U.S. Appl. No. 10/616,832, mailed on May 12, 2010.
Notice of Allowance received for U.S. Appl. No. 10/616,832, mailed on Sep. 20, 2010.
Notice of Allowance received for U.S. Appl. No. 10/617,090, mailed on Jul. 6, 2005.
Notice of Allowance received for U.S. Appl. No. 10/617,090, mailed on Oct. 5, 2005.

(56) **References Cited**

OTHER PUBLICATIONS

Notice of Allowance received for U.S. Appl. No. 10/638,115, mailed on Apr. 2, 2010.
Notice of Allowance received for U.S. Appl. No. 10/638,115, mailed on Aug. 13, 2010.
Notice of Allowance received for U.S. Appl. No. 10/638,115, mailed on Dec. 1, 2009.
Notice of Allowance received for U.S. Appl. No. 10/638,115, mailed on May 7, 2009.
Notice of Allowance received for U.S. Appl. No. 10/667,144, mailed on Oct. 28, 2011.
Notice of Allowance received for U.S. Appl. No. 10/669,313, mailed on Jan. 11, 2006.
Notice of Allowance received for U.S. Appl. No. 10/669,313, mailed on Jun. 28, 2006.
Notice of Allowance received for U.S. Appl. No. 10/682,459, mailed on Apr. 1, 2011.
Notice of Allowance received for U.S. Appl. No. 10/786,444, mailed on Jul. 11, 2013.
Notice of Allowance received for U.S. Appl. No. 10/787,073, mailed on Aug. 25, 2010.
Notice of Allowance received for U.S. Appl. No. 10/787,073, mailed on Feb. 17, 2010.
Notice of Allowance received for U.S. Appl. No. 10/908,721, filed Jul. 18, 2013.
Notice of Allowance received for U.S. Appl. No. 11/048,503, filed Jan. 11, 2010.
Notice of Allowance received for U.S. Appl. No. 11/048,503, filed Jul. 30, 2010.
Notice of Allowance received for U.S. Appl. No. 11/048,503, mailed on Apr. 26, 2010.
Notice of Allowance received for U.S. Appl. No. 11/113,549, mailed on Mar. 14, 2014.
Notice of Allowance received for U.S. Appl. No. 11/152,562, mailed on Sep. 16, 2010.
Notice of Allowance received for U.S. Appl. No. 11/198,811, filed Jun. 29, 2010.
Notice of Allowance received for U.S. Appl. No. 11/344,891, filed Jan. 22, 2013.
Notice of Allowance received for U.S. Appl. No. 11/390,586, filed May 3, 2012.
Notice of Allowance received for U.S. Appl. No. 11/396,141, mailed on Nov. 4, 2013.
Notice of Allowance received for U.S. Appl. No. 11/396,731, filed Jul. 9, 2015.
Notice of Allowance received for U.S. Appl. No. 11/406,203, filed Jan. 29, 2008.
Notice of Allowance received for U.S. Appl. No. 11/406,203, filed Jun. 18, 2010.
Notice of Allowance received for U.S. Appl. No. 11/406,203, filed May 23, 2008.
Notice of Allowance received for U.S. Appl. No. 11/406,203, mailed on Sep. 22, 2008.
Notice of Allowance received for U.S. Appl. No. 11/411,925, mailed on Feb. 5, 2014.
Notice of Allowance received for U.S. Appl. No. 11/427,297, filed Jun. 26, 2012.
Notice of Allowance received for U.S. Appl. No. 11/427,309, filed Jun. 7, 2013.
Notice of Allowance received for U.S. Appl. No. 11/455,993, filed Aug. 11, 2014.
Notice of Allowance received for U.S. Appl. No. 11/532,325, filed Jan. 16, 2015.
Notice of Allowance received for U.S. Appl. No. 11/674,930, filed Apr. 3, 2014.
Notice of Allowance received for U.S. Appl. No. 11/675,462, filed Dec. 22, 2011.
Notice of Allowance received for U.S. Appl. No. 11/744,089, filed Aug. 8, 2013.
Notice of Allowance received for U.S. Appl. No. 11/767,818, filed Feb. 3, 2012.
Notice of Allowance received for U.S. Appl. No. 11/852,190, filed Feb. 12, 2014.
Notice of Allowance received for U.S. Appl. No. 11/958,295, filed Jun. 13, 2014.
Notice of Allowance received for U.S. Appl. No. 11/959,334, filed Apr. 14, 2010.
Notice of Allowance received for U.S. Appl. No. 11/959,334, filed Jan. 12, 2010.
Office Action received for U.S. Appl. No. 13/026,989, filed Aug. 23, 2013.
Office Action received for U.S. Appl. No. 13/026,989, filed Jun. 8, 2012.
Office Action received for U.S. Appl. No. 13/026,989, mailed on Sep. 16, 2011.
Office Action received for U.S. Appl. No. 13/028,041, filed Feb. 26, 2013.
Office Action Received for U.S. Appl. No. 13/028,041, mailed on Jan. 4, 2013.
Office Action received for U.S. Appl. No. 13/030,922, filed Dec. 18, 2012.
Office Action received for U.S. Appl. No. 13/030,922, filed Jan. 31, 2013.
Office Action received for U.S. Appl. No. 13/030,922, filed Jul. 18, 2013.
Office Action received for U.S. Appl. No. 13/039,087, mailed on Jul. 17, 2012.
Office Action received for U.S. Appl. No. 13/112,618, filed Jan. 29, 2016.
Office Action received for U.S. Appl. No. 13/112,618, mailed on Dec. 15, 2014.
Office Action received for U.S. Appl. No. 13/112,618, mailed on Jun. 7, 2013.
Office Action received for U.S. Appl. No. 13/112,618, mailed on Mar. 29, 2013.
Office Action received for U.S. Appl. No. 13/112,618, mailed on May 18, 2015.
Office Action received for U.S. Appl. No. 13/112,618, mailed on Nov. 20, 2013.
Office Action received for U.S. Appl. No. 13/112,631, mailed on Apr. 15, 2015.
Office Action received for U.S. Appl. No. 13/112,631, mailed on Dec. 2, 2013.
Office Action received for U.S. Appl. No. 13/112,631, mailed on Jun. 26, 2013.
Office Action received for U.S. Appl. No. 13/112,631, mailed on Mar. 29, 2013.
Office Action received for U.S. Appl. No. 13/112,631, mailed on Nov. 20, 2014.
Office Action received for U.S. Appl. No. 13/153,594, filed Jan. 29, 2013.
Office Action received for U.S. Appl. No. 13/153,594, filed May 29, 2013.
Office Action received for U.S. Appl. No. 13/222,899, filed Aug. 5, 2015.
Office Action received for U.S. Appl. No. 13/222,899, filed Jan. 10, 2014.
Office Action received for U.S. Appl. No. 13/222,899, mailed on Apr. 1, 2015.
Office Action received for U.S. Appl. No. 13/222,899, mailed on Jul. 31, 2014.
Office Action received for U.S. Appl. No. 13/308,227, filed Jul. 14, 2015.
Office Action received for U.S. Appl. No. 13/308,227, mailed on Apr. 10, 2013.
Office Action received for U.S. Appl. No. 13/308,227, mailed on Sep. 11, 2013.
Office Action received for U.S. Appl. No. 13/490,143, filed on Jan. 4, 2013.
Office Action received for U.S. Appl. No. 13/525,839, filed Apr. 1, 2013.

(56) **References Cited**

OTHER PUBLICATIONS

Office Action received for U.S. Appl. No. 13/615,547, filed Jan. 18, 2013.
Office Action received for U.S. Appl. No. 13/725,589, filed Sep. 17, 2015.
Office Action received for U.S. Appl. No. 13/791,829, filed May 29, 2013.
Office Action received for U.S. Appl. No. 13/791,846, mailed on Jun. 4, 2015.
Office Action received for U.S. Appl. No. 13/837,801, filed Feb. 9, 2017.
Office Action received for U.S. Appl. No. 13/837,801, filed Jul. 6, 2017.
Office Action received for U.S. Appl. No. 13/837,801, filed Jun. 9, 2016.
Office Action received for U.S. Appl. No. 13/837,801, mailed on Dec. 16, 2015.
Office Action received for U.S. Appl. No. 13/898,202, mailed on Aug. 21, 2014.
Office Action received for U.S. Appl. No. 13/898,202, mailed on Jan. 3, 2014.
Office Action received for U.S. Appl. No. 13/908,796, filed Jul. 21, 2015.
Office Action received for U.S. Appl. No. 14/017,039, mailed on Jan. 23, 2015.
Office Action received for U.S. Appl. No. 14/017,039, mailed on Jun. 10, 2015.
Office Action received for U.S. Appl. No. 14/017,039, mailed on Oct. 27, 2015.
Office Action received for U.S. Appl. No. 14/023,428, filed Dec. 20, 2016.
Office Action received for U.S. Appl. No. 14/023,428, filed Feb. 9, 2016.
Office Action received for U.S. Appl. No. 14/023,428, filed Jul. 18, 2017.
Office Action received for U.S. Appl. No. 14/023,428, filed Jul. 27, 2015.
Office Action received for U.S. Appl. No. 14/023,428, filed Jun. 13, 2016.
Notice of Allowance received for U.S. Appl. No. 14/246,973, filed Nov. 9, 2016.
Notice of Allowance received for U.S. Appl. No. 14/312,339, mailed on Jul. 19, 2018.
Notice of Allowance received for U.S. Appl. No. 14/323,753, filed Apr. 15, 2016.
Notice of Allowance received for U.S. Appl. No. 14/466,576, filed Dec. 15, 2015.
Notice of Allowance received for U.S. Appl. No. 14/539,830, filed Nov. 18, 2016.
Notice of Allowance received for U.S. Appl. No. 14/732,977, filed May 29, 2018.
Notice of Allowance received for U.S. Appl. No. 14/839,658, filed Feb. 28, 2018.
Notice of Allowance received for U.S. Appl. No. 15/056,281, filed Apr. 17, 2019.
Notice of Allowance received for U.S. Appl. No. 15/069,230, filed Jun. 19, 2019.
Notice of Allowance received for U.S. Appl. No. 15/142,106, mailed on Sep. 25, 2019.
Notice of Allowance received for U.S. Appl. No. 15/344,978, mailed on Sep. 25, 2019.
Notice of Allowance received for U.S. Appl. No. 15/356,028, filed Nov. 20, 2018.
Notice of Allowance received for U.S. Appl. No. 15/419,335, filed Nov. 30, 2018.
Notice of Allowance received for U.S. Appl. No. 29/296,370, mailed on Apr. 1, 2009.
Notice of Allowance received for U.S. Appl. No. 29/296,370, mailed on Dec. 2, 2008.
Notice of Allowance received for U.S. Appl. No. 10/147,774, mailed on Feb. 4, 2008.
Notice of Allowance received for U.S. Appl. No. 11/532,576, mailed on Oct. 13, 2010.
Notice of Allowance received for U.S. Appl. No. 13/615,547, mailed on Apr. 12, 2013.
Office Action received for U.S. Appl. No. 09/610,238, mailed on Sep. 5, 2001.
Office Action received for U.S. Appl. No. 09/680,837, mailed on Jul. 9, 2002.
Office Action received for U.S. Appl. No. 09/680,837, mailed on Mar. 25, 2003.
Office Action received for U.S. Appl. No. 09/680,837, mailed on Nov. 6, 2002.
Office Action received for U.S. Appl. No. 09/732,178, mailed on Aug. 1, 2002.
Office Action received for U.S. Appl. No. 09/732,178, mailed on Dec. 24, 2002.
Office Action received for U.S. Appl. No. 09/732,178, mailed on Jul. 3, 2003.
Office Action received for U.S. Appl. No. 09/732,835, mailed on Feb. 9, 2004.
Office Action received for U.S. Appl. No. 09/732,835, mailed on Sep. 11, 2003.
Office Action received for U.S. Appl. No. 09/764,813, mailed on Mar. 26, 2001.
Office Action received for U.S. Appl. No. 09/933,299, mailed on Feb. 26, 2003.
Office Action received for U.S. Appl. No. 09/949,398, mailed on Mar. 4, 2003.
Office Action received for U.S. Appl. No. 09/949,438, mailed on Dec. 17, 2002.
Office Action received for U.S. Appl. No. 10/006,400, mailed on Apr. 2, 2008.
Office Action received for U.S. Appl. No. 10/006,400, mailed on Apr. 11, 2005.
Office Action received for U.S. Appl. No. 10/006,400, mailed on Apr. 19, 2007.
Office Action received for U.S. Appl. No. 10/006,400, mailed on Aug. 27, 2004.
Office Action received for U.S. Appl. No. 10/006,400, mailed on Feb. 23, 2005.
Office Action received for U.S. Appl. No. 10/006,400, mailed on Jan. 2, 2009.
Office Action received for U.S. Appl. No. 10/006,400, mailed on Jul. 27, 2005.
Office Action received for U.S. Appl. No. 10/006,400, mailed on Mar. 6, 2006.
Office Action received for U.S. Appl. No. 10/006,400, mailed on May 24, 2006.
Office Action received for U.S. Appl. No. 10/006,400, mailed on Oct. 26, 2006.
Office Action received for U.S. Appl. No. 10/081,723, mailed on Sep. 29, 2004.
Office Action received for U.S. Appl. No. 10/081,725, mailed on Apr. 13, 2004.
Office Action received for U.S. Appl. No. 10/147,774, mailed on Jun. 8, 2010.
Office Action received for U.S. Appl. No. 10/147,774, mailed on Jun. 30, 2008.
Office Action received for U.S. Appl. No. 10/147,774, mailed on Mar. 18, 2009.
Office Action received for U.S. Appl. No. 10/147,774, mailed on May 4, 2005.
Office Action received for U.S. Appl. No. 10/147,774, mailed on Nov. 4, 2004.
Office Action received for U.S. Appl. No. 10/147,774, mailed on Oct. 18, 2005.
Office Action received for U.S. Appl. No. 10/147,774, mailed on Oct. 26, 2009.
Office Action received for U.S. Appl. No. 11/757,108, mailed on Nov. 25, 2009.

(56) **References Cited**

OTHER PUBLICATIONS

Office Action received for U.S. Appl. No. 11/767,818, mailed on Dec. 24, 2009.
Office Action received for U.S. Appl. No. 11/767,818, mailed on Feb. 16, 2011.
Office Action received for U.S. Appl. No. 11/767,818, mailed on Mar. 22, 2010.
Office Action received for U.S. Appl. No. 11/767,818, mailed on Sep. 30, 2010.
Office Action received for U.S. Appl. No. 11/852,190, filed Apr. 24, 2013.
Office Action received for U.S. Appl. No. 11/852,190, mailed on Jun. 24, 2010.
Office Action received for U.S. Appl. No. 11/852,190, mailed on Mar. 2, 2011.
Office Action received for U.S. Appl. No. 11/852,190, mailed on Nov. 1, 2010.
Office Action received for U.S. Appl. No. 11/852,190, mailed on Nov. 26, 2013.
Office Action received for U.S. Appl. No. 11/958,281, filed Oct. 8, 2010.
Office Action received for U.S. Appl. No. 11/958,281, filed Sep. 2, 2010.
Office Action received for U.S. Appl. No. 11/958,281, mailed on Mar. 10, 2011.
Office Action received for U.S. Appl. No. 11/958,295, mailed on Aug. 27, 2009.
Office Action received for U.S. Appl. No. 11/958,295, mailed on May 25, 2010.
Office Action received for U.S. Appl. No. 11/959,334, filed Aug. 19, 2009.
Office Action received for U.S. Appl. No. 12/106,928, filed Jan. 23, 2009.
Office Action received for U.S. Appl. No. 12/106,928, filed Oct. 25, 2010.
Office Action received for U.S. Appl. No. 12/106,928, mailed on Dec. 2, 2013.
Office Action received for U.S. Appl. No. 12/106,928, mailed on Jun. 28, 2013.
Office Action received for U.S. Appl. No. 12/106,928, mailed on May 10, 2010.
Office Action received for U.S. Appl. No. 12/106,928, mailed on Oct. 5, 2009.
Office Action received for U.S. Appl. No. 12/106,937, mailed on Jan. 22, 2014.
Office Action received for U.S. Appl. No. 12/106,937, mailed on Jun. 28, 2013.
Office Action received for U.S. Appl. No. 12/106,937, mailed on Mar. 30, 2009.
Office Action received for U.S. Appl. No. 12/106,937, mailed on Nov. 18, 2009.
Office Action received for U.S. Appl. No. 12/113,851, mailed on Apr. 27, 2010.
Office Action received for U.S. Appl. No. 12/113,851, mailed on Apr. 27, 2011.
Office Action received for U.S. Appl. No. 12/113,851, mailed on Aug. 21, 2014.
Office Action received for U.S. Appl. No. 12/113,851, mailed on Dec. 16, 2010.
Office Action received for U.S. Appl. No. 12/113,851, mailed on Jun. 24, 2010.
Office Action received for U.S. Appl. No. 12/113,851, mailed on Mar. 17, 2014.
Office Action received for U.S. Appl. No. 12/113,851, mailed on Mar. 29, 2012.
Office Action received for U.S. Appl. No. 12/114,031, filed May 11, 2011.
Office Action received for U.S. Appl. No. 12/114,031, mailed on Aug. 2, 2011.
Office Action received for U.S. Appl. No. 12/114,031, mailed on Mar. 6, 2012.
Office Action received for U.S. Appl. No. 12/114,031, mailed on Mar. 10, 2014.
Office Action received for U.S. Appl. No. 12/114,031, mailed on Nov. 22, 2010.
Office Action received for U.S. Appl. No. 12/114,031, mailed on Oct. 5, 2010.
Office Action received for U.S. Appl. No. 12/114,091, mailed on Apr. 5, 2012.
Office Action received for U.S. Appl. No. 12/114,091, mailed on Dec. 17, 2010.
Office Action received for U.S. Appl. No. 12/114,091, mailed on Feb. 12, 2015.
Office Action received for U.S. Appl. No. 12/114,091, mailed on Jul. 7, 2011.
Office Action received for U.S. Appl. No. 12/114,091, mailed on Jul. 23, 2015.
Office Action received for U.S. Appl. No. 12/114,091, mailed on Nov. 8, 2012.
Office Action received for U.S. Appl. No. 12/114,091, mailed on Oct. 27, 2010.
Office Action received for U.S. Appl. No. 12/122,603, filed Apr. 22, 2011.
Office Action received for U.S. Appl. No. 12/122,603, filed Apr. 30, 2014.
Office Action received for U.S. Appl. No. 12/122,603, mailed on Apr. 9, 2015.
Office Action received for U.S. Appl. No. 12/122,603, mailed on Mar. 3, 2011.
Office Action received for U.S. Appl. No. 11/396,141, filed Apr. 30, 2013.
Office Action received for U.S. Appl. No. 11/396,141, mailed on Aug. 26, 2009.
Office Action received for U.S. Appl. No. 11/396,141, mailed on May 4, 2010.
Office Action received for U.S. Appl. No. 11/396,141, mailed on May 22, 2009.
Office Action received for U.S. Appl. No. 11/396,731, filed Feb. 12, 2015.
Office Action received for U.S. Appl. No. 11/396,731, filed Feb. 13, 2009.
Office Action received for U.S. Appl. No. 11/396,731, filed Jun. 29, 2010.
Office Action received for U.S. Appl. No. 11/396,731, filed Mar. 22, 2011.
Office Action received for U.S. Appl. No. 11/396,731, mailed on May 22, 2009.
Office Action received for U.S. Appl. No. 11/396,731, mailed on Sep. 1, 2011.
Office Action received for U.S. Appl. No. 11/406,203, mailed on Mar. 3, 2009.
Office Action received for U.S. Appl. No. 11/406,203, mailed on May 14, 2007.
Office Action received for U.S. Appl. No. 11/406,203, mailed on Sep. 16, 2009.
Office Action received for U.S. Appl. No. 11/411,925, filed Feb. 5, 2008.
Office Action received for U.S. Appl. No. 11/411,925, mailed on Jan. 12, 2009.
Office Action received for U.S. Appl. No. 11/411,925, mailed on Jun. 6, 2007.
Office Action received for U.S. Appl. No. 11/411,925, mailed on Oct. 1, 2013.
Office Action received for U.S. Appl. No. 11/411,925, mailed on Sep. 10, 2009.
Office Action received for U.S. Appl. No. 11/427,297, mailed on Jan. 30, 2009.
Office Action received for U.S. Appl. No. 11/427,297, mailed on Mar. 21, 2011.
Office Action received for U.S. Appl. No. 11/427,297, mailed on Sep. 15, 2009.

(56) **References Cited**

OTHER PUBLICATIONS

Office Action received for U.S. Appl. No. 11/427,309, mailed on Apr. 20, 2009.
Office Action received for U.S. Appl. No. 11/427,309, mailed on Apr. 26, 2010.
Office Action received for U.S. Appl. No. 11/427,309, mailed on Jan. 2, 2009.
Office Action received for U.S. Appl. No. 11/427,309, mailed on May 28, 2008.
Office Action received for U.S. Appl. No. 11/427,309, mailed on Nov. 6, 2009.
Office Action received for U.S. Appl. No. 11/427,309, mailed on Nov. 15, 2010.
Office Action received for U.S. Appl. No. 11/455,993, filed Dec. 16, 2009.
Office Action received for U.S. Appl. No. 11/455,993, mailed on Feb. 17, 2009.
Office Action received for U.S. Appl. No. 11/455,993, mailed on Jan. 29, 2014.
Office Action received for U.S. Appl. No. 11/508,715, mailed on Apr. 26, 2010.
Office Action received for U.S. Appl. No. 11/508,715, mailed on Jan. 6, 2010.
Office Action received for U.S. Appl. No. 11/508,715, mailed on Oct. 18, 2010.
Office Action received for U.S. Appl. No. 11/532,325, filed Jul. 17, 2013.
Office Action received for U.S. Appl. No. 11/532,325, mailed on Dec. 2, 2013.
Office Action received for U.S. Appl. No. 11/532,325, mailed on Feb. 23, 2009.
Office Action received for U.S. Appl. No. 11/532,325, mailed on Jan. 5, 2010.
Office Action received for U.S. Appl. No. 11/532,325, mailed on Jun. 17, 2009.
Office Action received for U.S. Appl. No. 11/532,576, mailed on Apr. 23, 2010.
Office Action received for U.S. Appl. No. 11/532,576, mailed on Mar. 1, 2010.
Office Action received for U.S. Appl. No. 11/674,930, filed Jan. 8, 2010.
Office Action received for U.S. Appl. No. 11/674,930, mailed on Jan. 8, 2010.
Office Action received for U.S. Appl. No. 11/674,930, mailed on Jun. 4, 2009.
Office Action received for U.S. Appl. No. 11/675,462, filed Aug. 3, 2011.
Office Action received for U.S. Appl. No. 11/675,462, filed Aug. 31, 2010.
Office Action received for U.S. Appl. No. 11/675,462, filed Dec. 10, 2009.
Office Action received for U.S. Appl. No. 11/744,089, filed Apr. 15, 2013.
Office Action received for U.S. Appl. No. 11/744,089, filed Aug. 8, 2012.
Office Action received for U.S. Appl. No. 11/744,089, filed Aug. 14, 2009.
Office Action received for U.S. Appl. No. 11/744,089, mailed on Nov. 26, 2008.
Notice of Allowance received for U.S. Appl. No. 11/959,334, filed Jul. 23, 2010.
Notice of Allowance received for U.S. Appl. No. 12/106,928, mailed on Oct. 3, 2014.
Notice of Allowance received for U.S. Appl. No. 12/106,937, filed Mar. 5, 2015.
Notice of Allowance received for U.S. Appl. No. 12/113,851, filed Feb. 20, 2015.
Notice of Allowance received for U.S. Appl. No. 12/114,091, mailed on Apr. 6, 2016.
Notice of Allowance received for U.S. Appl. No. 12/122,603, filed Sep. 23, 2015.
Notice of Allowance received for U.S. Appl. No. 12/143,020, mailed on Feb. 23, 2012.
Notice of Allowance received for U.S. Appl. No. 12/393,877, filed Aug. 4, 2014.
Notice of Allowance received for U.S. Appl. No. 12/402,398, filed Mar. 13, 2013.
Notice of Allowance received for U.S. Appl. No. 12/403,256, mailed on Aug. 19, 2010.
Notice of Allowance received for U.S. Appl. No. 12/481,377, mailed on Aug. 10, 2012.
Notice of Allowance received for U.S. Appl. No. 12/608,769, filed Nov. 5, 2012.
Notice of Allowance received for U.S. Appl. No. 12/608,773, filed Sep. 17, 2015.
Notice of Allowance received for U.S. Appl. No. 12/642,319, filed May 27, 2014.
Notice of Allowance received for U.S. Appl. No. 12/684,400, filed Jul. 28, 2015.
Notice of Allowance received for U.S. Appl. No. 12/684,470, filed Apr. 22, 2016.
Notice of Allowance received for U.S. Appl. No. 12/684,562, filed Feb. 17, 2015.
Notice of Allowance received for U.S. Appl. No. 12/724,304, filed Jul. 11, 2012.
Notice of Allowance received for U.S. Appl. No. 12/848,642, filed Feb. 3, 2014.
Notice of Allowance received for U.S. Appl. No. 12/850,242, filed Aug. 6, 2013.
Notice of Allowance received for U.S. Appl. No. 12/897,358, filed Jan. 12, 2012.
Notice of Allowance received for U.S. Appl. No. 12/897,358, filed Mar. 5, 2012.
Notice of Allowance received for U.S. Appl. No. 12/941,809, mailed on Feb. 3, 2014.
Notice of Allowance received for U.S. Appl. No. 12/945,646, filed Feb. 21, 2012.
Notice of Allowance received for U.S. Appl. No. 12/950,628, filed Apr. 25, 2014.
Notice of Allowance received for U.S. Appl. No. 12/955,859, filed Aug. 1, 2013.
Notice of Allowance received for U.S. Appl. No. 12/961,331, filed Apr. 25, 2014.
Notice of Allowance received for U.S. Appl. No. 12/966,923, mailed on Feb. 3, 2012.
Notice of Allowance received for U.S. Appl. No. 12/973,204, filed Mar. 7, 2012.
Notice of Allowance received for U.S. Appl. No. 12/987,792, filed Aug. 25, 2014.
Notice of Allowance received for U.S. Appl. No. 13/028,041, filed Aug. 21, 2013.
Notice of Allowance received for U.S. Appl. No. 13/030,922, filed Jan. 8, 2014.
Notice of Allowance received for U.S. Appl. No. 13/039,087, mailed on Nov. 6, 2012.
Notice of Allowance received for U.S. Appl. No. 13/111,371, filed Jun. 6, 2013.
Notice of Allowance received for U.S. Appl. No. 13/112,618, filed Jul. 6, 2016.
Notice of Allowance received for U.S. Appl. No. 13/153,594, filed Oct. 16, 2013.
Notice of Allowance received for U.S. Appl. No. 13/222,899, filed Jan. 7, 2016.
Notice of Allowance received for U.S. Appl. No. 13/308,227, filed Feb. 1, 2016.
Notice of Allowance received for U.S. Appl. No. 13/488,233, filed Feb. 5, 2013.
Notice of Allowance received for U.S. Appl. No. 13/490,143, filed Apr. 29, 2013.
Notice of Allowance received for U.S. Appl. No. 13/525,839, filed Jul. 15, 2013.

(56) **References Cited**

OTHER PUBLICATIONS

Notice of Allowance received for U.S. Appl. No. 13/725,589, mailed on Mar. 18, 2016.
Notice of Allowance received for U.S. Appl. No. 13/791,829, mailed on Oct. 8, 2013.
Notice of Allowance received for U.S. Appl. No. 13/791,846, filed Oct. 27, 2015.
Notice of Allowance received for U.S. Appl. No. 13/898,202, mailed on Feb. 10, 2015.
Notice of Allowance received for U.S. Appl. No. 13/908,796, filed Nov. 6, 2015.
Notice of Allowance received for U.S. Appl. No. 14/017,039, filed Apr. 4, 2016.
Notice of Allowance received for U.S. Appl. No. 14/023,428, filed Jan. 4, 2018.
Notice of Allowance received for U.S. Appl. No. 14/077,007, filed Aug. 12, 2016.
Notice of Allowance received for U.S. Appl. No. 14/246,926, filed Oct. 3, 2016.
Office Action received for U.S. Appl. No. 12/684,470, filed Dec. 20, 2011.
Office Action received for U.S. Appl. No. 12/684,470, mailed on Jan. 21, 2016.
Office Action received for U.S. Appl. No. 12/684,470, mailed on Jun. 4, 2014.
Office Action received for U.S. Appl. No. 12/684,470, mailed on Mar. 23, 2012.
Office Action received for U.S. Appl. No. 12/684,470, mailed on Nov. 14, 2014.
Office Action received for U.S. Appl. No. 12/684,542, filed Dec. 1, 2014.
Office Action received for U.S. Appl. No. 12/684,542, filed Jun. 18, 2014.
Office Action received for U.S. Appl. No. 12/684,542, mailed on Apr. 16, 2012.
Office Action received for U.S. Appl. No. 12/684,542, mailed on Jan. 30, 2012.
Office Action received for U.S. Appl. No. 12/684,542, mailed on Sep. 13, 2012.
Office Action received for U.S. Appl. No. 12/684,562, filed Dec. 28, 2011.
Office Action received for U.S. Appl. No. 12/684,562, filed Feb. 16, 2012.
Office Action received for U.S. Appl. No. 12/684,562, mailed on Aug. 21, 2012.
Office Action received for U.S. Appl. No. 12/684,562, mailed on Sep. 10, 2014.
Office Action received for U.S. Appl. No. 12/684,569, filed Apr. 23, 2014.
Office Action received for U.S. Appl. No. 12/684,569, filed Dec. 20, 2011.
Office Action received for U.S. Appl. No. 12/684,569, filed Jan. 27, 2012.
Office Action received for U.S. Appl. No. 12/684,569, filed Jul. 30, 2012.
Office Action received for U.S. Appl. No. 12/688,065, filed Apr. 26, 2012.
Office Action received for U.S. Appl. No. 12/688,065, filed Mar. 13, 2012.
Office Action received for U.S. Appl. No. 12/688,065, filed Oct. 12, 2012.
Office Action received for U.S. Appl. No. 12/688,065, filed Oct. 18, 2013.
Office Action received for U.S. Appl. No. 12/688,065, mailed on Apr. 8, 2014.
Office Action received for U.S. Appl. No. 12/724,304, filed Feb. 10, 2012.
Office Action received for U.S. Appl. No. 12/848,642, filed Apr. 26, 2013.
Office Action received for U.S. Appl. No. 12/848,642, filed Nov. 9, 2012.
Office Action received for U.S. Appl. No. 12/848,642, filed Sep. 20, 2012.
Office Action received for U.S. Appl. No. 12/850,242, mailed on Apr. 18, 2013.
Office Action received for U.S. Appl. No. 12/850,242, mailed on Aug. 6, 2012.
Office Action received for U.S. Appl. No. 12/850,242, mailed on Oct. 17, 2012.
Office Action received for U.S. Appl. No. 12/897,358, filed Aug. 22, 2011.
Office Action received for U.S. Appl. No. 12/941,809, mailed on Dec. 13, 2011.
Office Action received for U.S. Appl. No. 12/941,809, mailed on Jan. 30, 2012.
Office Action received for U.S. Appl. No. 12/941,809, mailed on Jul. 3, 2013.
Office Action received for U.S. Appl. No. 12/941,809, mailed on Jun. 1, 2012.
Office Action received for U.S. Appl. No. 12/941,809, mailed on Nov. 8, 2013.
Office Action received for U.S. Appl. No. 12/945,646, filed Jul. 6, 2011.
Office Action received for U.S. Appl. No. 12/945,646, mailed on Jan. 20, 2011.
Office Action received for U.S. Appl. No. 12/945,646, mailed on Oct. 26, 2011.
Office Action received for U.S. Appl. No. 12/955,859, filed Dec. 15, 2011.
Office Action received for U.S. Appl. No. 12/955,859, filed Jul. 21, 2011.
Office Action received for U.S. Appl. No. 12/955,859, filed May 26, 2011.
Office Action received for U.S. Appl. No. 12/955,859, mailed on Aug. 6, 2012.
Office Action received for U.S. Appl. No. 12/961,331, filed Feb. 1, 2013.
Office Action received for U.S. Appl. No. 12/961,331, filed Jul. 3, 2013.
Office Action received for U.S. Appl. No. 12/961,331, mailed on Dec. 4, 2012.
Office Action received for U.S. Appl. No. 12/987,792, filed Jun. 11, 2014.
Office Action received for U.S. Appl. No. 12/987,792, filed Mar. 13, 2012.
Office Action received for U.S. Appl. No. 12/987,792, filed Sep. 17, 2012.
Office Action received for U.S. Appl. No. 12/987,792, mailed on Jan. 21, 2014.
Office Action received for U.S. Appl. No. 11/396,141, mailed on Aug. 21, 2013.
Office Action received for U.S. Appl. No. 11/427,297, mailed on Sep. 15, 2010.
Office Action received for U.S. Appl. No. 13/111,371, mailed on Oct. 12, 2012.
OM Elashry et al, Comparative clinical study of port-closure techniques following laparoscopic surgery, Department of Surgery, Mallickrodt Institute of Radiography, J Am Coll Surg., Oct. 1996, pp. 335-344, vol. 183—No. 4.
P M N Werker, et al, Review of facilitated approaches to vascular anastomosis surgery towards minimally invasive coronary artery bypass grafting, Conference: Utrecht MICABG Workshop 2, The Annals of thoracic surgery, Apr. 1996, pp. 122-127, vol. 63—No. 6, Department of Plastic, Reconstructive and Hand surgery, University Hospital Utrecht Netherlands Departments of Cardiology and Cardiopulmonary Surgery, Heart Lung Institute, Utrecht Netherlands.; Utrect University Hospital Utrecht Netherlands.
PCT patent application No. PCT/US2006/024334, Written Opinion mailed Jan. 16, 2007.
PCT Publication No. WO 00/56223 entitled "Vascular Closure Device", Sep. 28, 2000.

(56) **References Cited**

OTHER PUBLICATIONS

Peter Rhee MD et al, Use of Titanium Vascular Staples in Trauma, Journal of Trauma-Injury Infection & Critical Care, Dec. 1998, pp. 1097-1099, vol. 45—No. 6, Institution from the Department of Surgery, Washington Hospital Center, Washington DC, and Uniformed Services University of the Health Sciences, Bethesda, Maryland.

ProstarXL—Percutaneous Vascular Surgical Device, www.Archive.org, Jun. 1998, Original Publisher: http://prostar.com, may also be found at http://web.archive.org/web/19980630040429/www.perclose.com/html/prstrxl.html.

Rachel et al., Percutaneous endovascular abdominal aortic aneurysm repair, Annals of vascular surgery, vol. 16, No. 1, 2002, p. 43-49.

Restriction Requirement received for U.S. Appl. No. 10/638,115, mailed on Sep. 22, 2006.

Sa Beyer-Enke et al, Immediate sealing of arterial puncture site following femoropopliteal angioplasty: A prospective randomized trial, Cardiovascular And Interventional Radiology 1996, Nov.-Dec. 1996, pp. 406-410, vol. 19—No. 6, Gen Hosp North, Dept Dianost & Intervent Radial, Nurnberg, Germany (Reprint).

Scott Hensley, Closing Wounds. New Devices seal arterial punctures in double time, Modern Healthcare (United States), Mar. 23, 2008, p. 48.

Serruys, PW et al., A Comparision Of Balloon-Expandable-Stent Implantaion With Balloon Angioplast in Patients With Coronary Artery Disease, New England Journal of Medicine, 331:489-495, 1994.

Sigmund Silber et al, A novel vascular device for closure of percutaneous arterial access sites, The American Journal of Cardiology, Apr. 1999, pp. 1248-1252, vol. 83—No. 8.

Simonetta Blengino et al., A Randomized Study of the 8 French Hemostatic Puncture Closure Device vs Manual Compression After Coronary Interventions, Journal of the American College of Cardiology, Feb. 1995, p. 262A, vol. 25.—No. 2, Supplement 1.

Starnes et al, Totally percutaneous aortic aneurysm repair: experience and prudence, Journal of vascular surgery, vol. 43, No. 2, 2006, p. 270-276.

Stretch Comb by Scunci, retrieved via internet at www.scunci.com/productdetail by examiner on Oct. 9, 2007, publication date unavailable.

Swee Lian Tan, MD, PhD, Fags, Explanation of Infected Hemostatic Puncture Closure Devices—A Case Report, Vascular and Endovascular Surgery, 1999, pp. 507-510, vol. 33—No. 5, Parkland Medical Center, Derry, New Hampshire.

Sy Nakada et al., Comparison of newer laparoscopic port closure techniques in the porcine model, J Endourol, Oct. 1995, pp. 397-401, vol. 9—No. 5, Department of Surgery/Urology, University of Wisconsin Medical School, Madison.

Taber's Cyclopedic Medical Dictionary, 18.sup.th Ed. 1997, pp. 747 and 1420.

Teh et al., Use of the percutaneous vascular surgery device for closure of femoral access sites during endovascular aneurysm repair: lessons from our experience, European Journal of Vascular and Endovascular Surgery, vol. 22, No. 5, 2001, p. 418-423.

U.S. Appl. filed May 3, 2007., U.S. Appl. No. 11/744,049.

U.S. Appl. filed Oct. 4, 2010, Carley., U.S. Appl. No. 12/987,358.

U.S. Appl. No. 10/027,681, filed Jul. 8, 2009, Office Action.

U.S. Appl. No. 10/081,725, Mail Date Feb. 9, 2004, Notice of Allowance.

U.S. Appl. No. 10/240,183, filed Aug. 11, 2006, Response to 312 Amendment.

U.S. Appl. No. 10/264,306, mailed May 26, 2005, Office Action.

U.S. Appl. No. 10/305,923, mail date Mar. 3, 2005, Notice Of Allowance.

U.S. Appl. No. 10/305,923, mail date Nov. 1, 2004, Office Action.

U.S. Appl. No. 10/356,214, filed Apr. 29, 2009, Office Action.

U.S. Appl. No. 10/787,073, filed Nov. 30, 2006, Office Action.

U.S. Appl. No. 11/316,775, filed Aug. 6, 2008, Office Action.

U.S. Appl. No. 11/461,323, filed Jul. 27, 2009, Office Action.

U.S. Appl. No. 11/461,323, Mail Date Apr. 25, 2008, Office Action.

U.S. Appl. No. 11/461,323, mail date Apr. 5, 2010, Notice Of Allowance.

U.S. Appl. No. 11/461,323, mail date May 2, 2007, Office Action.

U.S. Appl. No. 11/461,323, mailed Nov. 6, 2008, Office Action.

U.S. Appl. No. 11/461,323, mailed Oct. 29, 2007, Office Action.

* cited by examiner

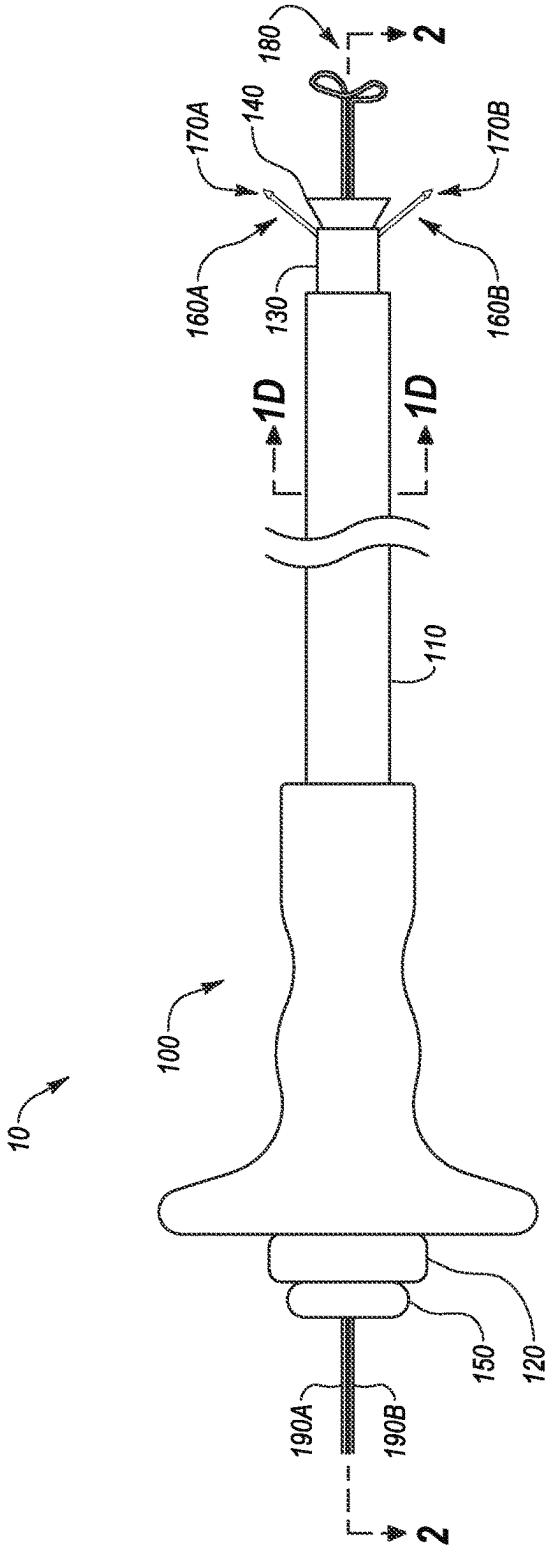

180
2
170A
140
170B
160A
130
160B
1D
1D
110
100
10
150
120
190A
190B
2

Fig. 1A

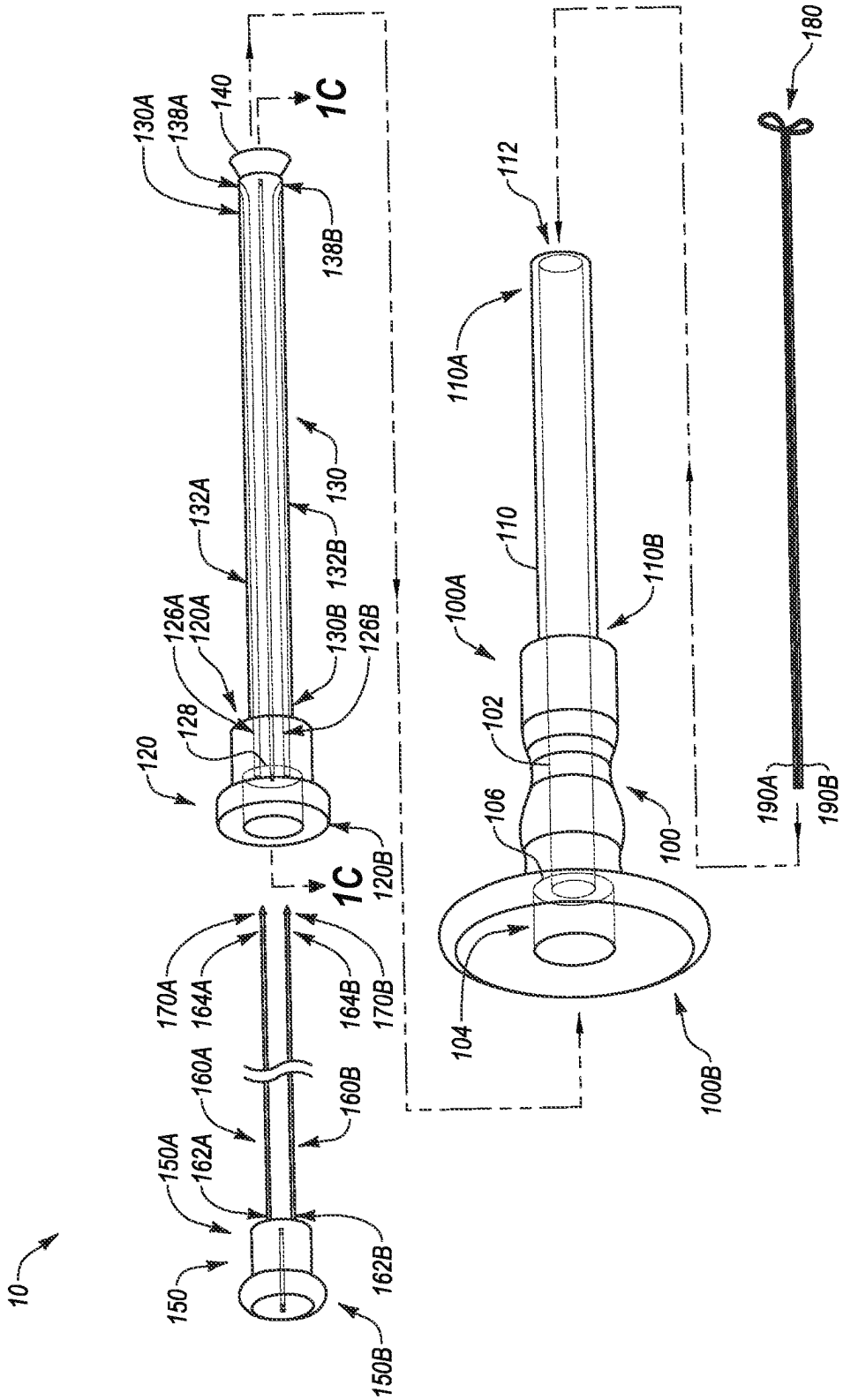

10
150
150A
162A
160A
170A
164A
150B
162B
160B
164B
170B
120
128
126A
120A
132A
120B
126B
130B
132B
130
140
130A
138A
138B
1C
1C
100
100A
102
104
106
110
110A
110B
112
100B
180
190A
190B

Fig. 1B

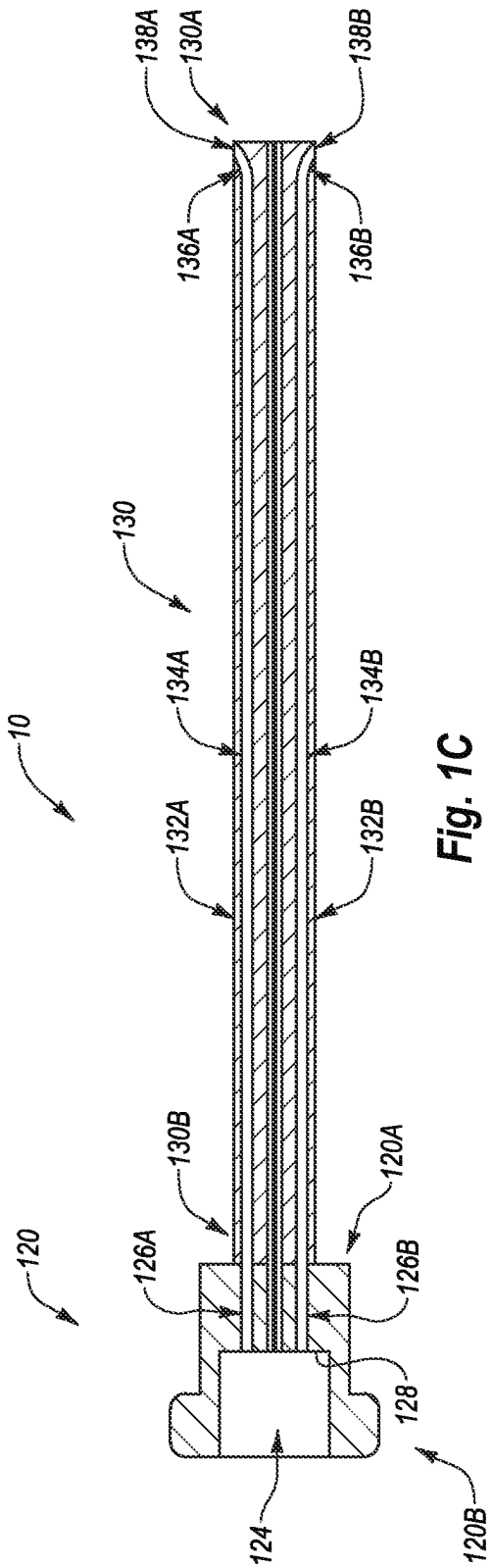

10
120
138A
130A
138B
136A
136B
130
134A
134B
132A
132B
130B
120A
126A
126B
128
124
120B

Fig. 1C

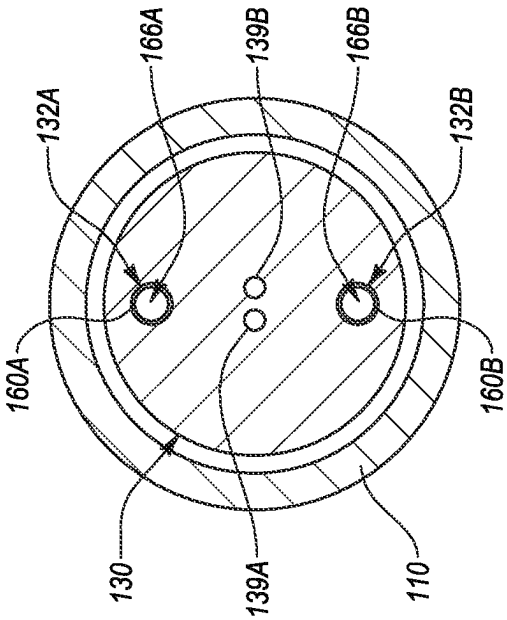

166A
139B
166B
132A
132B
160A
160B
130
139A
110

Fig. 1D

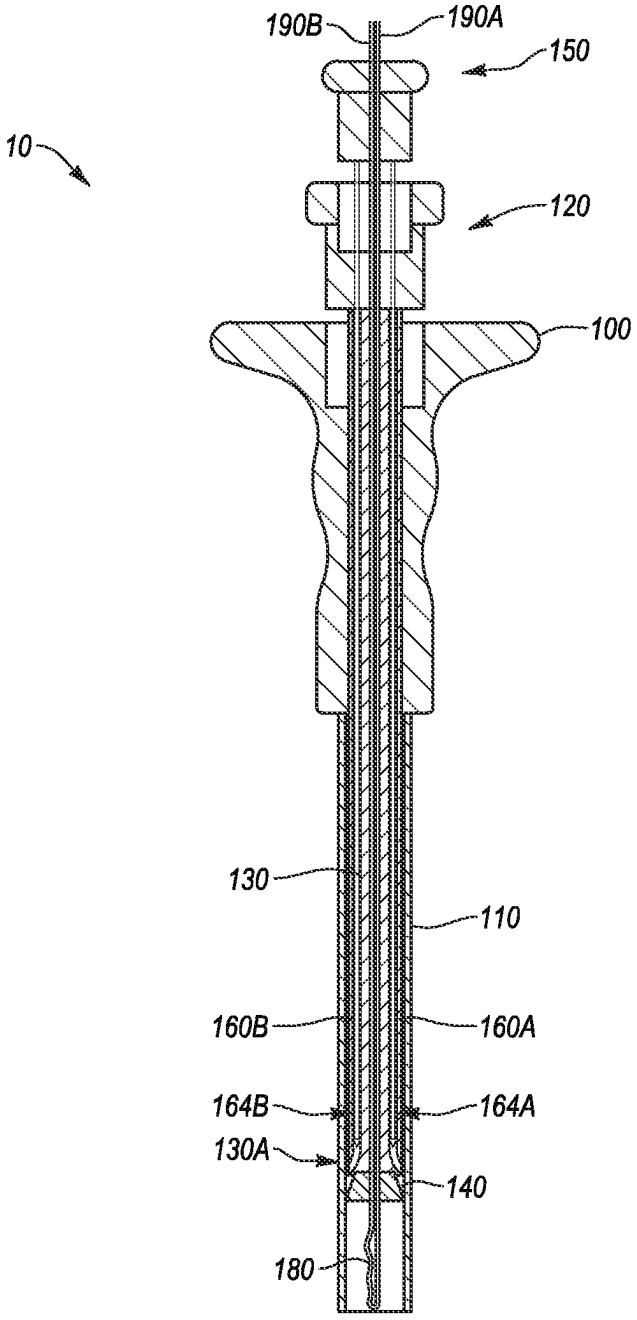

190B
190A
150
10
120
100
130
110
160B
160A
164B
164A
130A
140
180

Fig. 2A

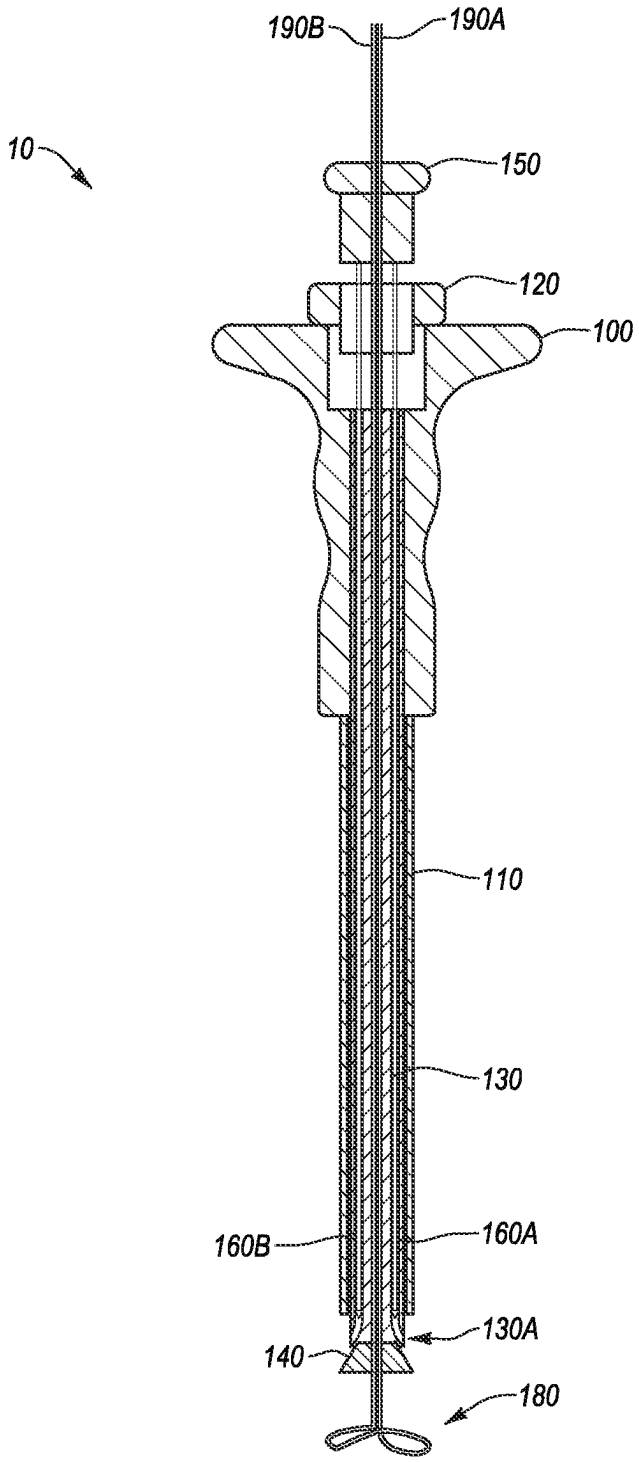


Fig. 2B

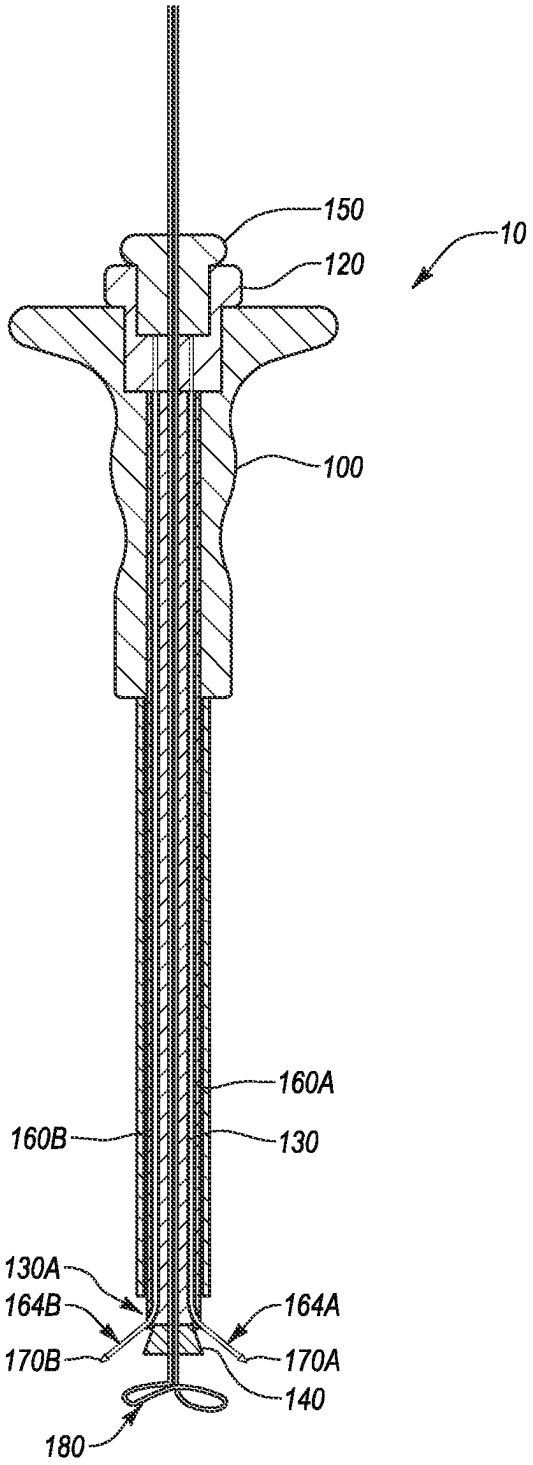


Fig. 2C

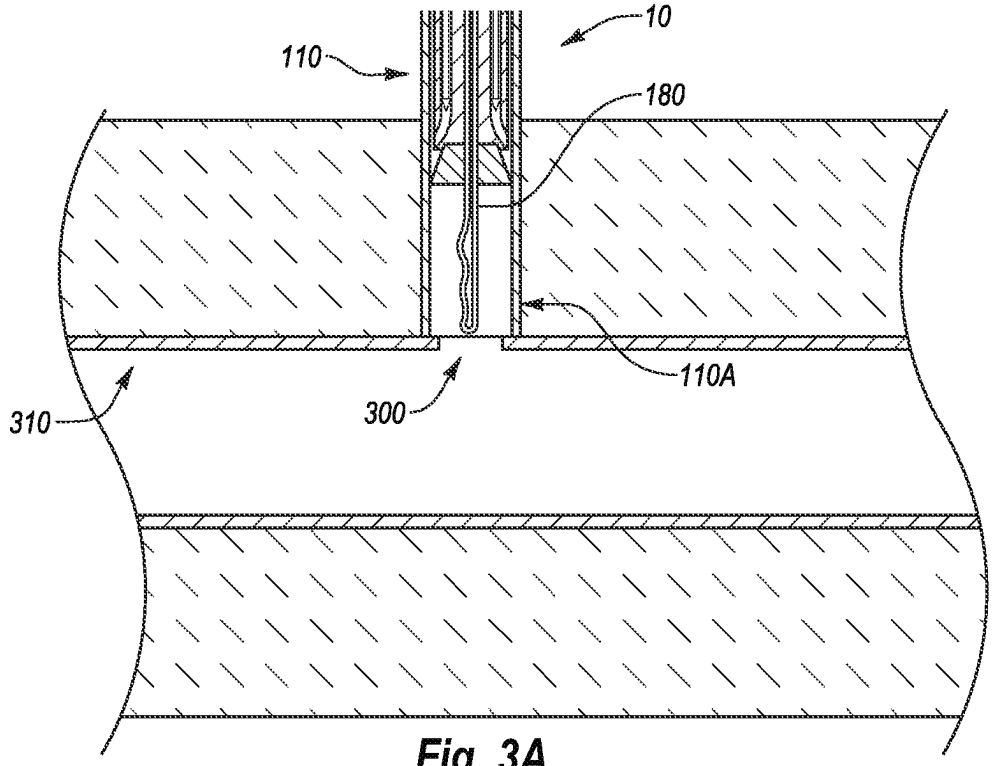


Fig. 3A

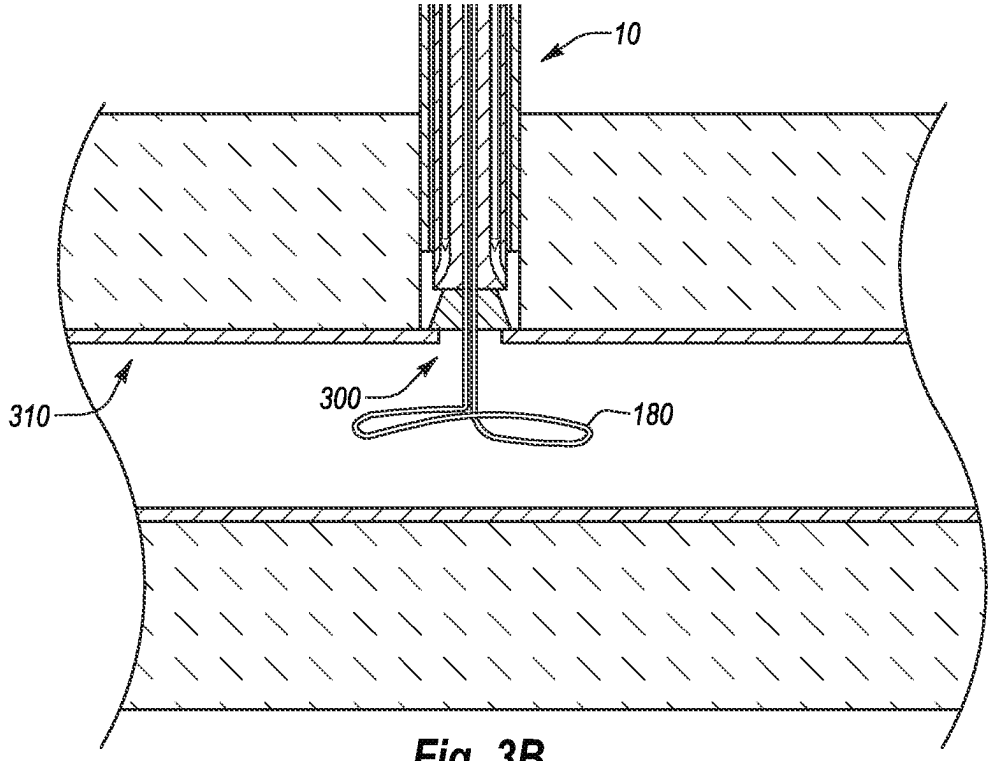


Fig. 3B

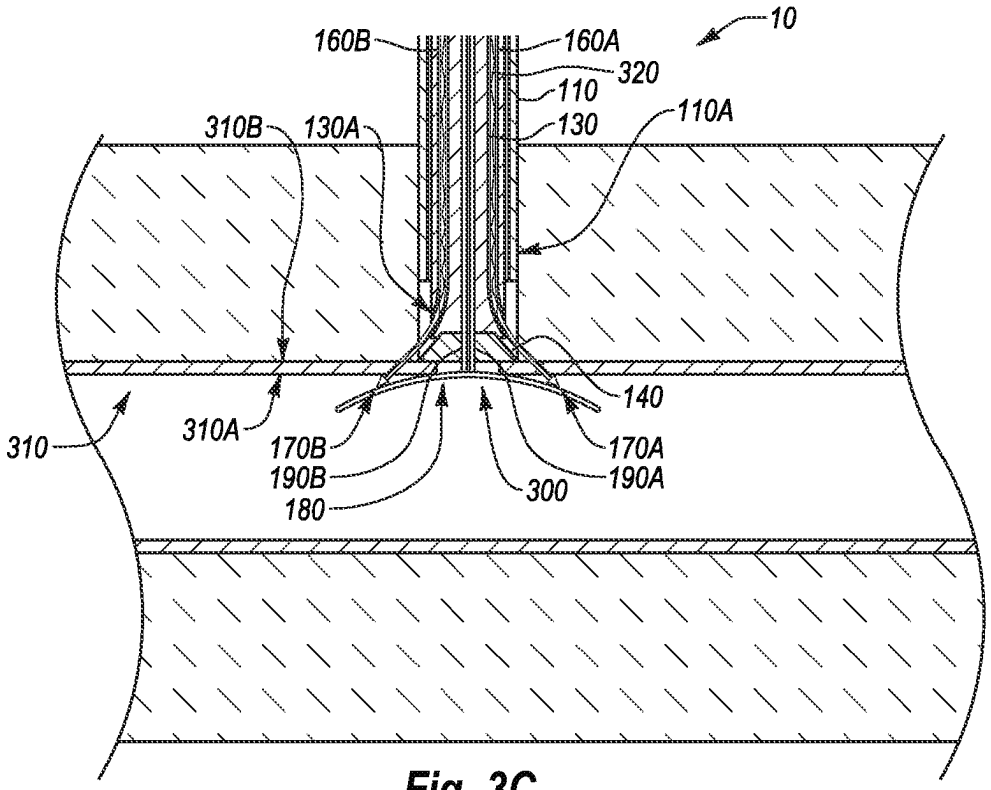

10
160B
160A
320
110
130
110A
310B
130A
140
310
310A
170B
190B
180
300
170A
190A

Fig. 3C

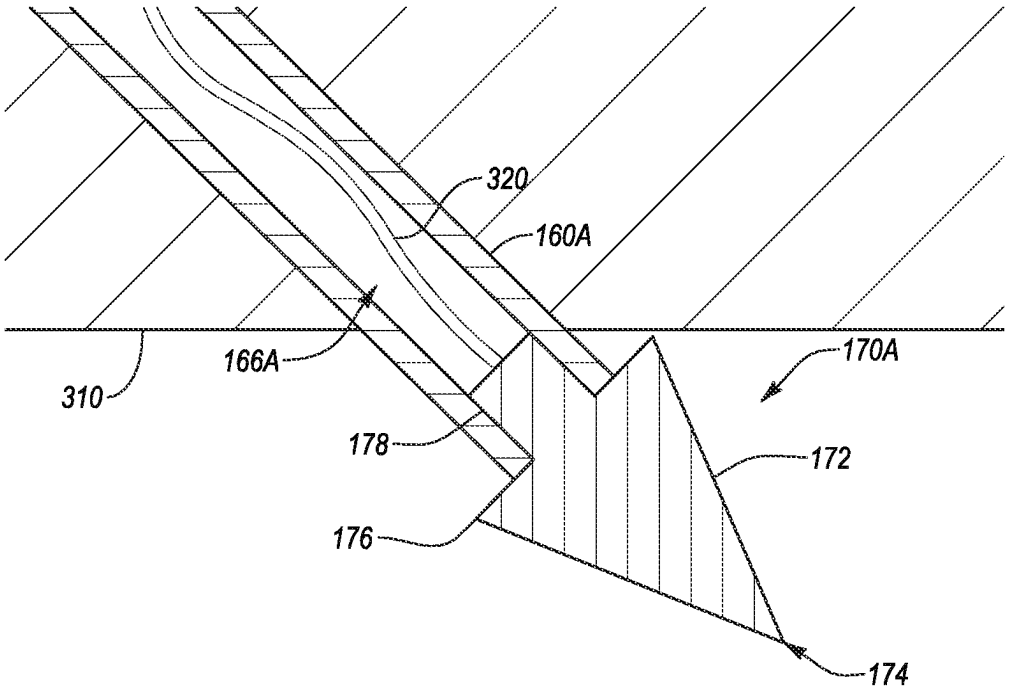

320
160A
166A
310
170A
178
172
176
174

Fig. 3D

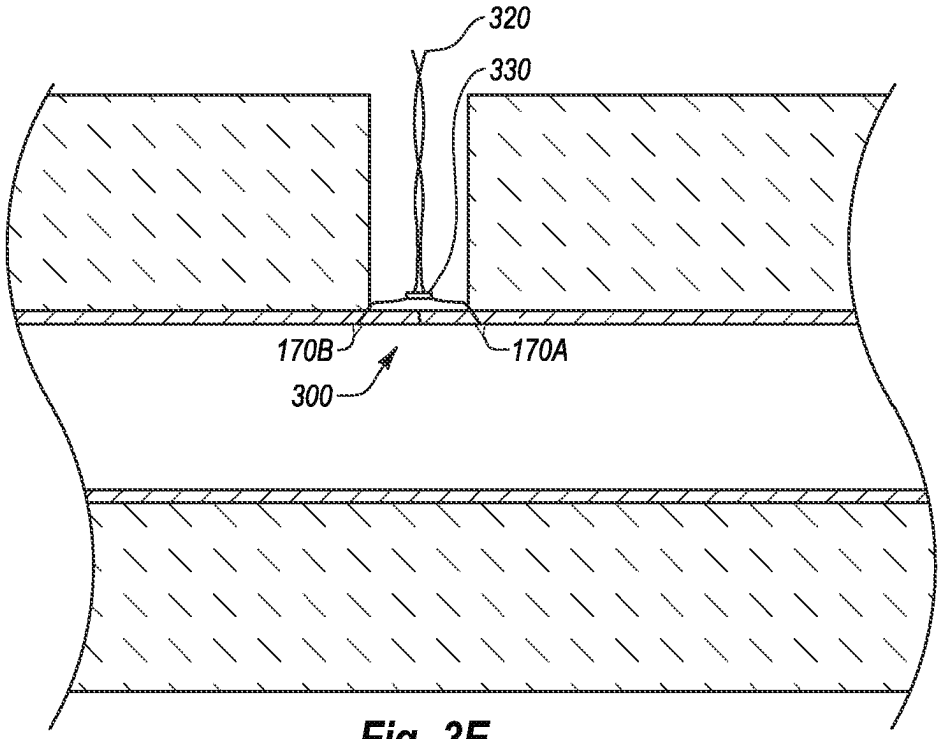


Fig. 3E

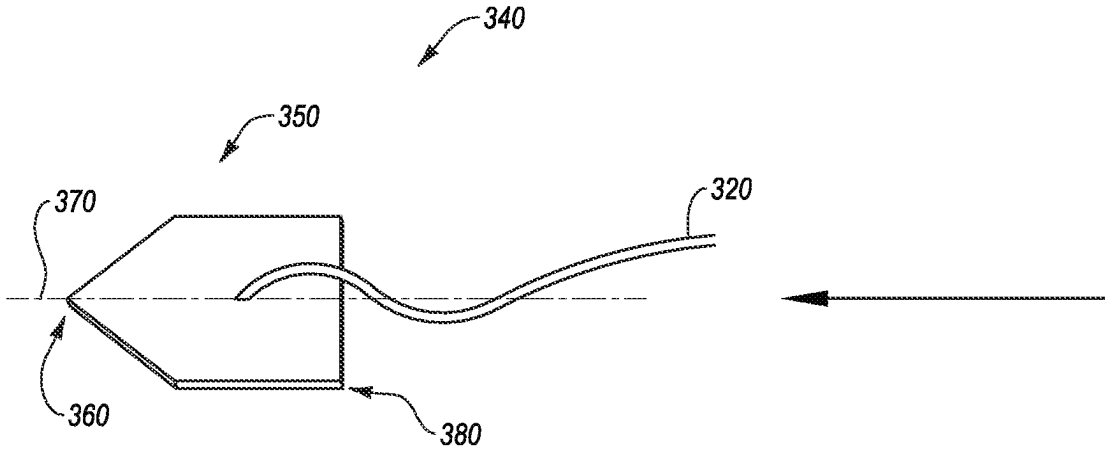


Fig. 4

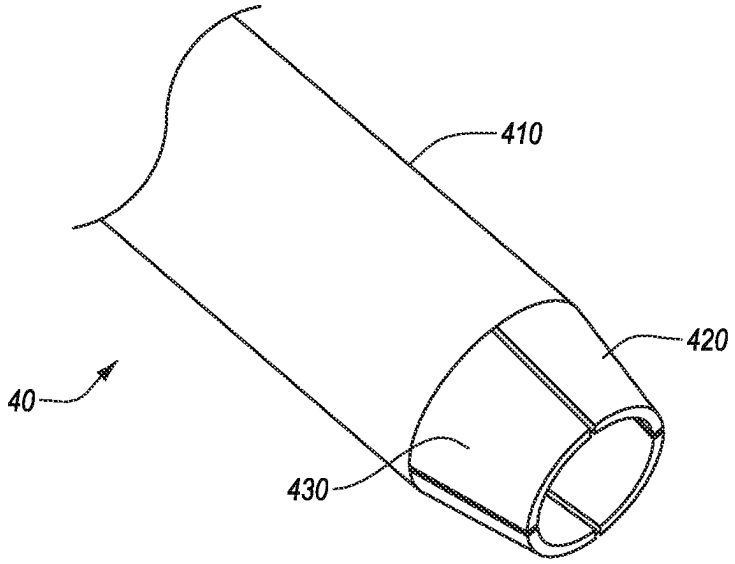


Fig. 5A

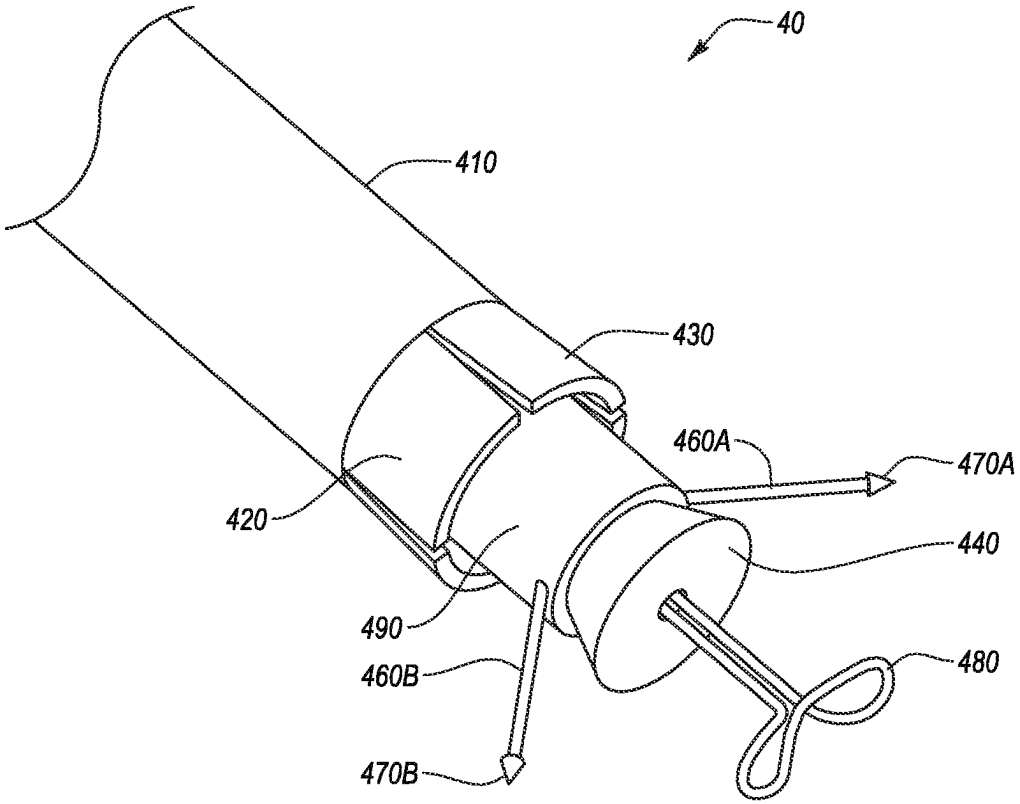


Fig. 5B

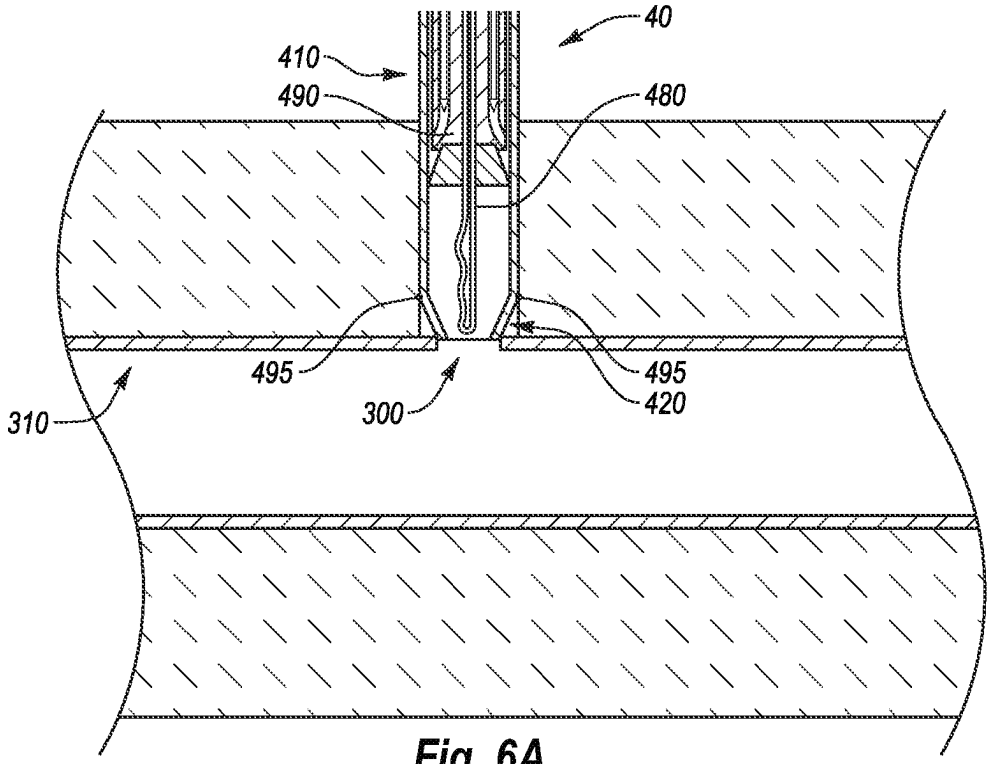

40
410
490
480
495
495
420
300
310

Fig. 6A

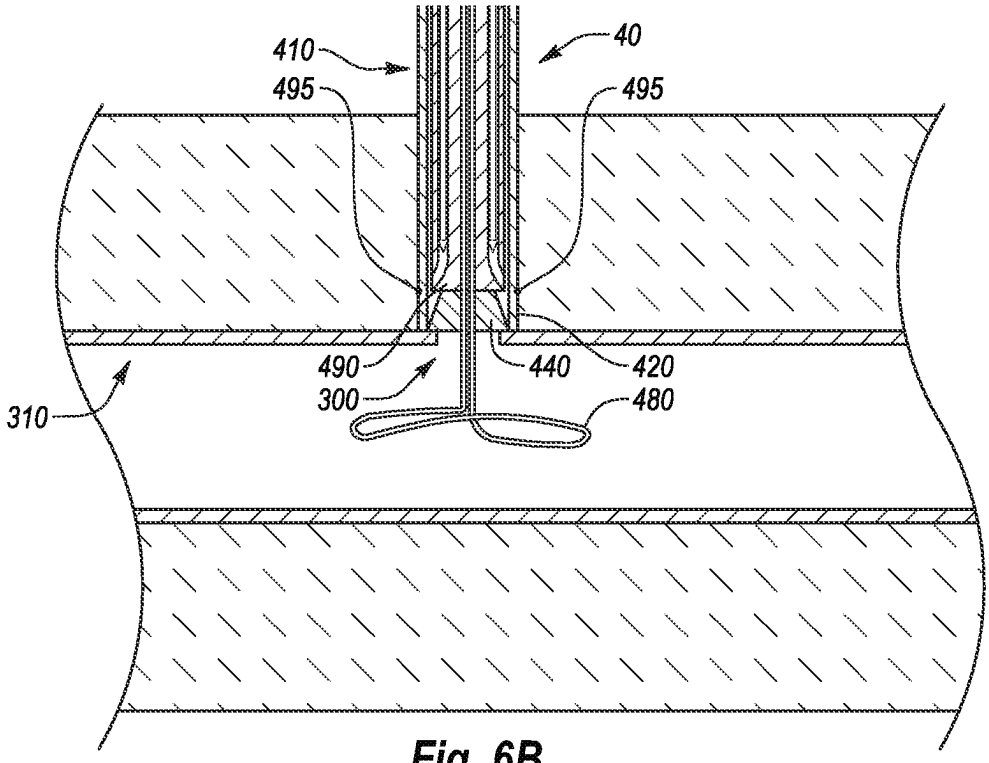

40
410
495
495
490
440
420
300
480
310

Fig. 6B

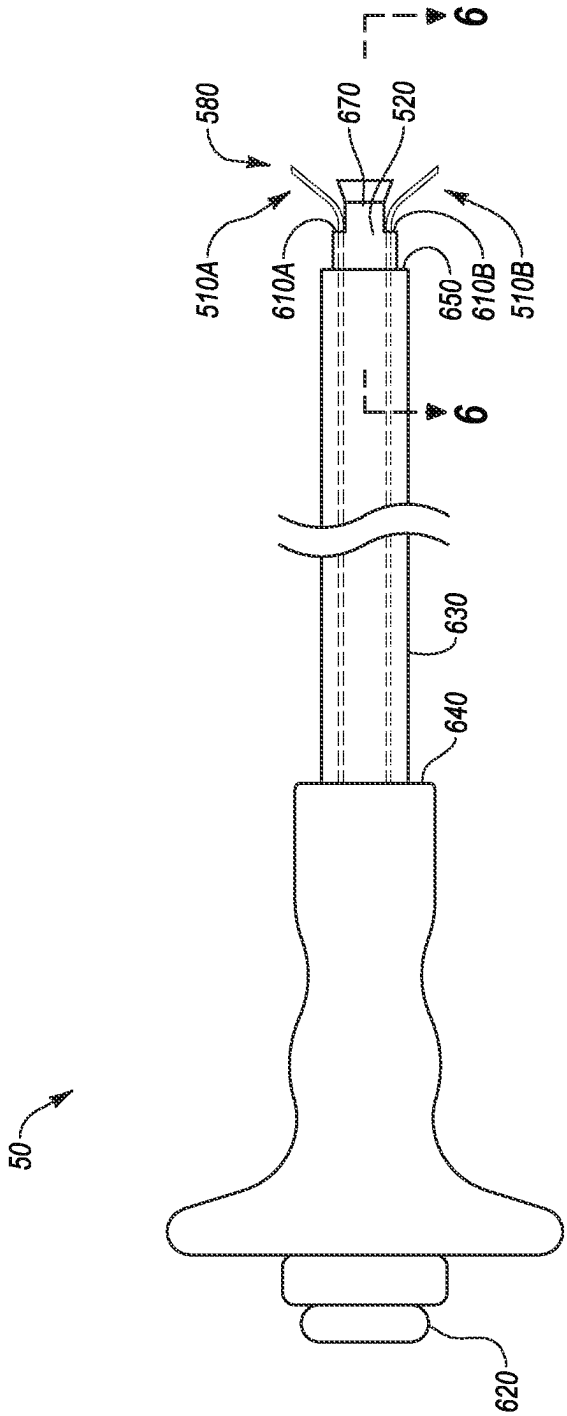

6
580
670
520
510A
610A
650
610B
510B
6
630
640
50
620

Fig. 7A

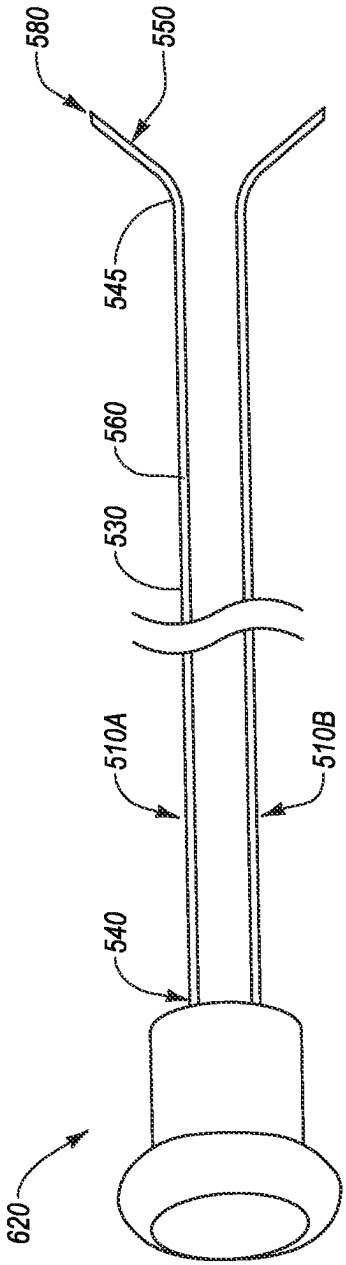

580
550
545
560
530
510A
510B
540
620

Fig. 7B

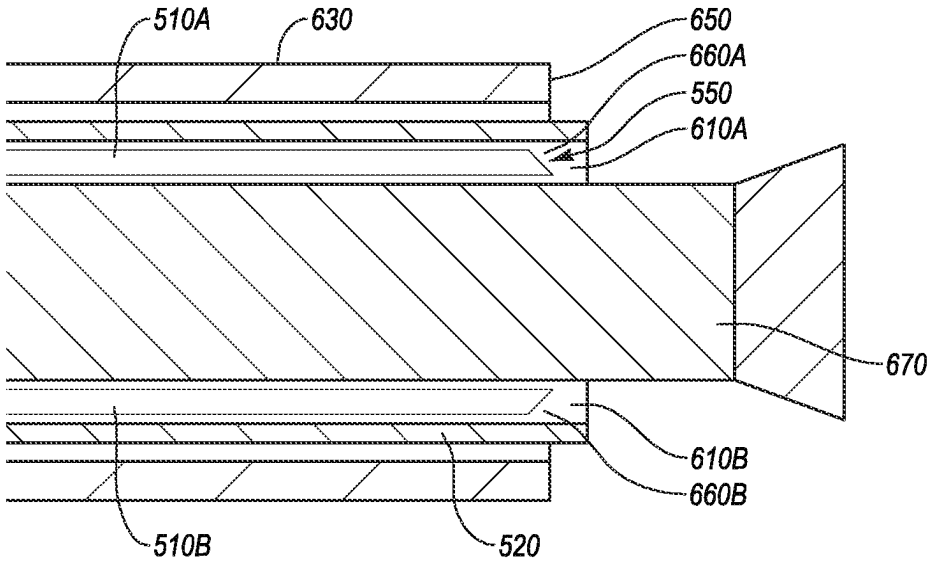

510A
630
650
660A
550
610A
670
610B
660B
510B
520

Fig. 8A

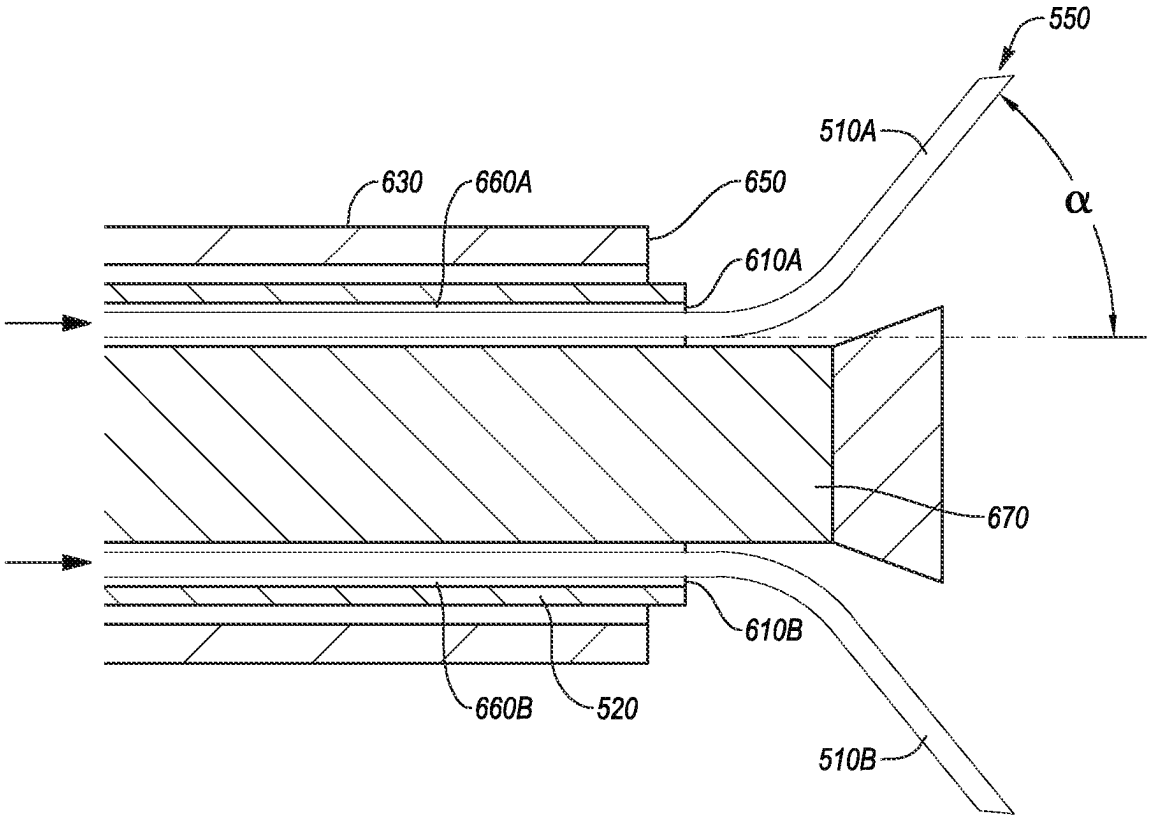

550
510A
α
630
660A
650
610A
670
610B
660B
520
510B

Fig. 8B

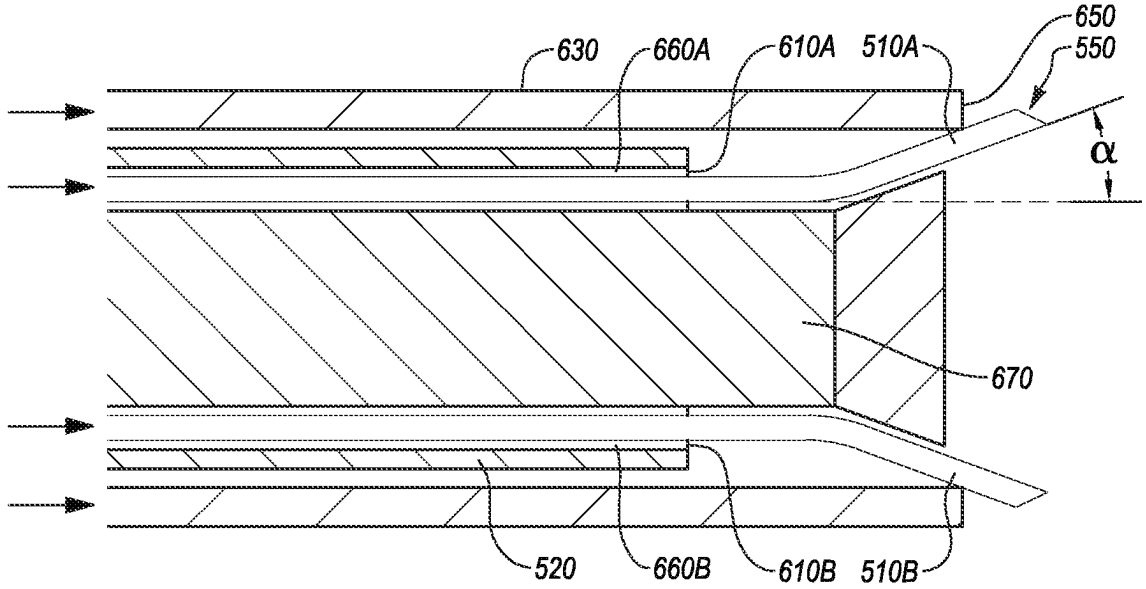

630
660A
610A
510A
650
550
α
670
520
660B
610B
510B

Fig. 8C

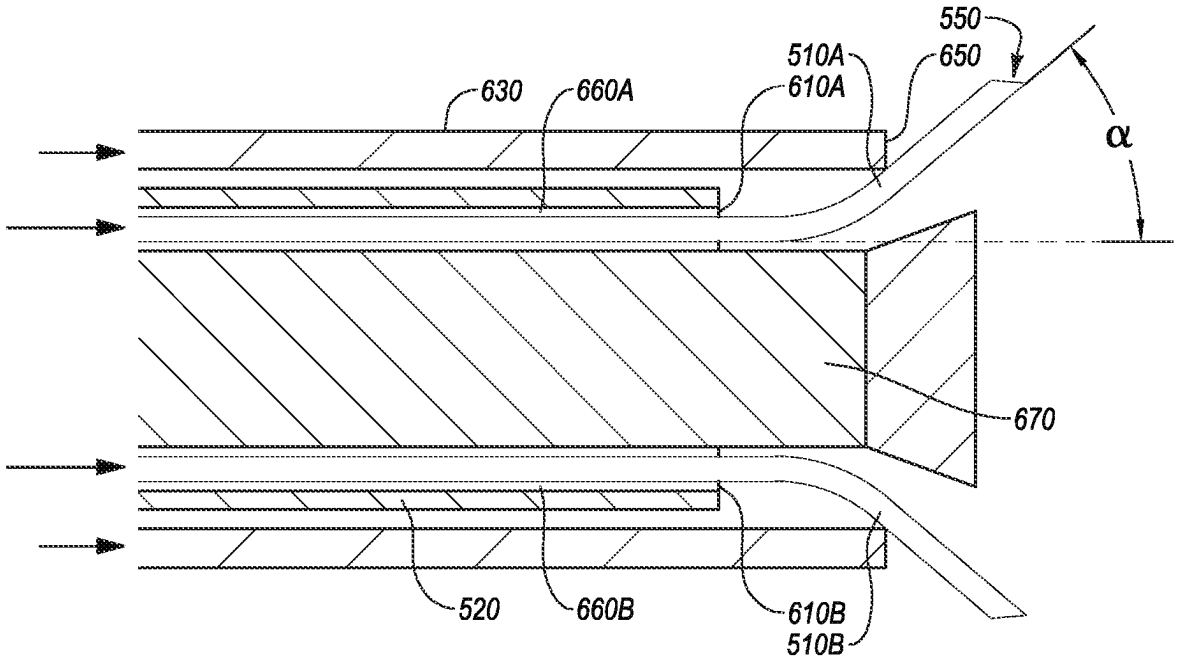

550
510A
650
630
660A
610A
α
670
520
660B
610B
510B

Fig. 8D

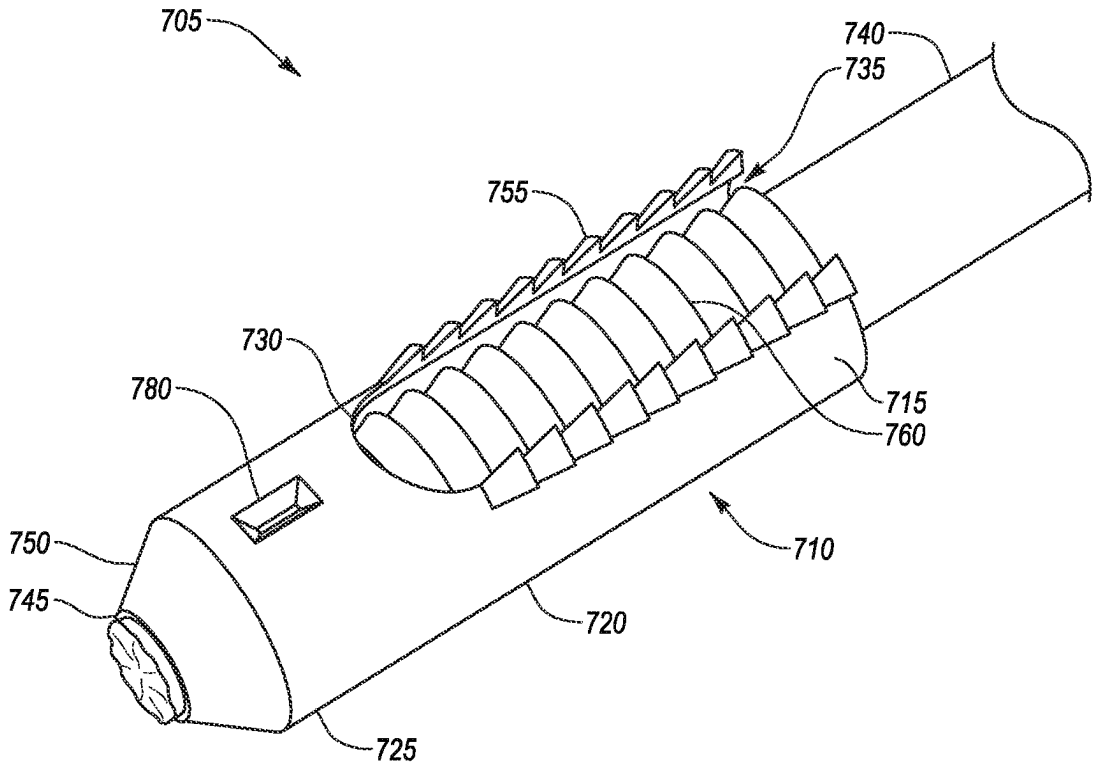


Fig. 9A

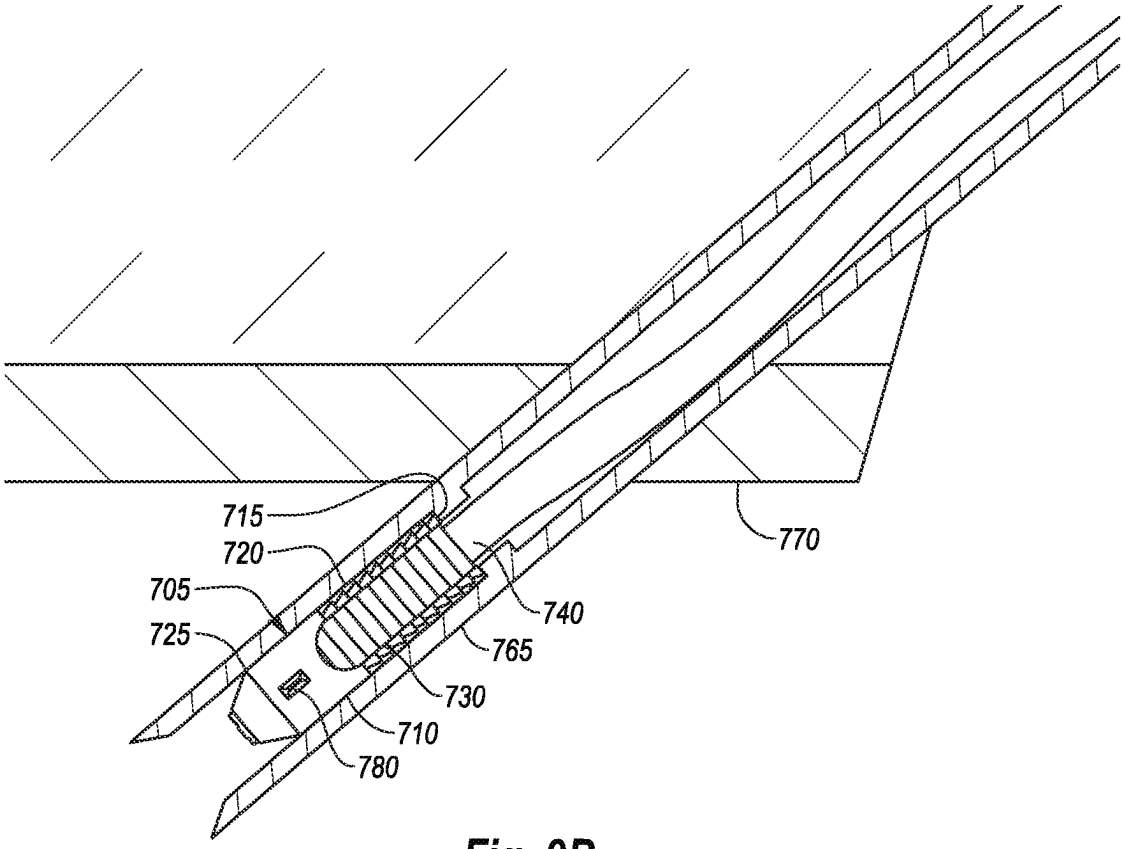

715
720
705
725
740
765
730
710
780
770

Fig. 9B

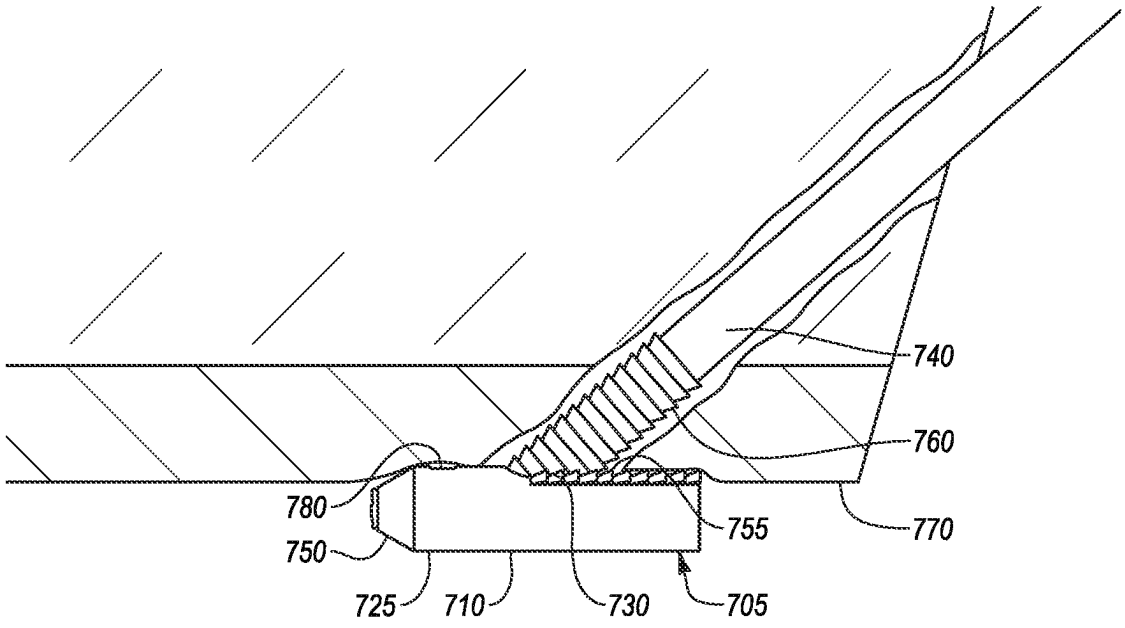

740
760
780
750
725
710
730
755
705
770

Fig. 9C

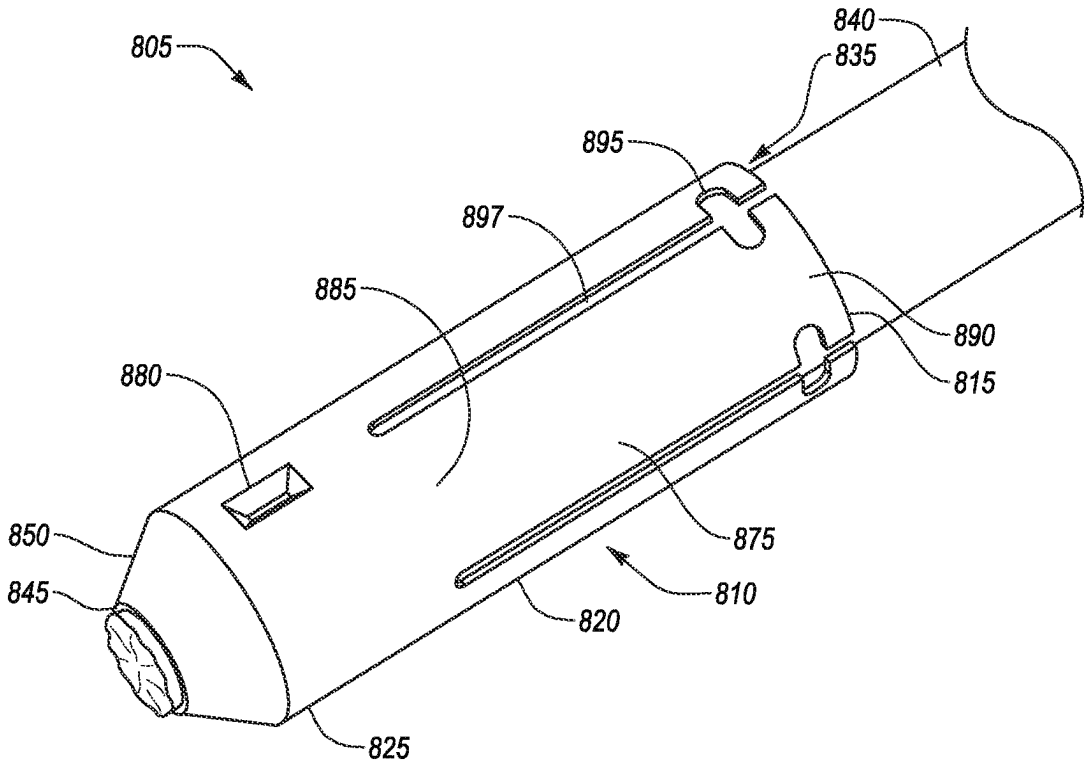


Fig. 10A

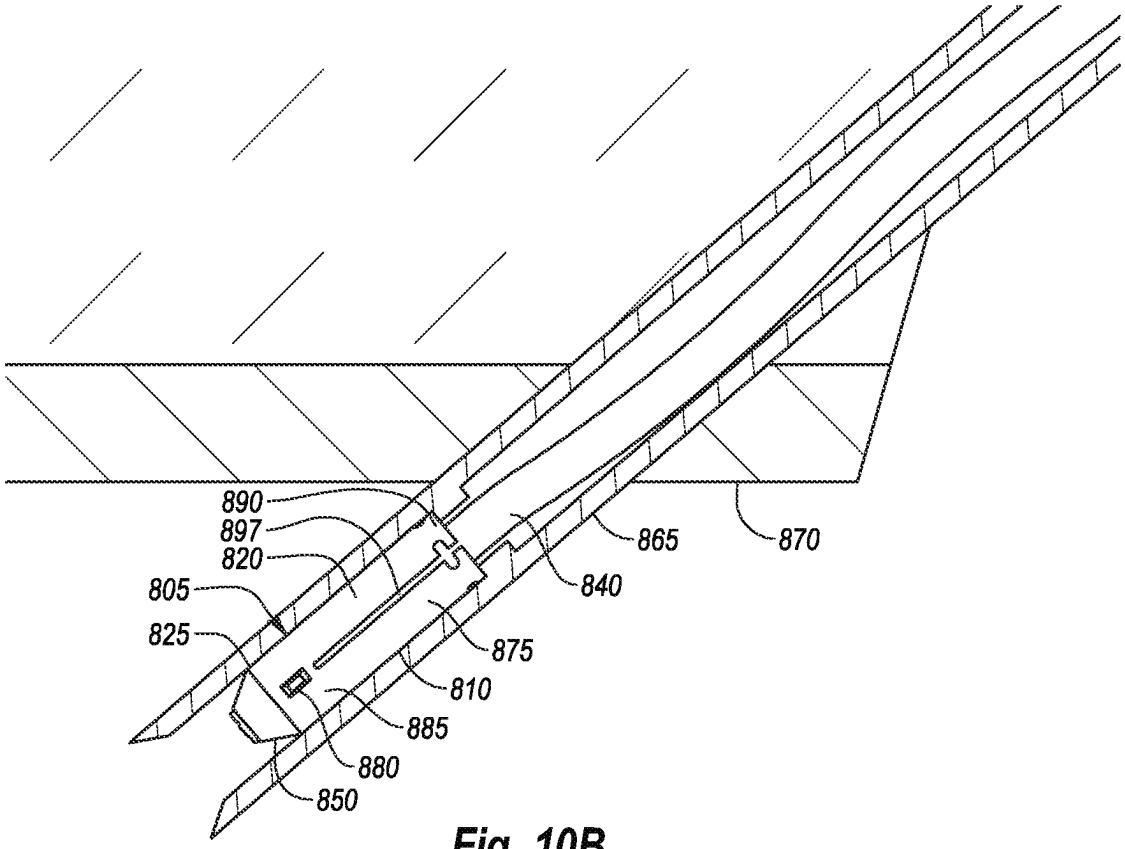


Fig. 10B

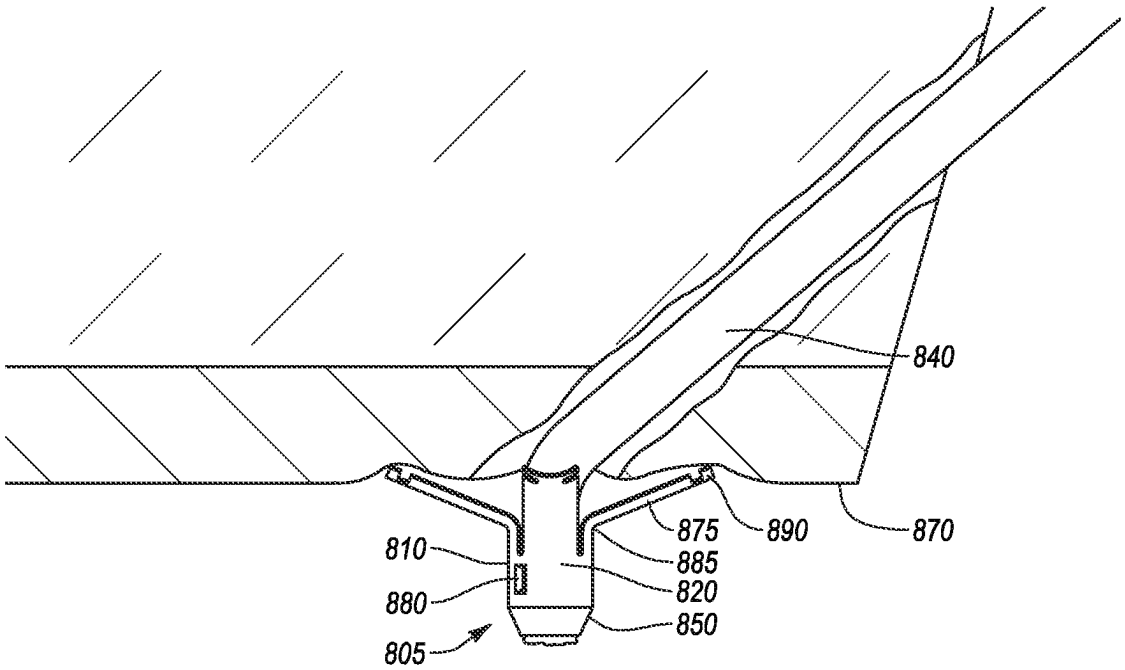


Fig. 10C

CLOSURE DEVICES AND METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 16/737,604, titled CLOSURE DEVICES AND METHODS, filed Jan. 8, 2020, which is a continuation of U.S. patent application Ser. No. 15/344,978, titled CLOSURE DEVICES AND METHODS, filed Nov. 7, 2016, now U.S. Pat. No. 10,537,313, which is a divisional of U.S. patent application Ser. No. 13/112,618, titled CLOSURE DEVICES AND METHODS, filed May 20, 2011, now U.S. Pat. No. 9,486,191, which is a continuation-in-part of U.S. patent application Ser. No. 12/684,470, titled CLOSURE DEVICES, SYSTEMS, AND METHODS, filed Jan. 8, 2010, now U.S. Pat. No. 9,414,820, which claims the benefit of U.S. Provisional Application No. 61/143,751, titled VESSEL CLOSURE DEVICES AND METHODS, filed Jan. 9, 2009, which are incorporated herein by reference in their entireties.

BACKGROUND

1. Technical Field

The present disclosure relates generally to medical devices and their methods of use. In particular, the present disclosure relates to vessel closure devices and corresponding methods of use.

2. The Technology

Catheterization and interventional procedures, such as angioplasty or stenting, generally are performed by inserting a hollow needle through a patient's skin and tissue into the vascular system. A guidewire may be advanced through the needle and into the patient's blood vessel accessed by the needle. The needle is then removed, enabling an introducer sheath to be advanced over the guidewire into the vessel, e.g., in conjunction with or subsequent to a dilator.

A catheter or other device may then be advanced through a lumen of the introducer sheath and over the guidewire into a position for performing a medical procedure. Thus, the introducer sheath may facilitate introducing various devices into the vessel, while minimizing trauma to the vessel wall and/or minimizing blood loss during a procedure.

Upon completing the procedure, the devices and introducer sheath are removed, leaving a puncture site in the vessel wall. Traditionally, external pressure would be applied to the puncture site until clotting and wound sealing occur; however, the patient must remain bedridden for a substantial period after clotting to ensure closure of the wound. This procedure may also be time consuming and expensive, requiring as much as an hour of a physician's or nurse's time. It is also uncomfortable for the patient and requires that the patient remain immobilized in the operating room, catheter lab, or holding area. In addition, a risk of hematoma exists from bleeding before hemostasis occurs. Although some closure systems may be available, they provide limited control and flexibility to the operator, which may lead to improper or undesirable closure of the puncture site.

BRIEF SUMMARY

The present invention provides a vessel closure device that is both manageable and versatile. A vessel closure device is provided that may include a guide member and one or more needle guides disposed at least partially within the guide member. The needle guides may be configured to move between a first position wherein the needle guides are substantially straightened at least partially within the guide member and a second position wherein the needle guides at least partially extend radially and distally away from the guide member. The vessel closure device may further include an angle adjustment member movably attached to the guide member. The angle adjustment member may be configured to move between a first position and a second position wherein the angle adjustment member can selectively deflect the needle guides radially toward the guide member when the needle guides are in the second position.

A vessel closure device is provided that may include a guide member and one or more needle guides moveably connected to the guide member. The needle guides may be configured to move between a first position wherein the needle guides are adjacent to the guide member and a second position wherein the needle guides at least partially extend distally away and radially outward from the guide member at a first angle. The vessel closure device may further include an angle adjustment member slidably attached to the guide member. The angle adjustment member may be configured to selectively reduce the first angle of the needle guides in the second position by selectively urging the needle guides toward the guide member.

A suture securing device is provided that may include an elongated body having a proximal end, a distal end, and an inner cavity. The elongated body may further include a first opening in the proximal end that is in communication with the inner cavity. The elongated body may further include a cutout extending distally from the first opening. The cutout may include tissue-engaging elements. The elongated body may be attached to a suture. The elongated body may be moveable between a first position wherein the elongated body is substantially parallel with a longitudinal axis of the suture and a second position wherein the elongated body is substantially non-parallel with the longitudinal axis of the suture and at least a portion of the suture is received within the cutout such that the elongated body can resist proximal movement against a distal surface of a vessel wall.

A suture securing device is provided that may include a body having a proximal end, a distal end, and an inner cavity. The body may further include a first opening in the proximal end and a second opening in the distal end, both in communication with the inner cavity. The body may further include elongated slots extending distally from the proximal end. The slots may define projections therebetween that have a fixed end connected to the body and a free end. The body may be attached to a suture extending through the inner cavity. The projections may be moveable between a first configuration wherein the projections are substantially parallel with a longitudinal axis of the body and a second configuration wherein the projections extend radially outwardly from the body such that the body can resist proximal movement against a distal surface of a vessel wall.

A vessel closure system is provided that may include a plurality of needle carriers having a distal end and a proximal end. The system may also include a plurality of detachable needles configured to resist proximal movement when deployed through a vessel wall. At least one of the detachable needles may be detachably coupled to the distal end of one of the needle carriers. The system may also include at least one suture secured to each of the detachable needles. A guide member can have a plurality of first lumens extending distally from a proximal end toward a distal end of the guide

member. Each of the first lumens can be sized to receive one of the needle carriers and one of the detachable needles coupled to the needle carrier. The first lumens can also be configured to direct the needle carrier and the detachable needle radially outward and distally away from the guide member. The system may also include an outer housing that has a second lumen defined between a distal end and a proximal end of the outer housing. The second lumen can be configured to receive at least a portion of the guide member. The distal end of the outer housing may also include a tapered tip portion. The tapered tip portion can be configured to move between a first configuration and a second configuration. An anchor member can also be configured to be at least partially disposed within the second lumen. The anchor member can comprise an anchor portion and an elongate portion. The anchor member can be disposed in the inner lumen in an initial configuration and move to an expanded configuration once positioned distally from the distal end of the outer housing. Finally, the system may include an expandable plug positioned between the guide member and the anchor member.

A method of closing a puncture in a vessel wall is provided that may include advancing a guide member into proximity with a puncture in a vessel wall, the guide member having openings near a distal end a plurality of needle guides disposed within. A distal end of an angle adjustment member, slidably coupled to the guide member, may then be positioned distal to the openings of the guide member. The needle guides and sutures and suture securing devices disposed within the needle guides may then be deployed distally and radially away from the guide member. The angle adjustment member may then deflect the needle guides toward a longitudinal axis of the guide member. The deflected needle guides and suture securing devices may then be advanced through the vessel wall. Thereafter, the needle guides may be retracted into the guide member to release the suture securing devices. Tension may then be established in the sutures to move the suture securing devices toward each other to thereby close the puncture.

These and other advantages and features of the present disclosure will become more fully apparent from the following description and appended claims, or may be learned by the practice of the disclosure as set forth hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

To further clarify at least some of the advantages and features of the present disclosure, a more particular description of the disclosure will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. It is appreciated that these drawings depict only illustrated embodiments of the disclosure and are therefore not to be considered limiting of its scope. The disclosure will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

FIG. **1**A illustrates a side view of a closure device according to one example;

FIG. **1**B illustrates an exploded view of the closure device of FIG. **1**A;

FIG. **1**C illustrates a cross-sectional view of the guide member and associated first plunger of FIG. **1**B taken along section **1**C-**1**C of FIG. **1**B;

FIG. **1**D illustrates a cross-sectional view of the closure device shown in FIG. **1**A taken along section **1**D-**1**D of FIG. **1**A;

FIG. **2**A illustrates a closure device in a pre-deployed state according to one example;

FIG. **2**B illustrates the closure device of FIG. **2**A in an intermediate state according to one example;

FIG. **2**C illustrates the closure device of FIGS. **2**A-**2**B in a deployed state;

FIG. **3**A illustrates steps for closing a puncture in a vessel wall in which a closure device is in a pre-deployed state and in proximity to an arteriotomy according to one example;

FIG. **3**B illustrates steps for closing a puncture in a vessel wall in which the closure device of FIG. **3**A is located relative to a vessel wall;

FIG. **3**C illustrates steps for closing a puncture in a vessel wall in which detachable needles are deployed through the vessel wall;

FIG. **3**D illustrates a more detailed view of engagement between a detachable needle and the vessel wall of FIG. **3**A;

FIG. **3**E illustrates steps for closing a puncture in a vessel wall in which the sutures and needles are secured in place to close the puncture in the vessel wall;

FIG. **4** illustrates a detachable needle according to one example;

FIG. **5**A illustrates a distal portion of a closure device according to one example;

FIG. **5**B illustrates the closure device shown in FIG. **5**A in a deployed state;

FIG. **6**A illustrates a cross-sectional view of the closure device shown in FIG. **5**A located relative to a vessel wall in a pre-deployed state;

FIG. **6**B illustrates a cross-sectional view of the closure device shown in FIG. **5**A located relative to a vessel wall in a semi-deployed state;

FIG. **7**A illustrates a side view of a closure device according to one example;

FIG. **7**B illustrates a perspective view of needle guides removed from the closure device shown in FIG. **7**A;

FIG. **8**A illustrates a cross-section view of the closure device taken along section **6**-**6** of FIG. **7**A with the needle guides in a pre-deployed state and an angle adjustment member in a retracted position;

FIG. **8**B illustrates the closure device shown in FIG. **8**A with the needle guides deployed from the closure device and the angle adjustment member in the retracted position;

FIG. **8**C illustrates the closure device shown in FIG. **8**A with the needle guides deployed from the closure device and the angle adjustment member in an extended position;

FIG. **8**D illustrates the closure device shown in FIG. **8**A with the needle guides deployed from the vessel closure device and the angle adjustment member in an intermediate position;

FIG. **9**A shows a perspective view of a suture securing device according to one example;

FIG. **9**B shows the suture securing device shown in FIG. **9**A deployed through a vessel wall in a low-profile configuration within a needle guide;

FIG. **9**C shows the suture securing device shown in FIG. **9**B released from the needle guide in an expanded configuration.

FIG. **10**A shows a perspective view of a suture securing device according to one example;

FIG. **10**B shows the suture securing device shown in FIG. **10**A deployed through a vessel wall in a collapsed configuration within a needle guide; and

FIG. **10**C shows the suture securing device shown in FIG. **10**B released from the needle guide in an expanded configuration.

It should be noted that the figures are not drawn to scale and that elements of similar structures or functions are generally represented by like reference numerals for illustrative purposes throughout the figures. It also should be noted that the figures are only intended to facilitate the description of example configurations of the present disclosure.

DETAILED DESCRIPTION

The present disclosure relates to devices and methods for closing an opening in a body lumen. In one example embodiment, a closure device of the present disclosure may allow an operator to quickly and efficiently close a body lumen opening or puncture in a vessel wall while simultaneously providing the operator with a greater measure of control and flexibility in positioning and anchoring the closure device than previously available. For example, the closure device may allow an operator to achieve a more intimate securement of a suture securing device in the tissue surrounding a body lumen opening. In a further embodiment, the closure device may be compatible with a wider range of body lumen wall thicknesses, thereby taking into account the possibility of calcifications or scar tissue in the lumen wall. In yet a further embodiment, the closure device may be compatible with varying sizes of body lumen openings.

FIG. **1**A illustrates a side view of a closure device **10** according to one example. The closure device **10** may include a handle **100**, an outer housing **110**, a first plunger **120** coupled to a guide member **130**, an optional plug **140**, a second plunger **150** coupled to a plurality of needle carriers **160**A, **160**B, a plurality of detachable needles **170**A, **170**B removably coupled to the needle carriers **160**A, **160**B respectively, an anchor member **180** and control members **190**A, **190**B coupled to the anchor member **180**.

The anchor member **180** and control members **190**A, **190**B may cooperate to allow the closure device **10** to be located relative to a puncture in a vessel wall, such as an arteriotomy. Any type of locator having any configuration may be used as desired to position the closure device **10** in proximity to a vessel wall.

In the illustrated example, the control members **190**A, **190**B can be manipulated to move the anchor member **180** between a pre-deployed state (not shown in FIG. **1**A) to the expanded or deployed state shown in FIG. **1**A. In particular, the control members **190**A, **190**B may be coupled to the anchor member **180** and extend proximally from the anchor member **180** through the plug **140**, the guide member **130**, the first plunger **120**, and the second plunger **150**. In the illustrated example, manipulation of the control members **190**A, **190**B may be performed manually, though it will be appreciated that any suitable device and/or method may be used to manipulate the control members **190**A, **190**B.

As shown in FIG. **1**B, the control members **190**A, **190**B and the anchor member **180** may form a continuous member. In such an example, retracting the control members **190**A, **190**B may anchor the anchor member **180** against an inner surface of a vessel wall or any other surface against which the anchor member **180** is positioned. In one embodiment, retracting both control members **190**A, **190**B simultaneously may produce tension or some other force in the anchor member **180** which may increase the resistance of the anchor member **180** to contracting.

For example, the tension of both control members **190**A, **190**B may be simultaneously transferred to the anchor member **180** thereby creating sufficient tension in the anchor member **180** to resist movement away from its expanded configuration. In addition, providing an opposing force against a proximal surface of the anchor member **180**, such as with a vessel wall, may also assist in creating sufficient tension in the anchor member **180** to resist contraction of the anchor member **180**. In a further implementation, the wires of the anchor member **180** may overlap or cross over each other in order to increase resistance.

In at least one example, retracting only one of the control members **190**A, **190**B, may lessen the tension in the anchor member **180**, thereby allowing the anchor member **180** to move from its deployed, expanded configuration to a contracted configuration. As a result, by retracting only one of the control members **190**A or **190**B, without applying tension to the other control member **190**B or **190**A or by applying a distal force to the other control member **190**B or **190**A, the anchor member **180** may contract and be retracted into the outer housing **110**.

Referring again to FIG. **1**A, the guide member **130** may be configured to house at least a portion of the control members **190**A, **190**B and to allow axial movement of the control members **190**A, **190**B relative to the guide member **130**. Such a configuration may allow the control members **190**A, **190**B to be manipulated at a proximal location to control the anchor member **180** at a distal location.

The guide member **130**, and thus the control members **190**A, **190**B that extend therethrough, may be at least partially housed within the outer housing **110** and/or within the handle **100**. As previously discussed, the guide member **130** may be coupled to the first plunger **120**. Such a configuration may cause actuation of the first plunger **120** to result in axial movement of the guide member **130**. In at least one example, axial movement of the first plunger **120** results in similar axial movement of the guide member **130**. Such a configuration may allow the first plunger **120** to extend and retract the guide member **130** from the outer housing **110** as desired. While actuation of the first plunger **120** may have been described with reference to axial movement of the first plunger **120** relative to the handle **100**, it will be appreciated that actuation of the first plunger **120** may include any type of action that results in desired movement of the guide member **130**.

The optional plug **140** may be secured to the distal end of the guide member **130** in such a manner that axial movement of the first plunger **120** also results in a corresponding movement of the plug **140**. Such a configuration may thereby allow axial movement of the first plunger **120** to also extend and retract the plug **140** from the outer housing **110** as desired by extending and retracting the guide member **130**. Although the guide member **130** and the plug **140** are shown as moving together, it will be appreciated that the plug **140** may also be independently controlled and moved, such as by the use of additional plungers and/or shafts.

In addition to serving as a mandrel to thereby move the plug, the guide member **130** may also be configured to house the needle carriers **160**A, **160**B and the detachable needles **170**A, **170**B. More specifically, the guide member **130** may be configured to allow the needle carriers **160**A, **160**B and the detachable needles **170**A, **170**B to move between a pre-deployed state (not shown in FIG. **1**A) and the deployed state shown in FIG. **1**A. In a pre-deployed state (not shown in FIG. **1**A), the needle carriers **160**A, **160**B and/or the detachable needles **170**A, **170**B are retracted within the guide member **130**. In the deployed state shown in FIG. **1**A, the detachable needles **170**A, **170**B and/or the needle carriers **160**A, **160**B extend radially and/or distally from the guide member **130**.

The needle carriers **160**A, **160**B are coupled to the second plunger **150** in such a way that actuation of the second plunger **150** causes the needle carriers **160**A, **160**B to move between the pre-deployed and deployed states described above. In at least one example, axial movement of the second plunger **150** relative to the first plunger **120** moves the needle carriers **160**A, **160**B between the pre-deployed and deployed states. While actuation of the second plunger **150** may be provided by axial movement of the second plunger **150** relative to the first plunger **120**, it will be appreciated that actuation of the second plunger **150** may include any type of action that results in desired movement of the needle carriers **160**A, **160**B.

As will be described in more detail, the actions described above allow the closure device **10** to deploy the detachable needles **170**A, **170**B into a vessel wall as part of a method for closing a puncture in the vessel wall. Exemplary structure of each of the components introduced above will first be introduced briefly followed by a discussion of the assembly and interaction of adjacent components. Thereafter, function of an exemplary closure device will be discussed, followed by a discussion of an exemplary method of closing a puncture in a vessel wall.

FIG. **1**B illustrates an exploded view of the closure device **10**. As illustrated in FIG. **1**B, the handle **100** includes a distal end **100**A and a proximal end **100**B. A guide member receiving lumen **102** extends proximally from the distal end **100**A. A first plunger receiving lumen **104** extends distally from the proximal end **100**B and is in communication with the guide member receiving lumen **102**. In the illustrated example, a shoulder **106** is formed at a transition between the guide member receiving lumen **102** and the first plunger receiving lumen **104**.

The outer housing **110** may be coupled to the distal end **100**A of the handle **100**. In particular, the outer housing **110** may include a distal end **110**A and a proximal end **110**B. A guide member receiving lumen **112** may be formed therein that extends through the distal end **110**A and the proximal end **110**B. The guide member receiving lumen **112** may be configured to allow the guide member **130** to move axially within the outer housing **110** as will be described in more detail hereinafter. In at least one example, the guide member receiving lumen **112** may have approximately the same size as the guide member receiving lumen **102** defined in the handle **102**.

As shown in FIG. **1**B, the proximal end **110**B of the outer housing **110**A may be coupled to the distal end **100**A of the handle **100** in such a manner that the guide member receiving lumens **102**, **112** are aligned to thereby form a single lumen that is in communication with the distal end **110**A of the outer housing **110** and the first plunger receiving lumen **104** in the handle **100**. Such a configuration may allow the first plunger **120** to move axially relative to the handle **100** while moving the guide member **130** axially relative to outer housing **110** and the handle **100**.

More specifically, the first plunger **120** may include a distal end **120**A and a proximal end **120**B. The distal end **120**A may be sized to fit within the first plunger receiving lumen **104**. In the example shown, proximal translation of the first plunger **120** relative to the handle **100** may be limited by engagement between the distal end **120**A of the first plunger **120** and the shoulder **106** in the handle **100**.

As previously introduced, the first plunger **120** may be coupled to the guide member **130**. In particular, the distal end **120**A of the first plunger **120** may be coupled to a proximal end **130**B of the guide member **130**. Accordingly, as the first plunger **120** moves proximally relative to the handle **100**, the proximal end **130**B of the guide member **130** also moves proximally relative to the handle **100** as well as to the outer housing **110**. In at least one example, axial movement of the proximal end **130**B of the guide member **130** results in a proportional or similar movement of a distal end **130**A. This may allow an operator to move the first plunger **120** axially to cause the distal end **130**A of the guide member **130** to move between a first position, in which the distal end **130**A is retracted within the distal end **110**A of the outer housing **110**, and various other positions, in which the distal end **130**A extends beyond the distal end **110**A of the outer housing **110** to varying extents. The distal end **130**A of the guide member **130** can be extended distally beyond the distal end **110**A of the outer housing **110** to deploy the plug **140** and/or position the needle carriers **160**A, **160**B for deployment. Deployment of the plug **140** will first be discussed, followed by a discussion of the deployment of the needle carriers **160**A, **160**B.

As previously introduced, the plug **140** may be coupled to the distal end of the guide member **130**. As a result, the plug **140** may be retracted within and extended from the distal end **110**A of the outer housing **110** by axial movement of the first plunger **120**.

In at least one example, the plug **140** may be formed of an expandable material. Suitable materials can include, without limitation, collagen and/or one or more polymers such as PEG. When the plug **140** is moved out of the outer housing **110**, the plug **140** may move toward an expanded state. Similarly, when the plug **140** is retracted back into the outer housing **110**, the plug **140** may be compressed to fit within the outer housing **110**. Accordingly, the distal end **130**A of the guide member **130** can be extended beyond the distal end **110**A of the outer housing **110** to deploy the plug **140** and/or retracted within the outer housing **110** to retrieve the plug **140**.

The distal end **130**A of the guide member **130** can also be extended beyond the distal end **110**A to allow for deployment of the needle carrier **160**A, **160**B. In particular, relative movement between the second plunger **150** and the first plunger **120** may move the needle carriers **160**A, **160**B between retracted and extended positions relative to the guide member **130**. The configuration of the guide member **130** will first be discussed in more detail, followed by a discussion of the interaction of the guide member **130** and the needle carriers **160**A, **160**B.

FIG. **1**C illustrates a cross-sectional view of the first plunger **120** and the guide member **130**. As shown in FIG. **1**C, the first plunger **120** has a second plunger receiving recess **124** defined therein that extends distally from a proximal end **120**B. The first plunger **120** also has needle carrier lumens **126**A, **126**B defined therein that extend proximally from the distal end **120**A and into communication with the second plunger receiving recess **124**. A shoulder **128** is formed at a junction of the needle carrier lumens **126**A, **126**B and the second plunger receiving recess **124**.

The guide member **130** may also have needle carrier lumens **132**A, **132**B defined therein that extend distally from the proximal end **130**B. In the illustrated example, the needle carrier lumens **132**A, **132**B include parallel or axially aligned portions **134**A, **134**B and curved, angled portions **136**A, **136**B that are in communication with openings **138**A, **138**B in the guide member **130**. The axially aligned portions **134**A, **134**B are aligned with the needle carrier lumens **126**A, **126**B defined in the first plunger **120** to thereby form continuous lumens that extend from near the distal end **130**A of the guide member **130** to the second plunger receiving recess **124** in the first plunger member **120**. The configura-

tion of the guide member **130** can allow the guide member **130** to house the needle carriers **160**A, **160**B (FIG. **1**B) therein prior to deployment and to guide the needle carriers **160**A, **160**B radially outward and distally away from the guide member **130**. An exemplary configuration of the needle carriers **160**A, **160**B will first be discussed, followed by the interaction between the needle carriers **160**A, **160**B and the guide member **130** with reference to FIG. **1**B.

As shown in FIG. **1**B, proximal ends **162**A, **162**B of the needle carriers **160**A, **160**B may be coupled to a distal end **150**A of the second plunger **150** in such a way that axial movement of the second plunger **150** results in similar movement of the needle carriers **160**A, **160**B, including distal ends **164**A, **164**B. As a result, when the second plunger **150** is positioned at least partially within the second plunger receiving lumen **124**, the needle carriers **160**A, **160**B extend through the first plunger **120** by way of the needle carrier lumens **126**A, **126**B and into the guide member **130** by way of needle carrier lumens **132**A, **132**B.

The distal ends **164**A, **164**B of the needle carriers **160** A, **160**B may be positioned such that axial movement of the second plunger **150** relative to the first plunger **120** moves the needle carriers **160**A, **160**B between retracted and extended positions relative to the guide member **130**. When the needle carriers **160**A, **160**B are retracted, the distal ends **164**A, **164**B of the needle carriers **160**A, **160**B may be positioned proximally and/or radially inward relative to the openings **138**A, **138**B. When the needle carriers **160**A, **160**B are extended, the distal ends **164**A, **164**B extend both radially outward and distally away from the openings **138**A, **138**B in the guide member **130**. Accordingly, the guide member **130** is configured to house the needle carriers **160**A, **160**B and to guide the needle carriers **160**A, **160**B between the retracted and extended positions described above.

In at least one example, guide member **130** can be used to initially position the anchor member **180**. Further, the guide member **130** may be configured to house the control members **190**A, **190**B in addition to the needle carriers **160**A, **160**B. FIG. **1**D illustrates a cross-sectional view of the closure device **10** taken along section **1**D-**1**D of FIG. **1**A. As shown in FIG. **1**D, the control member lumens **139**A, **139**B may be defined in the guide member **139**A, **139**B to pass through the guide member **130**. The control member lumens **139**A, **139**B may be positioned at any location and orientation desired. FIG. **1**D also illustrates that the needle carriers **160**A, **160**B may have suture lumens **166**A, **166**B defined therein. The suture lumens **166**A, **166**B may house sutures (not shown), which may be coupled to the detachable needles **170**A, **170**B (FIG. **1**B). As will be discussed in more detail below, the closure device **10** may be configured to deploy the detachable needles **170**A, **170**B (FIG. **1**B) through a vessel wall as part of a method for closing a puncture in a vessel wall. The function of the closure device **10** will first be described in isolation, followed by a discussion of the method for closing a puncture in a vessel wall using the closure device.

FIGS. **2**A-**2**C are cross-sectional views of the closure device **10** at various positions taken along section **2**-**2** of FIG. **1**A. In particular, FIG. **2**C is a cross-section view of the closure device **10** in the deployed state shown in FIG. **1**A while FIGS. **2**A and **2**B show the closure device in a pre-deployed state and a location state according to one example. For ease of reference, various components will be described in which one component is being moved toward a second component. It will be appreciated that a second member can also be moved toward the first member or some combination of movement of the two can also be used to accomplish the same function.

As shown in FIG. **2**A, while in a pre-deployed state the first plunger **120** is drawn proximally from the handle **100** to thereby position the distal end **130**A of the guide member **130** as well as the plug **140** within the outer housing **110**. While the plug **140** is thus positioned within the outer housing **110**, the plug **140** may be compressed (FIG. **1**B). Further, the second plunger **150** may be positioned proximally from the first plunger **120** to thereby position the distal ends **160**A, **160**B of the needle carriers **160**A, **160**B within the guide member **130**. As also shown in FIG. **2**A, the control members **190**A, **190**B may be manipulated and positioned to move the anchor member **180** to a pre-deployed position within the outer housing **110**.

The closure device **10** may be moved from the pre-deployed state shown in FIG. **2**A to the locator state shown in FIG. **2**B by manipulating the control members **190**A, **190**B and moving the first plunger **120** toward the handle **100**. In at least one example the second plunger **150** may move with the first plunger **120** as the first plunger **120** moves toward the handle **100**. Such a configuration may allow the second plunger **150** to deploy the needle carriers **160**A, **160**B separately from movement of the first plunger **120**.

As shown in FIG. **2**B, as the first plunger **120** moves toward the handle **100**, the anchor member **180**, the plug **140** and/or the distal end **130**A of the guide member **130** move distally from the distal end of the outer housing **110**. The anchor member **180** may then be manipulated by the control members **190**A, **190**B to move to the deployed state shown in FIG. **2**B.

More specifically, the anchor member **180** may be configured to move from an initial, contracted configuration within the outer housing **110** to a deployed, expanded configuration once deployed from the outer housing **110**. To facilitate movement from an initial, contracted configuration to a deployed, expanded configuration, the anchor member **180** may include one or more superelastic or shape memory materials such as shape memory alloys.

For example, the anchor member **180** may be heat set in a deployed, expanded configuration. The anchor member **180** may then be elastically deformed into an initial, contracted configuration contracted and disposed within the outer housing **110**. In its initial, contracted configuration shown in FIG. **2**A, the anchor member **180** may store sufficient energy to return to its deployed, expanded configuration once released from the outer housing **110** shown in FIG. **2**B.

Retracting the handle **100** in a proximal direction may position and/or anchor the anchor member **180** against a distal or inner surface of a vessel wall. In a further embodiment, further retracting the plunger member **130** in a proximal direction may retract the anchor member **180** from the vessel and/or into the outer housing **110**.

Once the anchor member **180** is at a desired position, the first plunger **120** can be moved toward the handle **100** while holding the control members **190**A, **190**B stationary to thereby the advance the plug **140** toward the anchor member **180**. The plug **140**, which may have expanded from the compressed state described above upon exiting the outer housing **110**, can thus be positioned relative to the anchor member **180**. Such a configuration can allow the closure device **10** to engage a proximal or outer surface of the vessel's walls of varying thicknesses as the plug **140** can be advanced until it engages a vessel wall since the anchor member **180** is positioned on an opposing side of the vessel

wall. Such a configuration can also place the distal end **130**A of the guide member **130** in position to deploy the needle carriers **160**A, **160**B.

As shown in FIG. **2**C, the needle carriers **160**A, **160**B can be deployed by moving the second plunger **150** toward the first plunger **120**. As the second plunger **150** moves toward the first plunger **120**, the needle carriers **160**A, **160**B, and the distal ends **164**A, **164**B in particular, move the detachable needles **170**A, **170**B distally and radially away from the distal end **130**A of the guide member **130**. Such a configuration can allow the detachable needles **170**A, **170**B to be moved into engagement with a vessel wall, as part of an exemplary method for closing a puncture in a vessel wall, which will now be discussed in more detail with reference to FIG. **3**A-**3**D.

FIG. **3**A illustrates first steps of a method for closing a puncture **300** in a vessel wall **310**. For ease of reference, only the distal portion of the closure device **10** is shown and described. It will be appreciated that the distal components can be manipulated by proximal components in a similar manner as described above with reference to FIGS. **1**A-**2**C.

Referring now to FIG. **3**A, the method can begin by positioning a distal end **110**A of the outer housing **110** in proximity with the puncture **300** while the closure device **10** is in a pre-deployed state. With the distal end **110**A of the outer housing **110** in proximity with the puncture **300**, the anchor member **180** can be passed through the puncture **300** and moved to the deployed, expanded position as shown in FIG. **3**B.

As shown in FIG. **3**C, the anchor member **180** can then be drawn proximally into engagement with an inner surface or posterior side **310**A of the vessel wall **310** adjacent the puncture **300** and the distal end **130**A of the guide member **130** can be urged distally toward the outer surface or anterior side **310**B of the vessel wall **310**, thereby positioning the vessel wall **310** adjacent the puncture **300** between the plug **140** and the anchor member **180**. With the vessel wall **310** positioned between the anchor member **180** and the plug **140**, the vessel wall **310** can be described as being located by the closure device **10** since the position of vessel wall **310** is established as being between the plug **140** and the anchor member **180**. In at least one example, the expanded plug **140** can cover the puncture **300** while pressure between the plug **140** and the anchor member can provide sufficient contact between the plug **140** and the vessel wall **310** to limit the flow of fluid from the puncture **300**.

As also shown in FIG. **3**C, when the guide member **130** is in position with respect to the vessel wall **310**, the distal end **130**A of the guide member **130** can be positioned distally of the distal end **110**A of the outer housing **110** to thereby expose the openings **138**A, **138**B (FIG. **1**C) from within the outer housing **110**. With the openings **138**A, **138**B (FIG. **1**C) thus exposed, the needle carriers **160**A, **160**B and detachable needles **170**A, **170**B can be moved distally beyond and radially outward from the distal end **130**A of the guide member **130** to move the detachable needles **170**A, **170**B at least partially through the vessel wall **310** on opposing sides of the puncture **300**. As shown, the anchor member **180** in the expanded state can extend beyond the position of the detachable needles **170**A, **170**B in the vessel wall **310**. Such a configuration can improve the ability of the anchor member **180** to support user pullback by increasing the area over which the anchor member **180** engages the inner surface of the vessel wall **300**. In addition, the loop-type configuration of the anchor member **180** in the expanded state can allow the anchor member **180** to locate the vessel wall **310** without substantial interference from the detachable needles **170**A, **170**B. While the anchor member **180** in the expanded state is shown extending beyond the position of the detachable needle **170**A, **170**B, any size and/or configuration of the anchor member **180** that is suitable to support user pullback against the vessel wall **310** is possible. In one embodiment, the anchor member **180** in the expanded state can extend between the position of the detachable needles **170**A, **170**B and the sides of the puncture **300**. In other embodiments, the anchor member **180** in the expanded state can extend considerably beyond the position of the detachable needles **170**A, **170**B.

FIG. **3**D shows the detachable needle **170**A in more detail. While a single detachable needle **170**A is shown in FIG. **3**D, it will be appreciated that the discussion of the detachable needle **170**A can be equally applicable to the detachable needle **170**B (FIG. **3**C) as well as any number of other detachable needles. As shown in FIG. **3**D, the detachable needle **170**A may include features that allow it to readily pierce the vessel wall **310** while resisting retraction therefrom. In particular, the detachable needle **170**A includes a generally conical body **172** having a tip **174** and a base **176**. The detachable needle **170**A may also include a shaft **178** coupled to the base **178**.

In at least one example, the shaft **178** is configured to have a suture **320** coupled thereto. The shaft **178** can be further configured to be positioned within the suture lumen **166**A to provide a slip fit between the needle carrier **160**A and the shaft **178**. The shaft **178** may also have a narrower aspect than the base **176**. Such a configuration allows the needle carrier **160**A to exert a distally acting force on the detachable needle **170**A by way of the base **176**. Such a distally acting force can cause the tip **174** to pierce the vessel wall **310** while the width of the base **176** anchors the detachable needle **170**A to the vessel wall **310** and resists proximal retraction.

Referring again to FIG. **3**C, once the detachable needles **170**A, **170**B are anchored in the vessel wall **310**, the needle carriers **160**A, **160**B can be drawn proximally into the guide member **130**. The engagement between the detachable needles **170**A, **170**B and the vessel wall **310** can be sufficient to detach the detachable needles **170**A, **170**B from the needle carriers **160**A, **160**B as the needle carriers **160**A, **160**B are withdrawn.

After the needle carriers **160**A, **160**B are drawn into the guide member **130**, one of the control members **190**A, **190**B can be moved in one direction more than the other of the control members **190**A, **190**B to move the anchor member **180** into a contracted or collapsed state. The guide member **130**, the plug **140**, and the control member **180** can then be drawn into the outer housing **110**. Thereafter, the closure device **10** can be withdrawn, leaving the detachable needles **170**A, **170**B engaged in the vessel wall **310** with the sutures **320** extending proximally from the detachable needles **170**A, **170**B as shown in FIG. **3**E.

As also shown in FIG. **3**E, a constrictor **330** can be passed over the sutures **320**. The constrictor **330** can have a smaller diameter than the distance between the detachable needles **170**A, **170**B. As a result, moving the constrictor **330** over the sutures **320** while maintaining tension on the sutures **320** can act to draw the detachable needles **170**A, **170**B toward each other, thereby pulling the puncture **300** closed, as shown in FIG. **3**E.

Once the puncture **300** is sufficiently closed, the constrictor **330** can be secured to maintain tension in the sutures **320** between the detachable needles **170**A, **170**B and the constrictor **330**. For example, in one embodiment the constrictor **330** can be an annular member that can be crimped to

maintain the tension in the sutures **320**. While an annular member can be used, it will be appreciated that any constrictor can be used to establish tension in the sutures **170**A, **170**B. It will also be appreciated that any suitable means may also be used to maintain the tension in the sutures **170**A, **170**B. Thereafter, the sutures **170**A, **170**B can be trimmed as desired using any appropriate method and/or device.

Accordingly, as shown in FIGS. **1**A-**3**E, the closure device **10** can be configured to deploy detachable needles **170**A, **170**B in a vessel wall **310**. A constrictor **330** can then be used to establish tension in suture extending away from the detachable needles **170**A, **170**B to thereby close the puncture **300** in the vessel wall **310**. In the illustrated example, two needle carriers **160**A, **160**B and detachable needles **170**A, **170**B have been described. It will be appreciated that in other examples, any number of needle carriers and detachable needles can be used, include four or more needle carriers and detachable needles.

In the example shown above, the detachable needles included a conical shape in which the sutures are anchored in a vessel wall by engagement with a proximal portion of the detachable needle. FIG. **4** illustrates one configuration for a detachable needle **340**. The detachable needle **340** can have a body **350** having a tapered point **360**. A suture **320** can be positioned in a manner that causes the detachable needle **340** to rotate when tension is applied to the suture **320** to thereby cause a lateral portion of the detachable needle **340** to engage a vessel wall to thereby anchor the detachable needle **340** thereto. For example, the suture **320** can be offset either radially from a center axis **370** of the detachable needle **340** and/or distally from a proximal end **380** of the body **350**.

FIGS. **5**A-**6**B illustrate a vessel closure device **40** according to one example. The closure device **40** may be similar in many respects to the closure device **10** previously described above in FIGS. **1**A-**4**, wherein certain features will not be described in relation to this configuration wherein those components may function in the manner as described above and are hereby incorporated into this additional configuration described below. As shown in FIG. **5**A, the closure device **40** may include an outer sheath **410** having a distal end with a tapered tip portion **420**. The tapered tip portion **420** may be formed of a polymer or any other suitable biocompatible material. The tapered tip portion **420** may be coupled to the outer sheath **410** or may be integrally formed on the outer sheath **410**. In one embodiment, the tapered tip portion **420** may include slits radially spaced about the tapered tip portion **420** and extending proximally from a distal end of the tapered tip portion **420**. The slits **430** may define intermediate portions of the tapered tip portion **420**, each intermediate portion having a free end and a fixed end. The slits **430** may be elongated, triangular, diamond shaped, oval, or any other configuration and/or shape suitable to define the intermediate portions of the tapered tip portion **420**. As shown in FIG. **5**B, the slits **430** may allow the intermediate portions of the tapered tip portion **420** to expand or open up as a guide member **490**, a plug **440**, an anchor member **480**, or needle guides **460**A, **460**B and detachable needles **470**A, **470**B are advanced from within the outer sheath **410**. Such a configuration can help protect the guide member **490**, the plug **440**, the anchor member **480**, the needle guides **460**A, **460**B and the detachable needles **470**A, **470**B, and/or the access tract. For example, the tapered tip portion **420** may help protect the access tract from damage that may be caused by the guide member **490**, the plug **440**, the anchor member **480**, the needle guides **460**A, **460**B and the detachable needles **470**A, **470**B by enclosing them within the outer sheath **410** up until immediately adjacent a puncture **300**. In addition, enclosing the same components within the outer sheath **410** up until immediately adjacent the puncture may help protect and improve the implementation of the guide member **490**, the plug **440**, the anchor member **480**, the needle guides **460**A, **460**B and the detachable needles **470**A, **470**B by limiting interference from the access tract and/or other biological materials. Moreover, the conical shape of the tapered tip portion **420** can help ease advancement of the outer sheath **410** through the access tract.

FIGS. **6**A and **6**B illustrate the tapered tip portion **420** in a first configuration and an expanded or open configuration over a puncture in a vessel wall **310**. As shown in FIG. **6**A, the distal portion of the outer sheath **410** may be advanced through the access tract and the tapered tip portion **420** may be positioned slightly within the puncture **300**. With the tapered tip portion **420** positioned in the puncture **300**, the anchor member **480** can be passed directly into the puncture **300**. The anchor member **480** can then be moved to a deployed expanded position as shown in FIG. **6**B. The guide member **490** and plug **440** can then be urged through the tapered tip portion **420** and distally toward an outer surface of a vessel wall **310**. As shown in FIG. **6**B, urging the guide member **490** and the plug **440** through the tapered tip portion **420** can rotate the intermediate portions of the tapered tip portion **420** about pivot points **495** which in turn can cause the tapered tip portion **420** to expand or open up. In other embodiments, the intermediate portions of the tapered tip portion **420** can be flexed outward by the plug **440** and/or the guide member **490** to cause the tapered tip portion to expand or open up. In one embodiment, once the plug **440** and the anchor member **480** are positioned on opposite sides of the vessel wall **310**, the outer housing **410** may be retracted distally a predetermined distance to allow for deployment of the needle guides **460**A, **460**B and the detachable needles **470**A, **470**B from the guide member **490**.

Accordingly, as shown in FIGS. **5**A-**6**B, the tapered tip portion **420** of the closure device may be configured to ease the advancement of the closure device **40** through an access tract; aid in the protection of the access tract, the closure device **40** and components thereof; and improve implementation of the closure device's components within the access tract.

Embodiments of the anchor, detachable needles and the like may include a material made from any of a variety of known suitable biocompatible materials, such as a biocompatible shape memory material (SMM). For example, the SMM may be shaped in a manner that allows for a delivery orientation while within the tube set, but may automatically retain the memory shape of the detachable needles once deployed into the tissue to close the opening. SMMs have a shape memory effect in which they may be made to remember a particular shape. Once a shape has been remembered, the SMM may be bent out of shape or deformed and then returned to its original shape by unloading from strain or heating. Typically, SMMs may be shape memory alloys (SMA) comprised of metal alloys, or shape memory plastics (SMP) comprised of polymers. The materials may also be referred to as being superelastic.

Usually, an SMA may have an initial shape that may then be configured into a memory shape by heating the SMA and conforming the SMA into the desired memory shape. After the SMA is cooled, the desired memory shape may be retained. This allows for the SMA to be bent, straightened, twisted, compacted, and placed into various contortions by the application of requisite forces; however, after the forces

are released, the SMA may be capable of returning to the memory shape. The main types of SMAs are as follows: copper-zinc-aluminum; copper-aluminum-nickel; nickel-titanium (NiTi) alloys known as nitinol; nickel-titanium platinum; nickel-titanium palladium; and cobalt-chromium-nickel alloys or cobalt-chromium-nickel-molybdenum alloys known as elgiloy alloys. The temperatures at which the SMA changes its crystallographic structure are characteristic of the alloy, and may be tuned by varying the elemental ratios or by the conditions of manufacture. This may be used to tune the detachable needles so that it reverts to the memory shape to close the arteriotomy when deployed at body temperature and when being released from the tube set.

For example, the primary material of an anchor, detachable needles, and/or ring may be of a NiTi alloy that forms superelastic nitinol. In the present case, nitinol materials may be trained to remember a certain shape, retained within the tube set, and then deployed from the tube set so that the tines penetrate the tissue as it returns to its trained shape and closes the opening. Also, additional materials may be added to the nitinol depending on the desired characteristic. The alloy may be utilized having linear elastic properties or non-linear elastic properties.

An SMP is a shape-shifting plastic that may be fashioned into a detachable needles in accordance with the present disclosure. Also, it may be beneficial to include at least one layer of an SMA and at least one layer of an SMP to form a multilayered body; however, any appropriate combination of materials may be used to form a multilayered device. When an SMP encounters a temperature above the lowest melting point of the individual polymers, the blend makes a transition to a rubbery state. The elastic modulus may change more than two orders of magnitude across the transition temperature (Ttr). As such, an SMP may be formed into a desired shape of an endoprosthesis by heating it above the Ttr, fixing the SMP into the new shape, and cooling the material below Ttr. The SMP may then be arranged into a temporary shape by force and then resume the memory shape once the force has been released. Examples of SMPs include, but are not limited to, biodegradable polymers, such as oligo(ϵ-caprolactone)diol, oligo(ρ-dioxanone)diol, and non-biodegradable polymers such as, polynorborene, polyisoprene, styrene butadiene, polyurethane-based materials, vinyl acetate-polyester-based compounds, and others yet to be determined. As such, any SMP may be used in accordance with the present disclosure.

An anchor, detachable needles, ring and the like may have at least one layer made of an SMM or suitable superelastic material and other suitable layers may be compressed or restrained in its delivery configuration within the garage tube or inner lumen, and then deployed into the tissue so that it transforms to the trained shape. For example, a detachable needles transitions to close the opening in the body lumen while an anchor may expand to anchor the closure device.

Also, the anchor, detachable needles, ring, or other aspects or components of the closure device may be comprised of a variety of known suitable deformable materials, including stainless steel, silver, platinum, tantalum, palladium, nickel, titanium, nitinol, nitinol having tertiary materials (U.S. 2005/0038500, which is incorporated herein by reference, in its entirety), niobium-tantalum alloy optionally doped with a tertiary material (U.S. 2004/0158309, 2007/0276488, and 2008/0312740, which are each incorporated herein by reference, in their entireties) cobalt-chromium alloys, or other known biocompatible materials. Such biocompatible materials may include a suitable biocompatible polymer in addition to or in place of a suitable metal. The polymeric detachable needles may include biodegradable or bioabsorbable materials, which may be either plastically deformable or capable of being set in the deployed configuration.

In one embodiment, the detachable needles, anchor, and/or ring may be made from a superelastic alloy such as nickel-titanium or nitinol, and includes a ternary element selected from the group of chemical elements consisting of iridium, platinum, gold, rhenium, tungsten, palladium, rhodium, tantalum, silver, ruthenium, or hafnium. The added ternary element improves the radiopacity of the nitinol detachable needles. The nitinol detachable needles has improved radiopacity yet retains its superelastic and shape memory behavior and further maintains a thin body thickness for high flexibility.

In one embodiment, the anchor, detachable needles, and/or ring may be made at least in part of a high strength, low modulus metal alloy comprising Niobium, Tantalum, and at least one element selected from the group consisting of Zirconium, Tungsten, and Molybdenum.

In further embodiments, the detachable needles, anchor, and/or ring may be made from or be coated with a biocompatible polymer. Examples of such biocompatible polymeric materials may include hydrophilic polymer, hydrophobic polymer biodegradable polymers, bioabsorbable polymers, and monomers thereof. Examples of such polymers may include nylons, poly(alpha-hydroxy esters), polylactic acids, polylactides, poly-L-lactide, poly-DL-lactide, poly-L-lactide-co-DL-lactide, polyglycolic acids, polyglycolide, poly-lactic-co-glycolic acids, polyglycolide-co-lactide, polyglycolide-co-DL-lactide, polyglycolide-co-L-lactide, polyanhydrides, polyanhydride-co-imides, polyesters, polyorthoesters, polycaprolactones, polyesters, polyanydrides, polyphosphazenes, polyester amides, polyester urethanes, polycarbonates, polytrimethylene carbonates, polyglycolide-co-trimethylene carbonates, poly(PBA-carbonates), polyfumarates, polypropylene fumarate, poly(p-dioxanone), polyhydroxyalkanoates, polyamino acids, poly-L-tyrosines, poly(beta-hydroxybutyrate), polyhydroxybutyrate-hydroxyvaleric acids, polyethylenes, polypropylenes, polyaliphatics, polyvinylalcohols, polyvinylacetates, hydrophobic/hydrophilic copolymers, alkylvinylalcohol copolymers, ethylenevinylalcohol copolymers (EVAL), propylenevinylalcohol copolymers, polyvinylpyrrolidone (PVP), combinations thereof, polymers having monomers thereof, or the like.

In yet a further embodiment, a closure device **50** may include needle guides that can be deployed from the closure device **50** at varying angles. The closure device **50** may be similar in many respects to the closure devices **10** and **40** previously described above in FIGS. **1**A-**6**B, wherein certain features will not be described in relation to this configuration wherein those components may function in the manner as described above and are hereby incorporated into this additional configuration described below.

FIG. **7**A shows a side view of the closure device **50**. As shown, the closure device **50** may include a guide member **520**, needle guides **510**A, **510**B deployable from the guide member **520**, a needle guide activation handle **620** coupled to the needle guides **510**A, **510**B, and an angle adjustment member **630** movably attached to the guide member **520**. FIG. **7**B shows the needle guides **510**A, **510**B removed from the closure device **50**. While features of a single needle guide **510**A are discussed, it will be appreciated that any discussion of the features of the needle guide **510**A can be equally applicable to the features of the needle guide **510**B as well as any number of other needle guides.

The needle guides **510**A, **510**B may comprise a substantially flexible or semi-rigid body **530** having a proximal portion **540** and a distal portion **550**. The proximal portions **540** are substantially parallel to or axially aligned with one another, whereas the distal portions **550** of the needle guides **510**A, **510**B may be angled or curved to extend laterally outward from the proximal portions **540**. In one embodiment, the distal portions **550** of the needle guides **510**A, **510**B may be self-biased to extend laterally outward from the proximal portions **540**. In another embodiment, the needle guides **510**A, **510**B may have a memory shape where the distal portions **550** extend laterally outward from the proximal portions **540**. The needle guides **510**A, **510**B can be configured such that the needle guides **510**A, **510**B can be forcibly straightened but return to their curved or angled shape upon release from external forces.

As discussed in more detail below, the design of the needle guides **510**A, **510**B allows the angle adjustment member **630** to be configured to adjust a deployment angle "α" of the needle guides **510**A, **510**B. The deployment angle "α" is defined as the greatest acute angle between the needle guides **510**A, **510**B and a longitudinal axis of the guide member **520**. In one configuration, the deployment angle "α" is in a range between about 20 degrees and about 60 degrees, while in another configuration the deployment angle "α" is between about 30 degrees and 50 degrees. One skilled in the art will understand that the deployment angle "α" can range between any puncture angle commonly used to suture an body lumen opening. Adjusting the deployment angle "α" allows the closure device **50** to be used on body lumen openings of varying sizes.

It will be understood by those skilled in the art that various other configurations of the needle guides **510**A, **510**B are possible. For example, although the needle guides **510**A, **510**B have at least an angled or curved portion **545**, the body **530** of the needle guides **510**A, **510**B being entirely curved or substantially angled is possible. Moreover, the needle guides **510**A, **510**B may include a substantially rigid portion, a flexible portion and/or a semi-rigid portion. The needle guides **510**A, **510**B may be comprised of a biocompatible material such as one or more polymers, elastomers, plastics, metals, composites, other similar materials, or any combination thereof. The needle guides **510**A, **510**B may also include one or more superelastic or shape memory materials such as shape memory alloys. The needle guides **510**A, **510**B may have a cross-sectional configuration that is rectangular, circular, elliptical, triangular, uniform, varying, substantially solid, substantially hollow, or any other cross-sectional configuration suitable for deployment through a vessel wall (not shown in FIG. **7**A). In one embodiment, the needle guides **510**A, **510**B may be configured to hold a suture (not shown) and/or a suture securing device (not shown). For example, the needle guides **510**A, **510**B can include a suture lumen **560** defined between the proximal portion **540** and the distal portion **550**. The suture lumens **560** can be sized, shaped and/or configured to hold the suture and/or the suture securing device. Further, although two needle guides **510**A, **510**B are shown, one needle guide or a plurality of needle guides is possible. The needle guides **510**A, **510**B can also be configured to form a penetration path though a vessel wall **570** immediately surrounding a body lumen opening. As shown, the distal portion **550** of the needle guides **510**A, **510**B may include a penetrator tip **580**. In another embodiment, the needle guides **510**A, **510**B may include a detachable penetrator tip disposed on the distal portion **550**. In a further example, the penetrator tip **580** may comprise one or more sharpened edges on the distal portion **550** of the needle guides **510**A, **510**B.

As illustrated in FIG. **7**A, the needle guides **510**A, **510**B can extend longitudinally along the length of the guide member **520** toward openings **610**A, **610**B near the distal end **670** of the guide member **520** (as shown by hidden lines in FIG. **7**A). While the needle guides **510**A, **510**B are shown disposed within the guide member **520**, the needle guides **510**A, **510**B disposed on the guide member **520** are possible. For example, the needle guides **510**A, **510**B may be positioned in between the outer surface of the guide member **520** and the inner surface of the angle adjustment member **630** in longitudinal grooves (not shown) formed on the outer surface of the guide member **520**.

The needle guide activation plunger or handle **620** can be coupled to the needle guides **510**A, **510**B such that movement of the needle guide activation handle **620** can deploy the needle guides **510**A, **510**B though openings the **610**A, **610**B and distally of the guide member **520**. While a needle activation plunger or handle is shown, any number of mechanisms can deploy the needle guides **510**A, **510**B distally of the guide member **520** such as a release button, a trigger, an actuator, or other mechanisms capable of deploying the needle guides **510**A, **510**B.

The angle adjustment member **630** may include a proximal end **640** and a distal end **650** and concentrically surround the guide member **520**. The angle adjustment member **630** can be configured to support the needle guide activation handle **620** and move relative to the length of the guide member **520**. In another embodiment, the guide member **520** may move relative to the angle adjustment member **630**. The angle adjustment member **630** may be further configured so that the angle adjustment member **630** can adjust the deployment angle "α" of the needle guides **510**A, **510**B. While the angle adjustment member **630** is shown as a sheath, the angle adjustment member **630** may comprise elongate members moveably attached to opposing sides of the guide member **520**, or an annular member moveably attached to the guide member **520** having one or more deflector rods aligned with the openings **610**A, **610**B, or any other configuration suitable to adjust the deployment angle "α" of the needle guides **510**A.

FIGS. **8**A-**8**D are cross-sectional views of the closure device **50** taken at various positions along section **6**-**6** of FIG. **7**A to illustrate adjustment of the deployment angle "α" by the angle adjustment member **630**. As shown in FIG. **8**A, while in a pre-deployed state the needle guides **510**A, **510**B may be positioned within the guide member **520**. Again, while the needle guides **510**A, **510**B are shown disposed within the guide member **520**, needle guides **510**A, **510**B disposed on the guide member **520** are possible. As shown, the guide member **520** may include a plurality of lumens **660**A, **660**B extending distally toward the openings **610**A, **610**B of the guide member **520**. The lumens **660**A, **660**B may be sized to receive at least one of the needle guides **510**A, **510**B. The lumens **660**A, **660**B may extend parallel to the longitudinal axis of the guide member **520**. The needle guides **510**A, **510**B may be forcibly straightened within the lumens **660**A, **660**B. This facilitates low-profile storage of the needle guides **510**A, **510**B and the closure device **10** generally. Moreover, storage of the needle guides **510**A, **510**B within the lumens **660**A, **660**B can help prevent contamination of the needle guides **510**A, **510**B.

The openings **610**A, **610**B may be aligned along the longitudinal axis of the guide member **520** and be in fluid communication with the lumens **660**A, **660**B. As shown, the openings **610**A, **610**B may be located near a distal end **670**

of the guide member **520**. Although the openings **610**A, **610**B in the guide member **520** are shown parallel to the longitudinal axis of the guide member **520**, the openings **610**A, **610**B can be oriented at any desirable angle relative to the guide member **520**. For example, the openings **610**A, **610**B may be oriented substantially non-parallel to the longitudinal axis of the guide member **520** such that the openings **610**A, **610**B direct the needle guides **510**A, **510**B radially away from the guide member **520**. Moreover, while the openings **610**A, **610**B are shown formed on the end of the guide member **520**, the openings **610**A, **610**B may be formed on the sidewalls of the guide member **520**. The needle guides **510**A, **510**B can be advanced through the openings **610**A, **610**B by manipulation of the needle guide activation handle **620** (not shown).

FIG. **8**B shows the needle guides **510**A, **510**B deployed from the guide member **520** with the angle adjustment member **630** in a retracted position. As shown, the angle adjustment member **630** can be advanced along and relative to the guide member **520** such that the distal end **650** of the angle adjustment member **630** is positioned proximal to the openings **610**A, **610**B in the guide member **520**. Consequently, the needle guides **510**A, **510**B may form a penetration path through the vessel wall **570** without being biased toward the longitudinal axis of the guide member **520** by the angle adjustment member **630**. With the angle adjustment member **630** in the retracted position, the primary deployment angle "α" of the needle guides **510**A, **510**B may be approximately 60 degrees relative to the longitudinal axis of the guide member **520**, as determined primarily by the configuration of the needle guides **510**A, **510**B. The primary deployment angle "α" minimizes the deployment depth, thereby minimizing the possibility of overshooting the vessel. Moreover, the primary deployment angle "α" maximizes the radial span of the needle guides **510**A, **510**B, thereby maximizing the size of the body lumen opening the needle guides **510**A, **510**B can close.

FIG. **8**C shows the needle guides **510**A, **510**B deployed from the guide member **520** with the angle adjustment member **630** positioned in an extended position. As shown, the angle adjustment member **630** can be advanced along and relative to the guide member **520** until the distal end **650** of the angle adjustment member **630** is distal of the openings **610**A, **610**B. The angle adjustment member **630** may be substantially aligned or proximal to the distal end **670** of the guide member **520**. In the extended position, the angle adjustment member **630** may deflect the needle guides **510**A, **510**B toward the deployment angle "α" of approximately 20 degrees relative to the guide member **520**. With the angle adjustment member **630** in the extended position, the needle guides **510**A, **510**B can close a smaller body lumen opening.

FIG. **8**D shows the needle guides **510**A, **510**B deployed from the guide member **520** with the angle adjustment member **630** positioned in an intermediate position. The intermediate position is defined between the retracted position and the extended position. In the intermediate position, the angle adjustment member **630** may be advanced along and relative to the guide member **520** such that the distal end **650** of the angle adjustment member **630** is positioned distal to the openings **610**A, **610**B but proximal to the position of the angle adjustment member **630** in the extended position. With the angle adjustment member **630** in the intermediate position, the angle adjustment member **630** may deflect the needle guides **510**A, **510**B toward the deployment angle "α" between about 20 degrees and about 60 degrees. Distal movement of the angle adjustment member **630** beyond the openings **610**A, **610**B will reduce the deployment angle "α" toward about 20 degrees until the angle adjustment member **630** reaches the extended position. Proximal movement of the angle adjustment member **630** beyond the openings **610**A, **610**B will increase the deployment angle "α" toward about 60 degrees until the angle adjustment member **630** reaches the retracted position. Thus, a user can adjust the deployment angle of the needle guides **510**A, **510**B anywhere between about 20 degrees and about 60 degrees by moving the angle adjustment member **630** between the retracted position and the extended position.

In another embodiment, the closure device **10**, closure device **40**, or closure device **50** may employ an articulating suture securing device having a low-profile configuration and an expanded configuration. FIG. **9**A shows a perspective view of a suture securing device **705** according to one example. As shown, the suture securing device **705** may comprise a tubular body **710**, a cutout **730** formed in the tubular body **710**, and a suture **740** attached to the tubular body **710**.

The tubular body **710** may be elongated and have a proximal end **715**, an intermediate portion **720**, and a distal end **725**. The tubular body **710** can include a first opening **735** at the proximal end **715** for receiving an end of the suture **740**. The suture **740** may extend into the interior of the tubular body **710** along its length. The suture **740** may exit the tubular body **710** through a second opening **745** located near the distal end **725**. While the suture **740** is shown exiting the tubular body through the second opening **745** located near the distal end **725**, the suture **740** may exit the tubular body **710** at any number of locations. For example, a second opening may be located near the intermediate portion **720** of the tubular body **710** such that the suture may exit the tubular body **710** near the intermediate portion **720**. In another example, a third opening (not shown) may be located between the intermediate portion **720** and the distal end **725** such that the suture **740** may exit through the third opening.

The tubular body **710** may be crimped, as shown at **780**, about the suture **740** to mechanically affix the suture **740** to the suture securing device **705**. In other embodiments, the tubular body **710** can be crimped in a plurality of locations. In addition and or instead to mechanical crimping, the suture **740** may be bonded to the suture securing device **705** using an adhesive, heat, fasteners, knots or the like. The tubular body **710** may also include a swaged portion **750** adjacent the second opening **745** to help retain the suture **740** in the tubular body **710**. The tubular body **710** may include any number of rigid or semi-rigid materials. For example, the tubular body **710** may include one or more polymers, elastomers, plastics, metals, composites, other similar materials, or combinations thereof. The tubular body **710** may also include one or more superelastic or shape memory materials such as shape memory alloys.

The cutout **730** may extend distally from the proximal end **715** of the tubular body **120**. In other embodiments, more than one cutout **730** is possible. While the cutout **730** is shown having being u-shaped, a rectangular, triangular, elliptical, oval, or any other suitable shape is possible. The cutout **730** may include a plurality of tissue-engaging elements **755** extending along each side of the cutout **730**. In other embodiments, the tissue-engaging elements **755** may also be formed on other portions of the tubular body **710**. For example, the tissue-engaging elements **755** may be formed over the entire outer surface of the tubular body. In a further example, the tissue-engaging elements **755** may be formed between the proximal end **715** and the intermediate portion

720 of the tubular body 710. In yet a further example, the tissue-engaging elements 755 may be formed between the proximal end 715 and the distal end 725 on the same surface as the cutout 730. In other embodiments, the cutout 730 may include one or more tissue-engaging elements.

The tissue-engaging elements 755 extend from opposing sides of the cutout 730 and may comprise teeth, serrations, tilted trapezoidal bodies, or any other shape or configuration suitable to increase friction when engaged against a vessel wall. It will be apparent to one skilled in the art that a variety of tissue-engaging element configurations may be possible. For example, the tissue-engaging elements 755 may have tapered bodies. The tissue-engaging elements 755 may have generally circular disc-shaped bodies. The tissue-engaging elements 755 may have setaceous bodies. The tissue-engaging elements 755 may have hook shaped bodies. The tissue-engaging elements 755 may have tine shaped bodies. The tissue-engaging elements 755 may comprise notches formed in the tubular body 710. The orientation of the tissue-engaging elements 755 may also vary. For example, the tissue-engaging elements 755 may be angled toward or away from the cutout 730. The tissue-engaging elements 755 may be curved inwardly or outwardly relative to the cutout 730. The tissue-engaging elements 755 may alternate between extending inward and outward from the cutout 730.

In another embodiment, at least a portion of the suture 740 may include friction producing structures 760. The friction producing structures 760 may include a plurality of annular vanes formed in the outer surface of the suture 740. In another embodiment, the friction producing structures 760 may include raised helically formed or threaded portions on or in the suture 740. In another embodiment, the friction producing structures 760 may include one or more annular grooves formed in the suture 740. In another embodiment, the friction producing structures 760 may be formed on a substantially rigid portion of the suture 740. In a further embodiment, the friction producing structures 760 may be non-uniformly distributed on the suture 740. In yet a further embodiment, the friction producing structures 760 may include a plurality of raised portions and a plurality of recessed portions.

FIGS. 9B and 9C show the suture securing device 705 in a low-profile configuration (FIG. 9B) and an expanded configuration (FIG. 9C). As shown in FIG. 9B, the suture securing device 705 may have a low-profile configuration in which the tubular body 710 is substantially aligned along the axis of the suture 740. The low-profile configuration shown in FIG. 9B facilitates storage and delivery of the suture securing device 705. For example, a needle guide 765 may hold the suture securing device 705 and the suture 740 as the needle guide 765 forms a penetration path through the vessel wall 770 immediately adjacent a body lumen opening. In another embodiment, the suture securing device 705 can be configured to penetrate the vessel wall 770 rather than the needle guide 765. For example, the suture securing device 705 can be disposed on the needle guide 765 with a penetrator tip (not shown) attached to the distal end 725 of the suture securing device 705.

As shown in FIG. 9C, the suture securing device 705 may have an expanded configuration. In one embodiment, the needle guide 765 may be retracted depositing or releasing the suture securing device 705 distally of the vessel wall 770. The tubular body 710 may then rotate relative to the suture 740 such that the suture 740 is received within the cutout 730 and the tubular body 710 is positioned substantially non-parallel to the suture 740 and substantially parallel to the vessel wall 770. In another embodiment, the tubular body 710 may include more than one cutout configured to receive the suture 740 such that the tubular body 710 may rotate relative to the suture 740 in a plurality of directions. For example, the tubular body 710 may include a second cutout (not shown) formed opposing the cutout 730 such that the tubular body 710 may rotate clockwise or counterclockwise about the suture 740. In a further embodiment, the cutout 730 may include a receptacle (not shown) configured to fix the orientation of the suture 740 relative to the tubular body 710 once the suture securing device 705 moves into the expanded configuration. In yet a further embodiment, the cutout 730 may include a locking clip (not shown) to fix the orientation of the suture 740 relative to the tubular body 710 once the suture securing device 705 moves into the expanded configuration. In yet a further embodiment, the cutout 730 may include a catch member (not shown) to fix the orientation of the suture 740 relative to the tubular body 710 once the suture securing device 705 moves into the expanded configuration.

Reference is now made to FIGS. 10A-10C which illustrates an additional example suture securing device 805. The suture securing device 805 may be similar in many respects to the suture securing device 705 previously described above in FIGS. 9A-9C. To the extent features or components of this configuration function in a manner similar to that as described above, such disclosure is hereby incorporated into the following additional configuration. Like structures and/or components are given like reference numerals. Additionally, the suture securing device 805 may incorporate at least one component of the suture securing device 705 described in FIGS. 9A-9C.

As shown in FIG. 10A, the suture securing device 805 may include a tubular body 810 having a proximal end 815, a mid-point 820, and a distal end 825. The tubular body 810 can include a first opening 835 at the proximal end 815 for receiving an end of a suture 840. The suture 840 may extend distally within the tubular body 810 along its length. The suture 840 can also exit the tubular body 810 through a second opening 845 located near the distal end 825. As shown, the tubular body 810 may be crimped 880 about the suture 840 near the distal end 825 to mechanically affix the suture 840 to the suture securing device 805. In other embodiments, the tubular body 810 can be crimped in a plurality of locations. In addition and or instead to mechanical crimping, the suture 840 may be bonded to the suture securing device 805 using an adhesive, heat, fasteners, knots or the like. The tubular body 810 may also include a swaged portion 850 adjacent the second opening 845 to help retain the suture 840 in the tubular body 710.

The tubular body 810 may include a plurality of elongated slots 897 radially spaced about the tubular body, and extending distally from the proximal end 815. The slots 897 may define a plurality of projections 875 therebetween. In one embodiment, each projection 875 may have a wire, strip-like, or ribbon like shape with a fixed end 885 and a free end 890. The projections 875 of the tubular body 810 may be formed by one of more strips of material. In one embodiment, the projections 875 may include notches 895 formed near the free end 890. The notches 895 may be sized, shaped, and configured to help anchor the projections 875 against a vessel wall 870. In another embodiment, the projections 875 may include tissue-engaging elements formed near the free end 890. For example, the projections 875 may include one or more teeth shaped elements, tines, and/or barbs that are oriented to engage the vessel wall 870. The free end 890 of the projections 875 may also be forked such that the free end 890 can penetrate the vessel wall 870.

In one embodiment, the tubular body **810** may have four projections **875**. In another embodiment, the tubular body **810** may have six projections **875**. In a further embodiment, the projections **875** may be spaced evenly about the tubular body **810**. In a further embodiment, the projections **875** may form a shape similar to an 'x'. In yet further embodiment, the tubular body **810** may have multiple layers of projections **875**. For example, the tubular body **810** may include a first set of projections **875***a* and a second set of projections **875***b*. Each set may include any number of projections **875** desired for a particular application. In further embodiments, each projection **875** may have any shape, size, or configuration desired for a particular application.

As shown in FIG. **10**B, the suture securing device **805** may have a collapsed configuration in which the projections **875** are substantially parallel with a longitudinal axis of the tubular body **810**. The collapsed configuration shown in FIG. **10**B may facilitate storage and delivery of the suture securing device **805**. A needle carrier **865** may hold the suture securing device **805** in the collapsed configuration as the needle carrier **865** forms a penetration path through the vessel wall **870** immediately adjacent a body lumen opening. In another embodiment, the suture securing device **805** can be configured to penetrate the vessel wall **870** rather than the needle guide **865**. For example, the suture securing device **805** can be disposed on the needle guide **865** with a penetrator tip (not shown) attached to the distal end **825** of the suture securing device **805**.

As shown in FIG. **10**C, the suture securing device **805** may have an expanded configuration. In one embodiment, the needle guide **865** may be retracted from the penetration path depositing or releasing the suture securing device **805** distally of the vessel wall **870**. The projections **875** may then move to the expanded configuration wherein the projections **875** are substantially non-parallel with the longitudinal axis of the tubular body **810**. In one embodiment, the projections **875** may include one or more elastic or shape memory materials, such as spring steel, nitinol, and/or other shape memory alloys, and may be heat set to have a memory shape. For example, the projections **875** may be heat set in their expanded configuration. As a result, when the suture securing device **805** is deployed, it may superelastically move to an expanded configuration. A user may apply a force to the suture securing device **805** to deform the projections **875** away from their memory shape and move the suture securing device **805** into a collapsed configuration, as shown in FIG. **10**B. Alternatively, the projections **875** may be resiliently biased towards the expanded configuration. As a result, when the suture securing device **805** is released from an external force such as the needle guide **865**, the projections **875** may move to their expanded configuration. In another embodiment, the projections **875** may be pivotally connected to the tubular body **810**. In a further embodiment, the projections **875** may be pivotally connected to the proximal end **815** of the tubular body **810**. When the suture securing device **805** is stored within the needle guide **865**, the projections **875** may be rotated to the collapsed configuration. As shown, when the suture securing device **810** is deployed from the needle guide **865**, the projections **875** can rotate to the expanded configuration.

The present disclosure may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the disclosure is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed is:

1. A method for closing a puncture in tissue, the method comprising:

advancing a guide member into proximity with the tissue, the guide member having a guide for a suture securing device;

positioning a distal end of the guide member in contact with tissue adjacent to the puncture with the guide toward the tissue to present an opening of the guide toward a proximal side of the tissue, the guide cooperating with the suture securing device that is slidably coupled to the guide member and a suture attached to the suture securing device;

deploying the suture securing device through the tissue with the opening toward the proximal side of the tissue, the suture securing device comprising a body with an anchor point for the suture and features that allow the suture securing device to pierce the tissue and resist retraction through the tissue, the suture being attached to the body, the features comprising a plurality of projections configured to extend laterally beyond a deployment location of the suture securing device in the tissue, the plurality of projections being disposed circumferentially about a longitudinal axis of the body, the body having a proximal end, a distal end, and an inner cavity, a notch being formed at the proximal end of each projection of the plurality of projections, the notch being sized and shaped to aid with anchoring the projections into the tissue; and

establishing tension in the suture to move the suture securing device toward another suture securing device to thereby close the puncture in the tissue.

2. The method of claim **1**, wherein the guide is deployed distally from the guide member and advanced through the tissue by moving an activation handle relative to the guide member.

3. The method of claim **1**, wherein each projection of the plurality of projections comprises a forked proximal end.

4. The method of claim **1**, wherein each of the plurality of projections comprising one or more teeth-shaped elements, tines or barbs.

5. The method of claim **1**, further comprising moving the body between a first position wherein the body is substantially parallel with a longitudinal axis of the suture and a second position where the plurality of projections extend laterally to be substantially non-parallel with the longitudinal axis of the suture and at least a portion of the suture.

6. The method of claim **1**, further comprising engaging the plurality of projections against the tissue.

7. The method of claim **1**, wherein the suture securing device comprises a tapered body.

8. A method for closing a puncture in tissue, the method comprising:

advancing a guide member into proximity with a puncture in tissue;

positioning a distal end of a guide in contact with tissue adjacent to the puncture and toward the tissue to present an opening of the guide toward a proximal side of the tissue, the guide cooperating with an anchor;

deploying the anchor through the tissue with the opening toward the proximal side of the tissue, the anchor comprising a body with an anchor point for a suture and features that allow the anchor to pierce the tissue and resist retraction through the tissue, the anchor point being at a location proximal an intermediate location of

the anchor, the suture being attached to the body, the features comprising a plurality of tissue-engaging elements that are configured to extend laterally beyond a deployment location of the anchor in the tissue, the plurality of tissue-engaging elements being disposed circumferentially about a longitudinal axis of the body with a projection of the plurality of tissue-engaging elements comprising a fixed end and a free end, the body having a proximal end, a distal end, and an inner cavity, and a notch being formed at the proximal end of each tissue-engaging element of the plurality of tissue-engaging elements, the notch being sized and shaped to aid with anchoring the tissue-engaging element into the tissue; and

moving the anchor toward a longitudinal axis of the guide member to close the puncture in the tissue.

9. The method of claim **8**, further comprising actuating a handle relative to the guide member to deploy the guide distally.

10. The method of claim **8**, further comprising advancing the anchor through the guide member to the deployment location.

11. The method of claim **10**, further comprising expanding the anchor to laterally extend beyond the deployment location.

12. The method of claim **8**, further comprising positioning a plug against the tissue.

13. The method of claim **8**, wherein the anchor comprises a conical body.

14. A method for closing a puncture in tissue, the method comprising:

advancing a distal end of a guide member into contact with tissue adjacent to the puncture to position openings near the distal end of the guide member into proximity with a proximal side of the tissue and a puncture in tissue;

deploying a plurality of anchors through the tissue with the openings toward the proximal side of the tissue, each of the plurality of anchors comprising a body with an anchor point for a suture and features that allow the anchors to pierce the tissue and resist retraction through the tissue, the anchor point being at a location proximal an intermediate location of the anchor, the suture being attached to the body, the features comprising a plurality of tissue-engaging elements that are configured to extend laterally beyond a deployment location of the anchor in the tissue, the plurality of tissue-engaging elements being disposed circumferentially about a longitudinal axis of the body with each tissue-engaging element of the plurality of tissue-engaging elements comprising a fixed end and a free end, the fixed end being integral with a distal portion of the anchor, the body having a proximal end, a distal end, and an inner cavity, a notch being formed at the proximal end of each tissue-engaging element of the plurality of tissue-engaging elements, the notch being sized and shaped to aid with anchoring the tissue-engaging element into the tissue; and

moving the plurality of anchors toward the longitudinal axis of the guide member to close the puncture in the tissue.

15. The method of claim **14**, further comprising actuating a handle relative to the guide member to deploy the plurality of anchors.

16. The method of claim **14**, further comprising advancing a locator through the guide member to the deployment location.

17. The method of claim **16**, further comprising expanding the locator to laterally extend beyond the deployment location.

18. The method of claim **14**, further comprising positioning a plug against the tissue.

19. The method of claim **14**, wherein the anchor comprises a conical body.

* * * * *