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(54) **TISSUE FIXATION SYSTEM AND METHOD**

(71) Applicant: **P Tech, LLC**, Effingham, IL (US)

(72) Inventors: **Peter M. Bonutti**, Manalapan, FL (US); **Glen A. Phillips**, Effingham, IL (US); **Lawrence Crainich**, Charlestown, NH (US)

(73) Assignee: **P Tech, LLC**, Effingham, IL (US)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

319,296 A 6/1885 Molesworth
668,878 A 2/1901 Jensen
(Continued)

FOREIGN PATENT DOCUMENTS

CA 2641580 8/2007
CA 2680827 9/2008
(Continued)

OTHER PUBLICATIONS

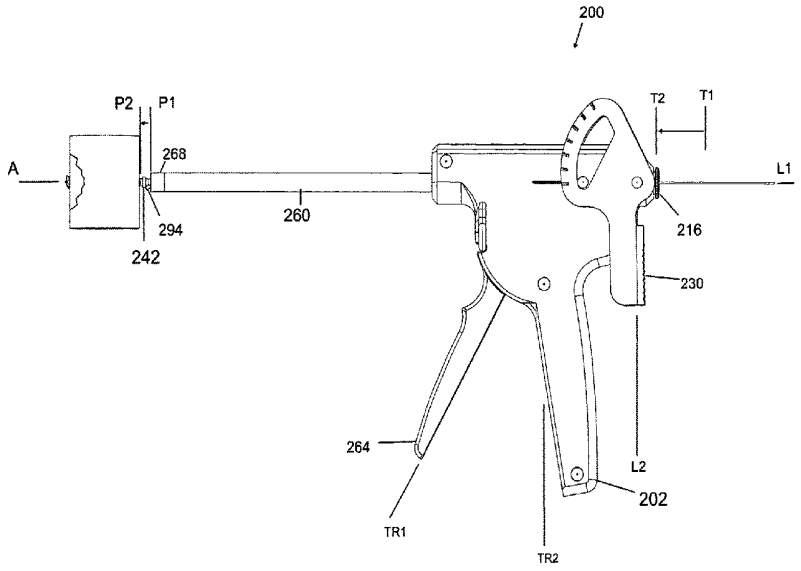
Karlsson et al, Repair of Bankart lesions with a suture anchor in recurrent dislocation of the shoulder, Scand. j. of Med & Science in Sports, 1995, 5:170-174.
(Continued)

Primary Examiner — Sameh Boles
(74) *Attorney, Agent, or Firm* — Senniger Powers LLP

(57) **ABSTRACT**

A tissue fixation system is provided for dynamic and rigid fixation of tissue. A fastener connected with an elongate fastening member, such as a cable, wire, suture, rod, or tube, is moved through a passage between opposite sides of tissue. The fastener is provided with a groove that accommodates at least a portion of the fastening member to reduce the profile during the movement through the passage. The fastener is then pivoted to change its orientation. A second fastener can then be connected with the fastening member. While tension is maintained in the fastening member, the fasteners are secured against relative movement. This may be done by deforming the fastening member, either the first or second fasteners, or a bushing placed against the second fastener.

20 Claims, 41 Drawing Sheets



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(56) **References Cited**

U.S. PATENT DOCUMENTS

668,879	A	2/1901	Miller
702,789	A	6/1902	Gibson
862,712	A	8/1907	Collins
2,121,193	A	12/1932	Hanicke
2,187,852	A	8/1936	Friddle
2,178,840	A	11/1939	Lorenian
2,199,025	A	4/1940	Conn
2,235,419	A	3/1941	Callahan
2,248,054	A	7/1941	Becker
2,270,188	A	1/1942	Longfellow
2,518,276	A	8/1950	Braward
2,557,669	A	6/1951	Lloyd
2,566,499	A	9/1951	Richter
2,621,653	A	12/1952	Briggs
2,725,053	A	11/1955	Bambara
2,830,587	A	4/1958	Everett
3,204,635	A	9/1965	Voss
3,347,234	A	10/1967	Voss
3,367,809	A	2/1968	Soloff
3,391,690	A	7/1968	Armao
3,477,429	A	11/1969	Sampson
3,513,848	A	5/1970	Winston
3,518,993	A	7/1970	Blake
3,577,991	A	5/1971	Wilkinson
3,596,292	A	8/1971	Erb
3,608,539	A	9/1971	Miller
3,625,220	A	12/1971	Engelsher
3,648,705	A	3/1972	Lary
3,653,388	A	4/1972	Tenckhoff
3,656,476	A	4/1972	Swinney
3,657,056	A	4/1972	Winston
3,678,980	A	7/1972	Guttshall
3,709,218	A	1/1973	Halloran
3,711,347	A	1/1973	Wagner
3,760,808	A	9/1973	Bleuer
3,788,318	A	1/1974	Kim
3,789,852	A	2/1974	Kim
3,802,438	A	4/1974	Wolvek
3,807,394	A	4/1974	Attenborough
3,809,075	A	5/1974	Matles
3,811,449	A	5/1974	Gravlee
3,825,010	A	7/1974	McDonald
3,833,003	A	9/1974	Taricco
3,835,849	A	9/1974	McGuire
3,842,824	A	10/1974	Neufeld
3,857,396	A	12/1974	Hardwick
3,867,932	A	2/1975	Huene
3,875,652	A	4/1975	Arnold
3,898,992	A	8/1975	Balamuth
3,918,442	A	11/1975	Nikolaev
3,968,800	A	7/1976	Vilasi
4,023,559	A	5/1977	Gaskell
4,064,566	A	12/1977	Fletcher
4,089,071	A	5/1978	Kainberz
4,156,574	A	5/1979	Boben
4,164,794	A	8/1979	Spector
4,171,544	A	10/1979	Hench
4,183,102	A	1/1980	Guiset
4,199,864	A	4/1980	Ashman
4,200,939	A	5/1980	Oser
4,210,148	A	7/1980	Stivala
4,213,816	A	7/1980	Morris
4,235,233	A	11/1980	Mouwen
4,235,238	A	11/1980	Ogui
4,257,411	A	3/1981	Cho
4,265,231	A	5/1981	Scheller
4,281,649	A	8/1981	Derweduwen
4,291,698	A	9/1981	Fuchs
4,309,488	A	1/1982	Heide
4,320,762	A	3/1982	Bentov
4,351,069	A	9/1982	Ballintyn
4,364,381	A	12/1982	Sher
4,365,356	A	12/1982	Broemer
4,388,921	A	6/1983	Sutter
4,395,798	A	8/1983	McVey
4,409,974	A	10/1983	Freedland
4,414,166	A	11/1983	Charlson
4,437,191	A	3/1984	Van der Zat
4,437,362	A	3/1984	Hurst
4,444,180	A	4/1984	Schneider
4,448,194	A	5/1984	DiGiovanni
4,456,005	A	6/1984	Lichty
4,461,281	A	7/1984	Carson
4,493,317	A	1/1985	Klaue
4,495,664	A	1/1985	Bianquaert
4,501,031	A	2/1985	McDaniel
4,504,268	A	3/1985	Herlitze
4,506,681	A	3/1985	Mundell
4,514,125	A	4/1985	Stol
4,526,173	A	7/1985	Sheehan
4,532,926	A	8/1985	O'Holla
4,535,772	A	8/1985	Sheehan
4,547,327	A	10/1985	Bruins
4,556,350	A	12/1985	Bernhardt
4,566,138	A	1/1986	Lewis
4,589,868	A	5/1986	Dretler
4,590,928	A	5/1986	Hunt
4,597,379	A	7/1986	Kihn
4,599,085	A	7/1986	Riess
4,601,893	A	7/1986	Cardinal
4,606,335	A	8/1986	Wedeen
4,621,640	A	11/1986	Mulhollan
4,630,609	A	12/1986	Chin
4,632,100	A	12/1986	Somers
4,632,101	A	12/1986	Freedland
4,645,503	A	2/1987	Lin
4,657,460	A	4/1987	Bien
4,659,268	A	4/1987	Del Mundo
4,662,063	A	5/1987	Collins
4,662,068	A	5/1987	Polonsky
4,662,887	A	5/1987	Turner
4,669,473	A	6/1987	RIchards
4,685,458	A	8/1987	Leckrone
4,691,741	A	9/1987	Affa
4,705,040	A	11/1987	Mueller
4,706,670	A	11/1987	Andersen
4,708,139	A	11/1987	Dunbar

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,713,077 A 12/1987 Small
4,716,901 A 1/1988 Jackson
4,718,909 A 1/1988 Brown
4,722,331 A 2/1988 Fox
4,722,948 A 2/1988 Sanderson
4,724,584 A 2/1988 Kasai
4,738,255 A 4/1988 Goble
4,739,751 A 4/1988 Sapega
4,741,330 A 5/1988 Hayhurst
4,743,257 A 5/1988 Tormala
4,749,585 A 6/1988 Greco
4,750,492 A 6/1988 Jacobs
4,768,507 A 9/1988 Fischell
4,772,286 A 9/1988 Goble
4,776,328 A 10/1988 Frey
4,776,738 A 10/1988 Winston
4,776,851 A 10/1988 Bruchman
4,781,182 A 11/1988 Purnell
4,790,303 A 12/1988 Steffee
4,792,336 A 12/1988 Hiavacek
4,817,591 A 4/1989 Klaue
4,822,224 A 4/1989 Carl
4,823,794 A 4/1989 Pierce
4,832,025 A 5/1989 Coates
4,832,026 A 5/1989 Jones
4,834,752 A 5/1989 Van Kampen
4,841,960 A 6/1989 Gamer
4,843,112 A 6/1989 Gerhart
4,846,812 A 7/1989 Walker
4,862,882 A 9/1989 Venturi
4,869,242 A 9/1989 Galluzzo
4,870,957 A 10/1989 Goble
4,883,048 A 11/1989 Purnell
4,890,612 A 1/1990 Kensey
4,895,148 A 1/1990 Bays
4,898,156 A 2/1990 Gattuma
4,899,729 A 2/1990 gill
4,899,744 A 2/1990 Fujitsuka
4,901,721 A 2/1990 Hakki
4,921,479 A 5/1990 Grayzel
4,922,897 A 5/1990 Sapega
4,924,866 A 5/1990 Yoon
4,932,960 A 6/1990 Green
4,935,026 A 6/1990 Drews
4,935,028 A 6/1990 Drews
4,945,625 A 8/1990 Winston
4,946,468 A 8/1990 Li
4,950,285 A 8/1990 Wilk
4,954,126 A 9/1990 Wallsten
4,955,910 A 9/1990 Bolesky
4,957,498 A 9/1990 Caspari
4,961,741 A 10/1990 Hayhurst
4,963,151 A 10/1990 Ducheyne
4,966,583 A 10/1990 Debbas
4,968,315 A 11/1990 Gatturna
4,968,317 A 11/1990 Tormala
4,969,888 A 11/1990 Scholten
4,969,892 A 11/1990 Burton
4,990,161 A 2/1991 Kampner
4,994,071 A 2/1991 MacGregor
4,997,445 A 3/1991 Hodorek
4,998,539 A 3/1991 Delsanti
5,002,550 A 3/1991 Li
5,002,563 A 3/1991 Pyka
5,009,652 A 4/1991 Morgan
5,009,663 A 4/1991 Broome
5,009,664 A 4/1991 Sievers
5,013,316 A 5/1991 Goble
5,019,090 A 5/1991 Pinchuk
5,021,059 A 6/1991 Kensey
5,035,713 A 7/1991 Friis
5,037,404 A 8/1991 Gold
5,037,422 A 8/1991 Hayhurst
5,041,093 A 8/1991 Chu
5,041,129 A 8/1991 Hayhurst
5,046,513 A 9/1991 Gatturna
5,047,055 A 9/1991 Bao
5,051,049 A 9/1991 Wills
5,053,046 A 10/1991 Janese
5,053,047 A 10/1991 Yoon
5,059,193 A 10/1991 Kuslich
5,059,206 A 10/1991 Winters
5,061,274 A 10/1991 Kensey
5,061,286 A 10/1991 Lyle
5,069,674 A 12/1991 Fearnot
5,078,731 A 1/1992 Hayhurst
5,078,744 A 1/1992 Chvapil
5,078,745 A 1/1992 Rhenter
5,084,050 A 1/1992 Draenert
5,084,051 A 1/1992 Tormala
5,085,660 A 2/1992 Lin
5,085,661 A 2/1992 Moss
5,098,433 A 3/1992 Freedland
5,098,434 A 3/1992 Serbousek
5,098,436 A 3/1992 Ferrante
5,100,405 A 3/1992 McLaren
5,100,417 A 3/1992 Cerier
5,102,417 A 4/1992 Palmaz
5,102,421 A 4/1992 Anspach
5,108,399 A 4/1992 Eitenmuller
5,120,175 A 6/1992 Arbegast
5,123,520 A 6/1992 Schmid
5,123,914 A 6/1992 Cope
5,133,732 A 7/1992 Wiktor
RE34,021 E 8/1992 Mueller
5,147,362 A 9/1992 Goble
5,154,720 A 10/1992 Trott
5,156,613 A 10/1992 Sawyer
5,156,616 A 10/1992 Meadows
5,158,566 A 10/1992 Pianetti
5,158,934 A 10/1992 Ammann
5,163,960 A 11/1992 Bonutti
5,171,251 A 12/1992 Bregen
5,176,682 A 1/1993 Chow
5,179,964 A 1/1993 Cook
5,180,385 A 1/1993 Sontag
5,180,388 A 1/1993 DiCarlo
5,183,464 A 2/1993 Dubrul
5,192,287 A 3/1993 Fournier
5,192,326 A 3/1993 Bao
5,197,166 A 3/1993 Meier
5,197,971 A 3/1993 Bonutti
5,203,784 A 4/1993 Ross
5,203,787 A 4/1993 Noblitt
5,208,950 A 5/1993 Merritt
5,209,776 A 5/1993 Bass
5,217,493 A 6/1993 Raad
5,219,359 A 6/1993 McQuilkin
5,226,899 A 7/1993 Lee
5,234,006 A 8/1993 Eaton
5,234,425 A 8/1993 Fogarty
5,234,443 A 8/1993 Phan
5,236,438 A 8/1993 Wilk
5,236,445 A 8/1993 Hayhurst
5,242,902 A 9/1993 Murphy
5,254,113 A 10/1993 Wilk
5,258,007 A 11/1993 Spetzler
5,258,015 A 11/1993 Li
5,258,016 A 11/1993 Di Poto
5,261,886 A 11/1993 Chesterfield
5,266,325 A 11/1993 Kuzma
5,269,783 A 12/1993 Sander
5,269,785 A 12/1993 Bonutti
5,269,809 A 12/1993 Hayhurst
5,281,235 A 1/1994 Haber
5,282,832 A 2/1994 Toso
5,290,281 A 3/1994 Tschakaloff
5,304,119 A 4/1994 Balaban
5,306,280 A 4/1994 Bregen
5,306,301 A 4/1994 Graf
5,315,741 A 5/1994 Dubberke
5,318,588 A 6/1994 Horzewski
5,320,611 A 6/1994 Bonutti
5,324,308 A 6/1994 Pierce

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,328,480 A 7/1994 Melker
5,329,846 A 7/1994 Bonutti
5,329,924 A 7/1994 Bonutti
5,330,468 A 7/1994 Burkhart
5,330,476 A 7/1994 Hiot
5,330,486 A 7/1994 Wilk
5,336,231 A 8/1994 Adair
5,336,240 A 8/1994 Metzler
5,339,799 A 8/1994 Kami
5,349,956 A 9/1994 Bonutti
5,352,229 A 10/1994 Goble
5,354,298 A 10/1994 Lee
5,354,302 A 10/1994 Ko
5,366,480 A 11/1994 Corriveaau
5,370,646 A 12/1994 Reese
5,370,660 A 12/1994 Weinstein
5,372,146 A 12/1994 Branch
5,374,235 A 12/1994 Ahrens
5,376,126 A 12/1994 Lin
5,382,254 A 1/1995 McGarry
5,383,883 A 1/1995 Wilk
5,383,905 A 1/1995 Golds
5,391,173 A 2/1995 Wilk
5,395,308 A 3/1995 Fox
5,397,311 A 3/1995 Walker
5,400,805 A 3/1995 Warren
5,403,312 A 4/1995 Yates
5,403,348 A 4/1995 Bonutti
5,405,359 A 4/1995 Pierce
5,411,523 A 5/1995 Goble
5,413,585 A 5/1995 Pagedas
5,417,691 A 5/1995 Hayhurst
5,417,701 A 5/1995 Holmes
5,417,712 A 5/1995 Whittaker
5,423,796 A 6/1995 Shikhman
5,431,670 A 7/1995 Holmes
5,439,470 A 8/1995 Li
5,441,538 A 8/1995 Bonutti
5,443,512 A 8/1995 Parr
5,447,503 A 9/1995 Miller
5,449,372 A 9/1995 Schmaltz
5,449,382 A 9/1995 Dayton
5,451,235 A 9/1995 Lock
5,453,090 A 9/1995 Martinez
5,456,722 A 10/1995 McLeod
5,458,653 A 10/1995 Davison
5,462,561 A 10/1995 Voda
5,464,424 A 11/1995 O'Donnell
5,464,426 A 11/1995 Bonutti
5,464,427 A 11/1995 Curtis
5,470,337 A 11/1995 Moss
5,472,444 A 12/1995 Huebner
5,474,554 A 12/1995 Ku
5,478,351 A 12/1995 Meade
5,478,353 A 12/1995 Yoon
5,480,403 A 1/1996 Lee
5,486,197 A 1/1996 Le
5,487,844 A 1/1996 Fujita
5,488,958 A 2/1996 Topel
5,496,292 A 3/1996 Burnham
5,496,318 A 3/1996 Howland
5,496,335 A 3/1996 Thomason
5,496,348 A 3/1996 Bonutti
5,500,000 A 3/1996 Feagin
5,501,700 A 3/1996 Hirata
5,504,977 A 4/1996 Weppner
5,505,735 A 4/1996 Li
5,507,754 A 4/1996 Green
5,522,844 A 6/1996 Johnson
5,522,845 A 6/1996 Wenstrom
5,522,846 A 6/1996 Bonutti
5,527,341 A 6/1996 Gogolewski
5,527,342 A 6/1996 Pietrzak
5,527,343 A 6/1996 Bonutti
5,529,075 A 6/1996 Clark
5,531,759 A 7/1996 Kensey
5,534,012 A 7/1996 Bonutti
5,534,028 A 7/1996 Bao
5,540,718 A 7/1996 Bartlett
5,542,423 A 8/1996 Bonutti
5,545,178 A 8/1996 Kensey
5,545,180 A 8/1996 Le
5,545,206 A 8/1996 Carson
5,545,630 A 8/1996 Bonutti
5,549,631 A 8/1996 Bonutti
5,556,402 A 9/1996 Xu
5,569,252 A 10/1996 Justin
5,569,305 A 10/1996 Bonutti
5,569,306 A 10/1996 Thal
5,573,517 A 11/1996 Bonutti
5,573,538 A 11/1996 Laboureau
5,575,801 A 11/1996 Habermeyer
5,578,046 A 11/1996 Liu
5,580,344 A 12/1996 Hasson
5,584,835 A 12/1996 Greenfield
5,584,839 A 12/1996 Gieringer
5,584,860 A 12/1996 Goble
5,584,862 A 12/1996 Bonutti
5,591,206 A 1/1997 Moufarrege
5,593,422 A 1/1997 Muijs Van De Moer
5,593,425 A 1/1997 Bonutti
5,593,625 A 1/1997 Riebel
5,601,557 A 2/1997 Hayhurst
5,601,558 A 2/1997 Torrie
5,601,595 A 2/1997 Schwartz
5,607,427 A 3/1997 Tschakaloff
5,609,595 A 3/1997 Pennig
5,618,314 A 4/1997 Harwin
5,620,461 A 4/1997 Muijs Van De Moer
5,626,612 A 5/1997 Bartlett
5,626,614 A 5/1997 Hart
5,626,718 A 5/1997 Philippe
5,630,824 A 5/1997 Hart
5,634,926 A 6/1997 Jobe
5,628,751 A 7/1997 Sander
5,643,274 A 7/1997 Sander
5,643,293 A 7/1997 Kogasaka
5,643,295 A 7/1997 Yoon
5,643,321 A * 7/1997 McDevitt A61B 17/0401 606/232
5,645,553 A 7/1997 Kolesa
5,645,597 A 7/1997 Krapiva
5,645,599 A 7/1997 Samani
5,649,955 A 7/1997 Hashimoto
5,649,963 A 7/1997 McDevitt
5,651,377 A 7/1997 O'Donnell
5,658,313 A 8/1997 Thal
5,660,225 A 8/1997 Saffran
5,662,658 A 9/1997 Wenstrom
5,665,089 A 9/1997 Dall
5,665,109 A 9/1997 Yoon
5,667,513 A 9/1997 Torrie
5,669,917 A 9/1997 Sauer
5,674,240 A 10/1997 Bonutti
5,681,310 A 10/1997 Yuan
5,681,333 A 10/1997 Burkhart
5,681,351 A 10/1997 Jamiolkowski
5,681,352 A 10/1997 Clancy
5,685,820 A 11/1997 Riek
5,688,283 A 11/1997 Knapp
5,690,654 A 11/1997 Ovil
5,690,655 A 11/1997 Hart
5,690,676 A 11/1997 Di Poto
5,693,055 A 12/1997 Zahiri
5,697,950 A 12/1997 Fucci
5,702,397 A 12/1997 Gonle
5,702,462 A 12/1997 Oberlander
5,707,395 A 1/1998 Li
5,713,903 A 2/1998 Sander
5,713,921 A 2/1998 Bonutti
5,718,717 A 2/1998 Bonutti
5,720,747 A 2/1998 Burke
5,725,541 A 3/1998 Anspach
5,725,556 A 3/1998 Moser

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,725,582 A 3/1998 Bevan
5,730,747 A 3/1998 Ek
5,733,306 A 3/1998 Bonutti
5,720,753 A 4/1998 Sander
5,735,875 A 4/1998 Bonutti
5,735,877 A 4/1998 Pagedas
5,735,899 A 4/1998 Schwartz
5,741,282 A 4/1998 Anspach
5,752,952 A 5/1998 Adamson
5,752,974 A 5/1998 Rhee
5,755,809 A 5/1998 Cohen
5,762,458 A 6/1998 Wang
5,766,221 A 6/1998 Benderev
5,769,894 A 6/1998 Ferragamo
5,772,672 A 6/1998 Toy
5,776,151 A 7/1998 Chan
5,779,706 A 7/1998 Tschakaloff
5,782,862 A 7/1998 Bonutti
5,785,713 A 7/1998 Jobe
5,792,096 A 8/1998 Rentmeester
5,797,931 A 8/1998 Bito
5,800,537 A 9/1998 Bell
5,807,403 A 9/1998 Beyar
5,810,849 A 9/1998 Kontos
5,810,853 A 9/1998 Yoon
5,810,884 A 9/1998 Kim
5,814,072 A 9/1998 Bonutti
5,814,073 A 9/1998 Bonutti
5,817,107 A 10/1998 Schaller
5,823,994 A 10/1998 SHarkey
5,824,009 A 10/1998 Fukuda
5,830,125 A 11/1998 Scribner
5,836,897 A 11/1998 Sakurai
5,839,899 A 11/1998 Robinson
5,843,084 A 12/1998 Hart
5,843,178 A 12/1998 Vanney
5,845,645 A 12/1998 Bonutti
5,851,185 A 12/1998 Berns
5,865,834 A 2/1999 McGuire
5,866,634 A 2/1999 Tokushige
5,868,749 A 2/1999 Reed
5,874,235 A 2/1999 Chan
5,879,372 A 3/1999 Bartlett
5,891,166 A 4/1999 Scervinsky
5,891,168 A 4/1999 Thal
5,893,880 A 4/1999 Egan
5,897,574 A 4/1999 Bonutti
5,899,911 A 5/1999 Carter
5,899,921 A 5/1999 Caspari
5,906,579 A 5/1999 Vander Salm
5,906,625 A 5/1999 Bito
5,908,429 A 6/1999 Yoon
5,911,721 A 6/1999 Nicholson
5,918,604 A 7/1999 Whelan
5,919,193 A 7/1999 Slavitt
5,919,194 A 7/1999 Anderson
5,919,208 A 7/1999 Valenti
5,919,215 A 7/1999 Wiklund
5,921,986 A 7/1999 BOnutti
5,925,064 A 7/1999 Meyers
5,928,244 A 7/1999 Tovey
5,928,267 A 7/1999 Bonutti
5,931,838 A 8/1999 Vito
5,931,869 A 8/1999 Boucher
5,940,942 A 8/1999 Fong
5,941,900 A 8/1999 Bonutti
5,941,901 A 8/1999 Egan
5,944,750 A 8/1999 Tanner
5,945,002 A 9/1999 Bonutti
5,947,982 A 9/1999 Duran
5,948,000 A 9/1999 Larsen
5,948,001 A 9/1999 Larsen
5,948,002 A 9/1999 Bonutti
5,951,590 A 9/1999 Goldfarb
5,957,953 A 9/1999 DiPoto
5,961,499 A 10/1999 Bonutti
5,961,521 A 10/1999 Roger
5,961,554 A 10/1999 Janson
5,964,765 A 10/1999 Fenton
5,964,769 A 10/1999 Wagner
5,968,046 A 10/1999 Castleman
5,968,047 A 10/1999 Reed
5,980,520 A 11/1999 Vancaillie
5,980,559 A 11/1999 Bonutti
5,984,929 A 11/1999 Bashiri
5,989,282 A 11/1999 Bonutti
5,993,458 A 11/1999 Vaitekunas
5,993,477 A 11/1999 Vaitekunas
6,007,567 A 12/1999 Bonutti
6,007,580 A 12/1999 Lehto
6,010,525 A 1/2000 Bonutti
6,010,526 A 1/2000 Sandstrom
6,017,321 A 1/2000 Boone
6,033,429 A 3/2000 Magovern
6,033,430 A 3/2000 Bonutti
6,045,551 A 4/2000 Bonutti
6,050,998 A 4/2000 Fletcher
6,056,751 A 5/2000 Fenton
6,056,772 A 5/2000 Bonutti
6,056,773 A 5/2000 Bonutti
6,059,797 A 5/2000 Mears
6,059,817 A 5/2000 Bonutti
6,059,827 A 5/2000 Fenton
6,063,095 A 5/2000 Wang
6,066,151 A 5/2000 Miyawaki
6,066,160 A 5/2000 Colvin
6,066,166 A 5/2000 Bischoff
6,068,637 A 5/2000 Popov
6,068,648 A 5/2000 Cole
6,077,277 A 6/2000 Mollenauer
6,077,292 A 6/2000 Bonutti
6,080,161 A 6/2000 Eaves
6,083,522 A 7/2000 Chu
6,086,593 A 7/2000 Bonutti
6,086,608 A 7/2000 Ek
6,090,072 A 7/2000 Kratoska
6,099,531 A 8/2000 Bonutti
6,099,537 A 8/2000 Sugai
6,099,550 A 8/2000 Yoon
6,099,552 A 8/2000 Adams
6,102,850 A 8/2000 Wang
6,106,545 A 8/2000 Egan
6,117,160 A 9/2000 Bonutti
6,120,536 A 9/2000 Ding
6,123,941 A 9/2000 Bissell et al.
6,125,574 A 10/2000 Ganaja
6,126,677 A 10/2000 Ganaja
6,139,320 A 10/2000 Hahn
RE36,974 E 11/2000 Bonutti
6,149,669 A 11/2000 Li
6,152,949 A 11/2000 Bonutti
6,155,756 A 12/2000 Mericle
6,159,224 A 12/2000 Yoon
6,159,234 A 12/2000 Bonutti
6,171,299 B1 1/2001 Bonutti
6,171,307 B1 1/2001 Bonutti
6,174,324 B1 1/2001 Egan
6,179,840 B1 1/2001 Bowman
6,179,850 B1 1/2001 Goradia
6,187,008 B1 2/2001 Hamman
6,190,400 B1 2/2001 Van De Moer
6,190,401 B1 2/2001 Green
6,200,322 B1 3/2001 Branch
6,217,591 B1 4/2001 Egan
6,224,593 B1 5/2001 Ryan
6,224,630 B1 5/2001 Bao
6,228,086 B1 5/2001 Wahl
6,231,592 B1 5/2001 Bonutti
6,238,395 B1 5/2001 Bonutti
6,238,396 B1 5/2001 Bonutti
6,258,091 B1 7/2001 Sevrain
6,264,675 B1 7/2001 Brotz
6,267,761 B1 7/2001 Ryan
6,273,717 B1 8/2001 Hahn

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,280,474	B1	8/2001	Cassidy	
6,286,746	B1	9/2001	Egan	
6,287,325	B1	9/2001	Bonutti	
6,293,961	B2	9/2001	Schwartz	
6,306,159	B1	10/2001	Schwartz	
6,309,405	B1	10/2001	Bonutti	
6,312,448	B1	11/2001	Bonutti	
6,338,730	B1	1/2002	Bonutti	
6,340,365	B2	1/2002	Dittrich	
6,348,056	B1	2/2002	Bates	
6,358,271	B1	3/2002	Egan	
6,364,897	B1	4/2002	Bonutti	
6,368,325	B1	4/2002	McKinley	
6,368,343	B1	4/2002	Bonutti	
6,371,957	B1	4/2002	Amrein	
6,409,742	B1	6/2002	Fulton	
6,409,743	B1	6/2002	Fenton	
6,419,704	B1	7/2002	Ferree	
6,423,088	B1	7/2002	Fenton	
6,425,919	B1	7/2002	Lambrecht	
6,428,562	B2	8/2002	Bonutti	
6,432,115	B1	8/2002	Mollenauer	
6,447,516	B1	9/2002	Bonutti	
6,450,985	B1	9/2002	Schoelling	
6,461,360	B1	10/2002	Adam	
6,468,293	B2	10/2002	Bonutti	
6,475,230	B1	11/2002	Bonutti	
6,488,196	B1	12/2002	fenton	
6,500,195	B2	12/2002	Bonutti	
6,503,259	B2	1/2003	Huxel	
6,527,774	B2	3/2003	Lieberman	
6,530,933	B1	3/2003	Yeung	
6,535,764	B2	3/2003	Imran	
6,544,267	B1	4/2003	Cole	
6,545,390	B1	4/2003	Hahn	
6,547,792	B1	4/2003	Tsuji	
6,551,304	B1	4/2003	Whalen	
6,551,343	B1	4/2003	Tormala	
6,554,852	B1	4/2003	Oberlander	
6,557,426	B2	5/2003	Reinemann	
6,558,390	B2	5/2003	Cragg	
6,568,313	B2	5/2003	Fukui	
6,569,187	B1	5/2003	Bonutti	
6,572,635	B1	6/2003	Bonutti	
D477,776	S	7/2003	Pontaoe	
6,585,750	B2	7/2003	Bonutti	
6,592,609	B1	7/2003	Bonutti	
6,594,517	B1	7/2003	Nevo	
6,585,764	B2	8/2003	Wright	
6,602,293	B1	8/2003	Biermann	
6,610,080	B2	8/2003	Morgan	
6,605,090	B1	9/2003	Trieu	
6,618,910	B1	9/2003	Pontaoe	
6,620,195	B2	9/2003	Goble et al.	
6,623,487	B1	9/2003	Goshert	
6,626,944	B1	9/2003	Taylor	
6,623,486	B1	10/2003	Weaver	
6,632,245	B2	10/2003	Kim	
6,635,073	B2	10/2003	Bonutti	
6,638,279	B2	10/2003	Bonutti	
6,641,592	B1	11/2003	Sauer	
6,645,227	B2	11/2003	Fallin	
6,666,877	B2	12/2003	Morgan	
6,669,705	B2	12/2003	Westhaver	
6,679,888	B2	1/2004	Green	
6,679,917	B2	1/2004	Ek	
6,685,750	B1	2/2004	Plos	
6,699,240	B2	3/2004	Fracischelli	
6,702,821	B2	3/2004	Bonutti	
6,705,179	B1	3/2004	Mohtasham	
6,709,457	B1	3/2004	Otte	
6,719,765	B2	4/2004	Bonutti	
6,719,795	B1	4/2004	Cornwall	
6,719,797	B1	4/2004	Ferree	
6,722,552	B2	4/2004	Fenton	
6,733,531	B1	5/2004	Trieu	
6,761,722	B2 *	7/2004	Cole	A61B 17/0401 606/232
6,770,078	B2	8/2004	Bonutti	
6,780,198	B1	8/2004	Gregoire	
6,786,989	B2	9/2004	Torriani	
6,796,003	B1	9/2004	Marvel	
6,818,010	B2	11/2004	Eichhorn	
6,823,871	B2	11/2004	Schmieding	
6,830,589	B2	12/2004	Erickson	
6,860,885	B2	3/2005	Bonutti	
6,878,167	B2	4/2005	Ferree	
6,890,334	B2	5/2005	Brace	
6,893,434	B2	5/2005	Fenton	
6,899,722	B2	5/2005	Bonutti	
6,913,666	B1	7/2005	Aeschlimann	
6,916,321	B2	7/2005	TenHuisen	
6,921,264	B2	7/2005	Mayer	
6,923,824	B2	8/2005	Morgan	
6,932,835	B2	8/2005	Bonutti	
6,942,684	B2	9/2005	Bonutti	
6,944,111	B2	9/2005	Nakamura	
6,955,540	B2	10/2005	Mayer	
6,955,683	B2	10/2005	Bonutti	
6,958,077	B2	10/2005	Suddaby	
6,981,983	B1	1/2006	Rosenblatt	
6,997,940	B2	2/2006	Bonutti	
7,001,411	B1	2/2006	Dean	
7,004,959	B2	2/2006	Bonutti	
7,008,226	B2	3/2006	Mayer	
7,033,379	B2	4/2006	Peterson	
7,048,755	B2	5/2006	Bonutti	
7,066,960	B1	6/2006	Dickman	
7,087,073	B2	8/2006	Bonutti	
7,090,111	B2	8/2006	Egan	
7,094,251	B2	8/2006	Bonutti	
7,104,996	B2	9/2006	Bonutti	
7,128,763	B1	10/2006	Blatt	
7,018,380	B2	12/2006	Cole	
7,147,652	B2	12/2006	Bonutti	
7,160,405	B2	1/2007	Aeschlimann	
7,179,259	B1	2/2007	Gibbs	
7,189,240	B1 *	3/2007	Dekel	A61B 17/1671 606/84
7,192,448	B2	3/2007	Ferree	
7,217,279	B2 *	5/2007	Reese	A61B 17/0401 606/232
7,217,290	B2	5/2007	Bonutti	
7,241,297	B2	7/2007	Shaolian	
7,250,051	B2	7/2007	Francischelli	
7,252,685	B2	8/2007	Bindseil	
7,273,497	B2	9/2007	Ferree	
7,326,200	B2	2/2008	Trieu	
7,329,263	B2	2/2008	Bonutti	
7,335,205	B2	2/2008	Aeschlimann	
7,429,266	B2	9/2008	Bonutti	
7,445,634	B2	11/2008	Trieu	
7,481,825	B2	1/2009	Bonutti	
7,481,831	B2	1/2009	Bonutti	
7,510,895	B2	3/2009	Rateman	
7,597,705	B2	10/2009	Forsberg	
7,854,750	B2	12/2010	Bonutti	
7,879,072	B2	2/2011	Bonutti	
7,891,691	B2	2/2011	Bearey	
7,967,820	B2	6/2011	Bonutti	
8,041,114	B2	10/2011	Rother et al.	
8,128,669	B2	3/2012	Bonutti	
8,140,982	B2	3/2012	Hamilton	
8,141,520	B2	3/2012	Matsumura et al.	
8,147,514	B2	4/2012	Bonutti	
8,162,977	B2	4/2012	Bonutti	
8,771,314	B2	7/2014	Crombie	
8,845,699	B2	9/2014	Bonutti	
2001/0002440	A1	5/2001	Bonutti	
2001/0009250	A1	7/2001	Hermanh	
2001/0041916	A1	11/2001	Bonutti	
2001/0056287	A1	12/2001	Bonutti	
2002/0016593	A1	2/2002	Hearn	
2002/0016633	A1	2/2002	Lin	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2002/0019649 A1 2/2002 Sikora
2002/0026244 A1 2/2002 Trieu
2002/0029067 A1 3/2002 Bonutti
2002/0029083 A1 3/2002 Zucherman
2002/0029084 A1 3/2002 Paul
2002/0045902 A1 4/2002 Bonutti
2002/0058966 A1 5/2002 Tormala
2002/0062153 A1 5/2002 Paul
2002/0087189 A1 7/2002 Bonutti
2002/0091391 A1 7/2002 Cole et al.
2002/0103495 A1 8/2002 Cole
2002/0120269 A1 8/2002 Lange
2002/0123750 A1 9/2002 Eisermann
2002/0161439 A1 10/2002 Strobel
2002/0183762 A1 12/2002 Anderson
2002/0188301 A1 12/2002 Dallara
2003/0039196 A1 2/2003 Nakamura
2003/0040758 A1 2/2003 Wang
2003/0065361 A1* 4/2003 Dreyfuss A61B 17/0401 606/232
2003/0065391 A1 4/2003 Re et al.
2003/0083667 A1 5/2003 Ralph
2003/0097148 A1 5/2003 Valimaa
2003/0105474 A1 6/2003 Bonutti
2003/0125749 A1 7/2003 Yuan
2003/0158555 A1 8/2003 Sanders
2003/0158582 A1 8/2003 Bonutti
2003/0167072 A1 8/2003 Oberlander
2003/0118518 A1 9/2003 HYahn
2003/0181800 A1 9/2003 Bonutti
2003/0195514 A1 10/2003 Trieu
2003/0195530 A1 10/2003 Thill
2003/0195565 A1 10/2003 Bonutti
2003/0204204 A1 10/2003 Bonutti
2003/0208203 A1 11/2003 Lim
2003/0216742 A1 11/2003 Wetzler
2003/0225438 A1 12/2003 Bonutti
2003/0229361 A1 12/2003 Jackson
2004/0010287 A1 1/2004 Bonutti
2004/0024459 A1 2/2004 Ferree
2004/0030341 A1 2/2004 Aeschlimann
2004/0034357 A1 2/2004 Beane
2004/0039392 A1 2/2004 Trieu
2004/0049207 A1 3/2004 Goldfarb
2004/0097939 A1 5/2004 Bonutti
2004/0098050 A1 5/2004 Foerster
2004/0102788 A1 5/2004 Huebner
2004/0116963 A1 6/2004 Lattouf
2004/0138703 A1 7/2004 Alleyne
2004/0138705 A1 7/2004 Heino
2004/0143268 A1 7/2004 Falahee
2004/0143334 A1 7/2004 Ferree
2004/0167548 A1 8/2004 BOnutti
2004/0172063 A1 9/2004 Li
2004/0186471 A1 9/2004 Trieu
2004/0220616 A1 11/2004 Bonutti
2004/0225325 A1 11/2004 Bonutti
2004/0230223 A1 11/2004 Bonutti
2004/0236374 A1 11/2004 Bonutti
2005/0033362 A1 2/2005 Grafton
2005/0033366 A1 2/2005 Cole
2005/0038514 A1 2/2005 Helm
2005/0043733 A1 2/2005 Eisermann
2005/0043796 A1 2/2005 Grant
2005/0065409 A1 3/2005 de la Torre
2005/0070765 A1 3/2005 Abdelgany
2005/0071012 A1 3/2005 Serhan
2005/0075644 A1 4/2005 DiPoto
2005/0090827 A1 4/2005 Gedebou
2005/0096699 A1 5/2005 Wixey
2005/0113928 A1 5/2005 Cragg
2005/0125072 A1 6/2005 Kolb
2005/0126680 A1 6/2005 Aeschlimann
2005/0143745 A1 6/2005 Hodorek et al.
2005/0143826 A1 6/2005 Zucherman
2005/0149024 A1 7/2005 Ferrante
2005/0149029 A1 7/2005 Bonutti
2005/0203521 A1 9/2005 Bonutti
2005/0216087 A1 9/2005 Zucherman
2005/0222620 A1 10/2005 Bonutti
2005/0234459 A1 10/2005 Falahee et al.
2005/0234460 A1 10/2005 Miller
2005/0240190 A1 10/2005 Gall
2005/0240227 A1 10/2005 Bonutti
2005/0246021 A1 11/2005 Ringeisen
2005/0256582 A1 11/2005 Ferree
2005/0261684 A1 11/2005 Shaolian
2005/0267481 A1 12/2005 Carl
2005/0267534 A1 12/2005 Bonutti
2005/0283246 A1 12/2005 Cauthen
2006/0009846 A1 1/2006 Trieu
2006/0009855 A1 1/2006 Goble
2006/0015101 A1 1/2006 Warburton
2006/0015108 A1 1/2006 Bonutti
2006/0024357 A1 2/2006 Carpenter
2006/0026244 A1 2/2006 Watson
2006/0064095 A1 3/2006 Senn
2006/0089646 A1 4/2006 Bonutti
2006/0122600 A1 6/2006 Cole
2006/0122704 A1 6/2006 Vresilovic
2006/0142799 A1 6/2006 Bonutti
2006/0167495 A1 7/2006 Bonutti
2006/0189982 A1 8/2006 Lange
2006/0200199 A1 9/2006 Bonutti
2006/0212073 A1 9/2006 Bonutti
2006/0217765 A1 9/2006 Bonutti
2006/0229623 A1 10/2006 Bonutti
2006/0235413 A1 10/2006 Denham
2006/0235470 A1 10/2006 Bonutti
2006/0241695 A1 10/2006 Bonutti
2006/0264953 A1 11/2006 Falahee
2006/0265009 A1 11/2006 Bonutti
2006/0265011 A1 11/2006 Bonutti
2007/0032825 A1 2/2007 Bonutti
2007/0088362 A1 4/2007 Bonutti
2007/0118129 A1 5/2007 Fraser
2007/0198555 A1 8/2007 Friedman
2007/0233092 A1 10/2007 Falahee
2007/0265561 A1 11/2007 Yeung
2007/0270833 A1 11/2007 Bonutti
2008/0021474 A1 1/2008 Bonutti
2008/0039845 A1 2/2008 BOnutti
2008/0039873 A1 2/2008 Bonutti
2008/0046090 A1 2/2008 Paul
2008/0097448 A1 4/2008 Binder
2008/0108897 A1 5/2008 Bonutti
2008/0108916 A1 5/2008 Bonutti
2008/0114399 A1 5/2008 Bonutti
2008/0132950 A1 6/2008 Lange
2008/0140116 A1 6/2008 Bonutti
2008/0140117 A1 6/2008 Bonutti
2008/0195145 A1 8/2008 Bonutti
2008/0269753 A1 10/2008 Cannestra
2008/0269808 A1 10/2008 Gall
2008/0275453 A1 11/2008 Lafosse et al.
2009/0024161 A1 1/2009 Bonutti
2009/0093684 A1 4/2009 Schorer
2009/0138014 A1 5/2009 Bonutti
2009/0194969 A1 8/2009 Bearey
2010/0211120 A1 2/2010 Bonutti
2011/0060375 A1 3/2011 Bonutti
2011/0295253 A1 12/2011 Bonutti
2012/0165841 A1 6/2012 Bonutti
2012/0191140 A1 7/2012 Bonutti
2012/0215233 A1 8/2012 Bonutti

FOREIGN PATENT DOCUMENTS

CA	2698057	3/2009
DE	1903316	10/1964
DE	1903016	8/1970
DE	3517204	11/1986
DE	3722538	1/1989
DE	9002844 U1	12/1990

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

EP	784454	5/1996
EP	773004	5/1997
EP	1614525	1/2006
EP	1988837	8/2007
EP	2134294	12/2009
FR	2717368	3/1994
FR	2696338	4/1994
FR	2728779	1/1995
FR	2736257	7/1995
FR	2750031	6/1996
FR	2771621	11/1997
FR	2785171	10/1998
GB	2093701 A	9/1982
GB	230611 A	4/1997
JP	8140982	6/1996
SU	184396	7/1966
WO	199112779	9/1991
WO	199323094	11/1993
WO	1994008642	4/1994
WO	1995016398	6/1995
WO	1995031941	11/1995
WO	1996014802	5/1996
WO	1997012779	4/1997
WO	1997049347	12/1997
WO	1998011838	3/1998
WO	1998026720	6/1998
WO	2002053011	7/2002
WO	2007092869	8/2007
WO	2008116203	9/2008
WO	2009029908	3/2009
WO	2009124215	10/2009
WO	2010099222	2/2010

OTHER PUBLICATIONS

Madjar et al, Minimally Invasive Pervaginam Procedures, for the Treatment of Female Stress Incontinence . . . , Artificial Organs, 22 (10) 879-885, 1998.

Nowak et al, Comparative Study of Fixation Techniques in the Open Bankart Operation Using Either a Cannulated Screw or Suture-Anchors, Acta Orthopcedica Belgica, vol. 64-2-1998.

Packer et al, Repair of Acute Scapho-Lunate Dissociation Facilitated by the "TAG"* Suture Anchor, Journal of Hand Surgery (British and European Volume, 1994) 198: 5: 563-564.

Richmond, Modificatio of the Bankart reconstruction with a suture anchor, Am J Sports Med, vol. 19, No. 4, p. 343-346, 1991.

Shea et al, Technical Note: Arthroscopic Rotator Cuff Repair Using a Transhumeral Approach to Fixation, Arthroscopy: The Journal of Arthroscopic and Related Surgery, vol. 14, No. 1 Jan.-Feb. 1998: pp. 118-122.

Tfix, Acufex just tied the knot . . . , Am. J. Sports Med., vol. 22, No. 3, May-Jun. 1994.

Wong et al, Case Report: Proper Insertion Angle Is Essential to Prevent Intra-Articular Protrusion of a Knotless Suture Anchor in Shoulder Rotator Cuff Repair, Arthroscopy: The Journal of Arthroscopic and Related Surgery, vol. 26, No. 2 Feb. 2010: pp. 286-290.

Cobb et al, Late Correction of Malunited Intercondylar Humeral Fractures Intra-Articular Osteotomy and Tricortical Bone Grafting, J BoneJointSurg [Br] 1994; 76-B:622-6.

Fellinger, et al, Radial avulsion of the triangular fibrocartilage complex in acute wrist trauma: a new technique for arthroscopic repair, Jun. 1997, Arthroscopy vol. 13 No. 3 p. 370-4.

Hecker et al , Pull-out strength of suture anchors for rotator cuff and Bankart lesion repairs, Nov.-Dec. 1993 , The American Journal of Sports Medicine, vol. 21 No. 6 p. 874-9.

Hernigou et al , Proximal Tibial Osteotomy for Osteoarthritis with Varus Deformity a Ten to Thirteen-Year Follow-Up Study, J Bone Joint Surg, vol. 69-A, No. 3. Mar. 1987, p. 332-354.

Ibarra et al, Glenoid Replacement in Total Shoulder Arthroplasty, The Orthopedic Clinics of Northamerica: Total Shoulder Arthroplasty, vol. 29 No. 3, Jul. 1998 p. 403-413.

Mosca et al, Calcaneal Lengthening for Valgus Deformity of the Hindfoot: Results in Children Who Had Severe, Symptomatic Flatfoot and Skewfoot, J Bone Joint Surg,, 1195—p. 499-512.

Murphy et al , Radial Opening Wedge Osteotomy in Madelung's Deformity, J. Hand Surg, vol. 21 A No. 6 Nov. 1996, p. 1035-44.

Biomet, Stanmore Modular Hip, J. Bone Joint Surg., vol. 76-B No. Two, Mar. 1994.

Non-Final Office Action dated Dec. 29, 2014 relating to U.S. Appl. No. 11/358,311, 8 pgs.

Final Office Action dated Jun. 9, 2014 relating to U.S. Appl. No. 11/358,311, 11 pgs.

Final Office Action dated Dec. 17, 2013 relating to U.S. Appl. No. 11/358,311, 8 pgs.

Non-Final Office Action dated Jul. 26, 2013 relating to U.S. Appl. No. 11/358,311, 7 pgs.

Final Office Action dated Oct. 18, 2012 relating to U.S. Appl. No. 11/358,311, 9 pgs.

Non-Final Office Action dated Mar. 20, 2012 relating to U.S. Appl. No. 11/358,311, 8 pgs.

Final Office Action dated Jan. 18, 2011 relating to U.S. Appl. No. 11/358,311, 12 pgs.

Non-Final Office Action dated May 14, 2010 relating to U.S. Appl. No. 11/358,311, 12 pgs.

Final Office Action dated Oct. 2, 2009 relating to U.S. Appl. No. 11/358,311, 12 pgs.

Non-Final Office Action dated Apr. 8, 2008 relating to U.S. Appl. No. 11/358,311, 13 pgs.

Petition for Inter Partes Review of U.S. Pat. No. 5,980,559, IPR 2013-00603, Filing Date Sep. 24, 2013.

Declaration of David Kaplan, Ph.D. Regarding U.S. Pat. No. 5,980,559, IPR 2013-00603, Sep. 24, 2013.

Petition for Inter Partes Review of U.S. Pat. No. 7,087,073, IPR 2013-00604, Filing Date Sep. 24, 2013.

Declaration of Wayne J. Sebastianelli, MD Regarding U.S. Pat. No. 7,087,073, Sep. 24, 2013, IPR 2013-00604.

Petition for Inter Partes Review of U.S. Pat. No. 6,500, 195, IPR 2013-00624, Filing Date Oct. 2, 2013.

Declaration of Dr. Philip Hardy in Support of Petition for Inter Partes Review of U.S. Pat. No. 6,500, 195, IPR 2013-00624, Sep. 25, 2013.

Petition for Inter Partes Review of U.S. Pat. No. 5,527,343, IPR 2013-00628, Filing Date Sep. 25, 2013.

Declaration of Dr. Philip Hardy in Support of Petition for Inter Partes Review of U.S. Pat. No. 5,527,343, IPR 2013-00628, Sep. 25, 2013.

Corrected Petition for Inter Parties Review of U.S. Pat. No. 5,921,986, IPR 2013-00631, Filing Date Sep. 27, 2013.

Expert Declaration of Steve E. Jordan, MD, for Inter Parties Review of U.S. Pat. No. 5,921,986, IPR 2013-00631, Sep. 24, 2013.

Corrected Petition for Inter Parties Reciew of U.S. Pat. No. 8,147,514, IPR 2013-00632, Filing Date Sep. 27, 2013.

Declaration of Steve Jordan for U.S. Pat. No. 8, 147,514, from IPR 2013-00632, dated Sep. 23, 2013 (exhibit 1009).

Corrected Petition for Inter Partes Review of U.S. Pat. No. 8,147,514, IPR 2013-00633, Filing Date Sep. 27, 2013.

Declaration of Steve Jordan for U.S. Pat. No. 8, 147,514, from IPR 2013-00633, dated Sep. 23, 2013 (exhibit 1006).

Flory, Principles of Polymer Chemistry, 1953, selected pages (cited in IPR 2013-00603, exhibit 1012).

Grizzi, Hydrolytic degradation of devices based on poly(DL-lactic acid) size-dependence, Biomaterials, 1995, vol. 16, No. 4, p. 305-11 (cited in IPR 2013-00603, exhibit 1006).

Gopferich, Mechanisms of polymer degradation and erosion, Biomaterials, 1996, vol. 17, No. 2, p. 103-114 (cited in IPR 2013-00603, exhibit 1013).

Gao et el, Swelling of Hydroxypropyl Methylcellulose Matrix Tablets . . . , Journal of Pharmaceutical Sciences, vol. 85, No. 7, Jul. 1996, p. 732-740 (cited in IPR 2013-00603, exhibit 1014).

Linvatec, Impact Suture Anchor brochure, 2004 (cited in IPR 2013-00628, exhibit 1010).

Seitz et al, Repair of the Tibiofibular Syndesmosis with a Flexible Implant, J_ of Orthopaedic Trauma, vol. 5, No. 1, p. 78-82, 1991 (cited in IPR 2013-00631, exhibit 1007) (cited in 2013-00632).

(56) **References Cited**

OTHER PUBLICATIONS

Translation of FR2696338 with translator's certificate dated Sep. 17, 2013 (cited in IPR 2013-00631, 2013-00632).
Translation of DE9002844.9 with translator's certificate dated Sep. 26, 2013 (cited in IPR 2013-00631, 2013-00632).
Declaration of Steve Jordan for U.S. Pat. No. 5,921,986, from IPR 2013-00632, dated Sep. 24, 2013 (exhibit 1010).
Declaration of Steve Jordan for U.S. Pat. No. 5,921,986, from IPR 2013-00633, dated Sep. 24, 2013 (exhibit 1007).
Declaration of Dr. Steve E. Jordan for U.S. Pat. No. 8,147,514, from IPR 2013-00631, dated Sep. 23, 2013.
The Search for the Holy Grail: A Centrury of Anterior Cruciate Ligament Reconstruction, R. John Naranja, American Journal of Orthopedics, Nov. 1997.
Femoral Bone Plug Recession in Endoscope Anterior Cruciate Ligament Reconstruction, David E. Taylor, Arthroscopy: The Journal of Arthroscopic and Related Surgery, Aug. 1996.
Meniscus Replacement with Bone Anchors: A Surgical Technique, Arthroscopy: The Journal of Arthroscopic and Related Surgery, 1994.
Problem Solving Report Question No. 1014984.066, Ultrasonic Welding, (c) 1999.
Guide to Ultrasound Plastic Assembly, Ultrasonic Division Publication, (c) 1995.
Branson, Polymers: Characteristics and Compatibility for Ultrasonic Assembly, Applied Technologies Group, Publication unknown.
Enabling Local Drug Delivery-Implant Device Combination Therapies, Surmodics, Inc., (c) 2003.
Stent Based Delivery of Sirolimus Reduces Neointimal Formation in a Porcine Coronary Model, Takeshi Suzuki, American Heart Association, Inc. (c) 2001.
Why Tie a Knot When You Can Use Y-Knot?, Innovasive Devices Inc., (c) 1998.
Ask Oxford, compact Oxford English dictionary: projection, Mar. 30, 2009.
Ask Oxford, compact Oxford English dictionary: slit, Mar. 30, 2009.
Textured Surface Technology, Branson Technolog, Branson Ultrasonics Copr., (c) 1992.
Arthrex, Protect your graft, Am J Sports Med, vol. 22, No. 4, Jul.-Aug. 1994.
Barrett et al, T-Fix endoscopic meniscal repair: technique and approach to different types of tears, Apr. 1995, Arthroscopy vol. 11 No. 2 p. 245-51.
Cope, Suture Anchor for Visceral Drainage, AJR, vol. 148 p. 160-162, Jan. 1986.
Gabriel, Arthroscopic Fixation Devices, Wiley Enc. of Biomed Eng., 2006.
Innovasive, We've got you covered, Am J Sports Med, vol. 26, No. 1, Jan.-Feb. 1998.
510k—TranSet Fracture Fixation System, Feb. 24, 2004, k033717.
510k—Linvatec Biomaterials modification of Duet and impact Suture Anchor, Nov. 19, 2004, k042966.
510k, arthrex pushlock, Jun. 29, 2005, K051219.
510k, mitek micro anchor, Nov. 6, 1996, K962511.
510k, Multitak Suture System, Jan. 10, 1997, K964324.
510k, Modified Mitek 3.5mm Absorbable Suture Anchor System, Jun. 9, 1997, K970896.
510k, Summary for Arthrex Inc. 's Bio-Interference Screw, Jul. 9, 1997, K971358.
510k, Surgicraft Bone Tie, Sep. 25, 1998, K982719.
Non-Final Office action for U.S. Appl. No. 15/163,425, 11 pages.

* cited by examiner

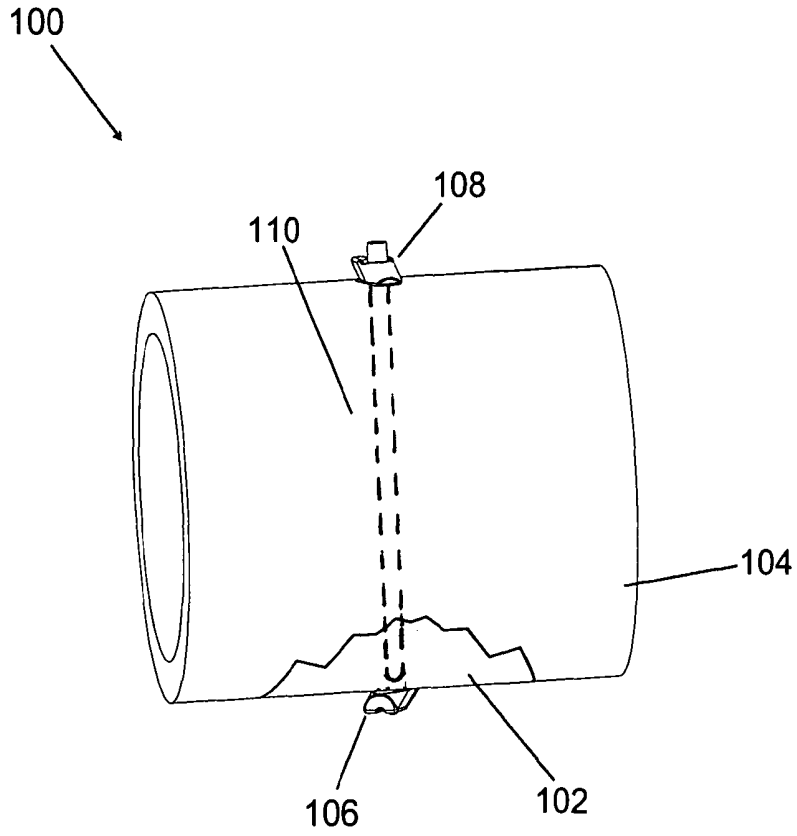


FIG. 1

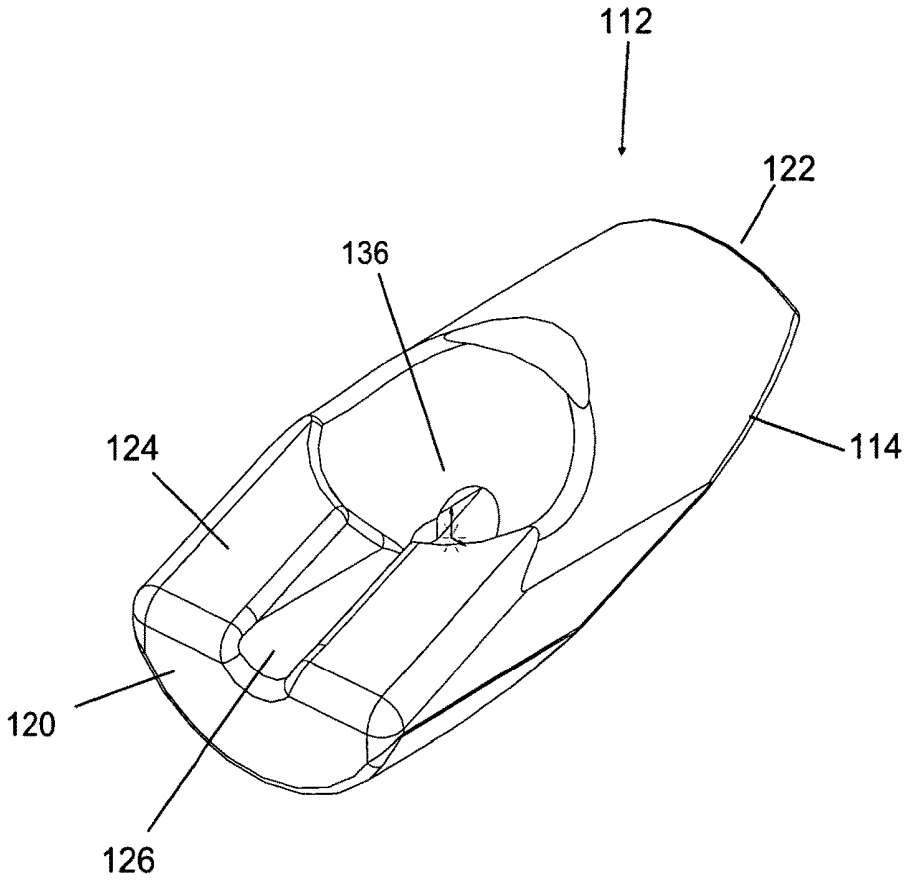


FIG. 2

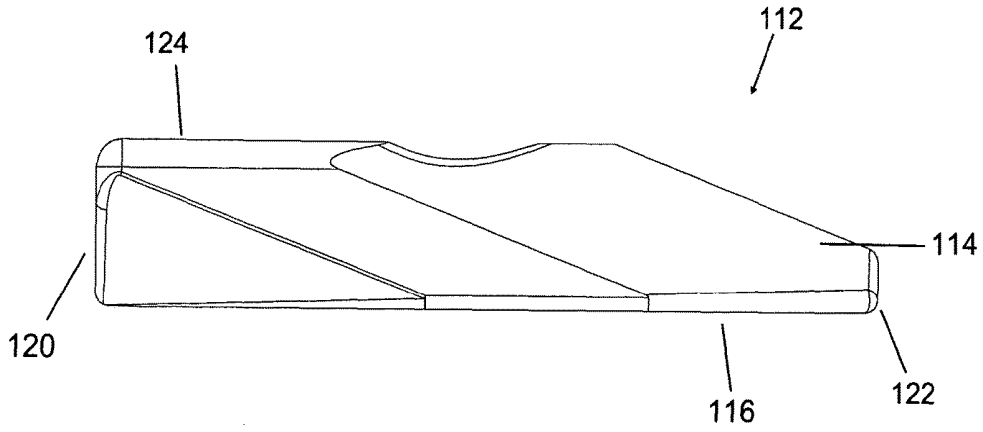


FIG. 3

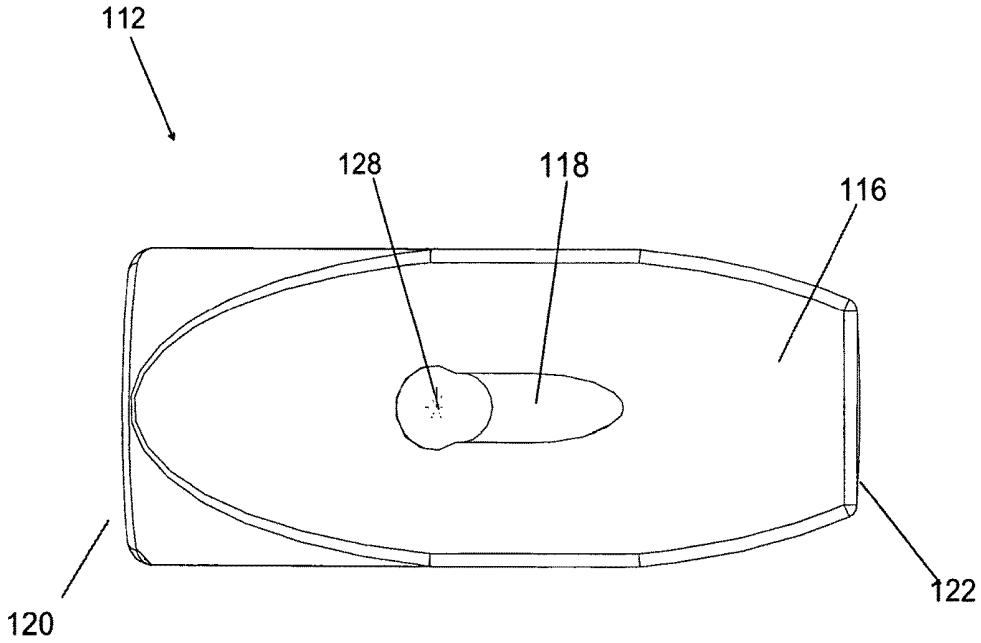


FIG. 4

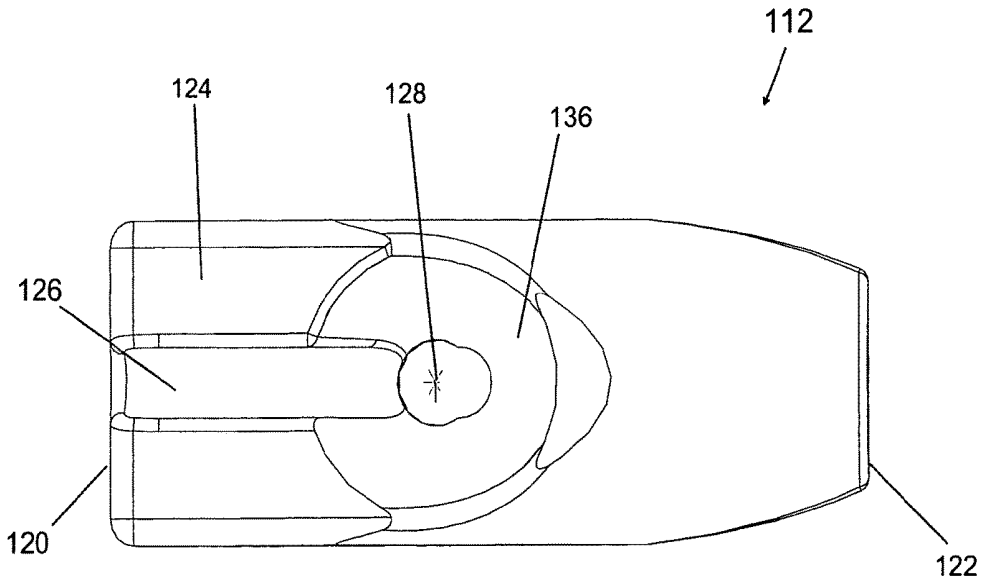


FIG. 5

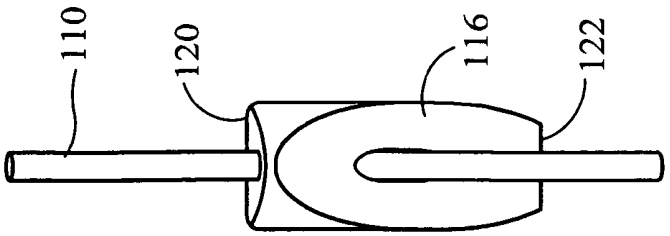


FIG. 8

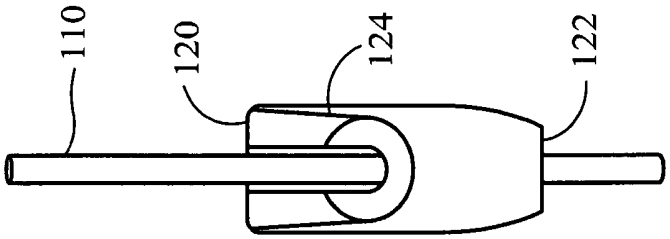


FIG. 7

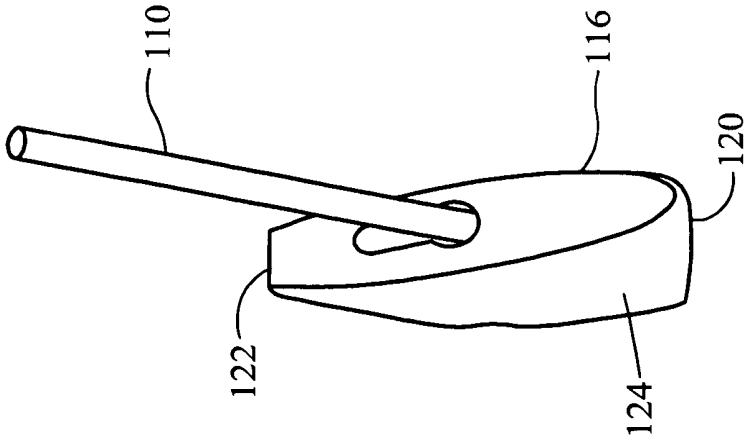


FIG. 6

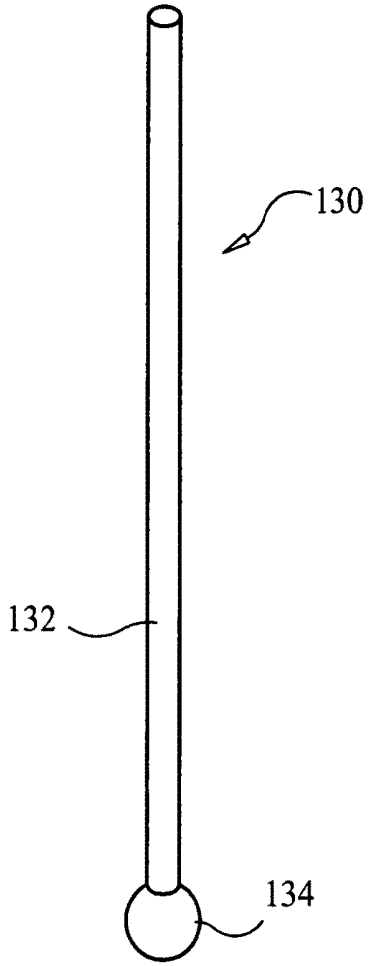


FIG. 9A

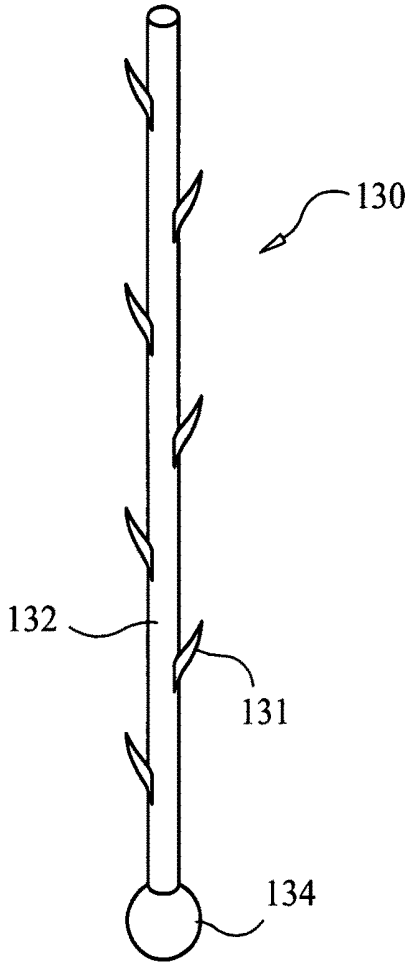


FIG. 9B

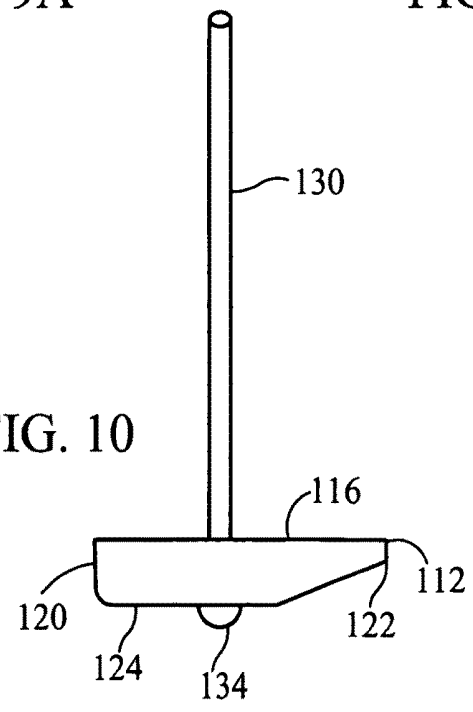


FIG. 10

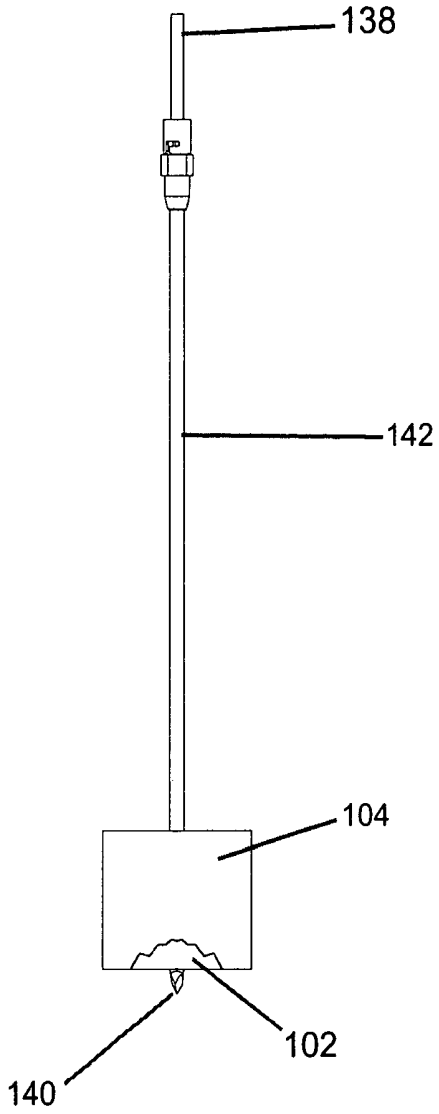


FIG. 11

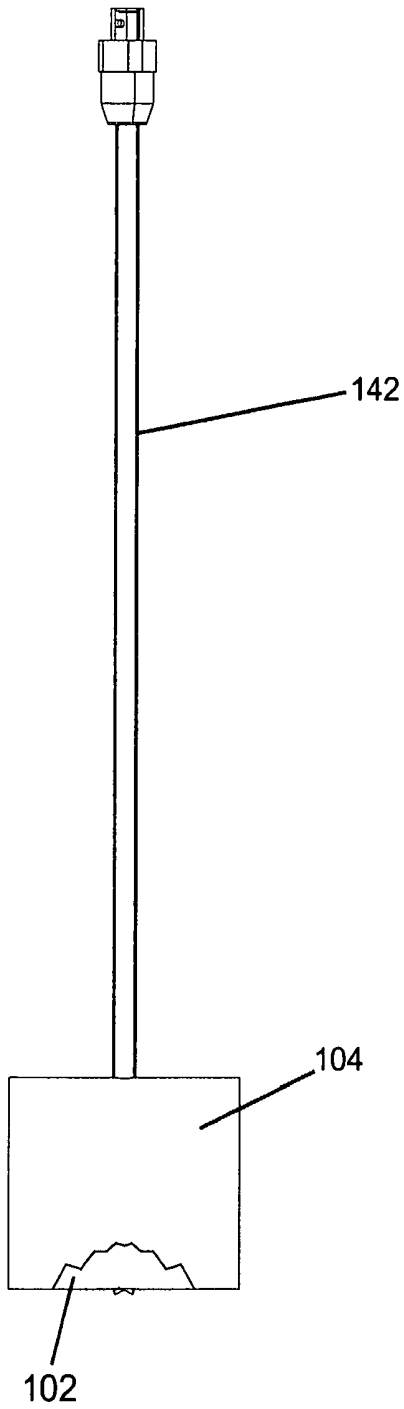


FIG. 12

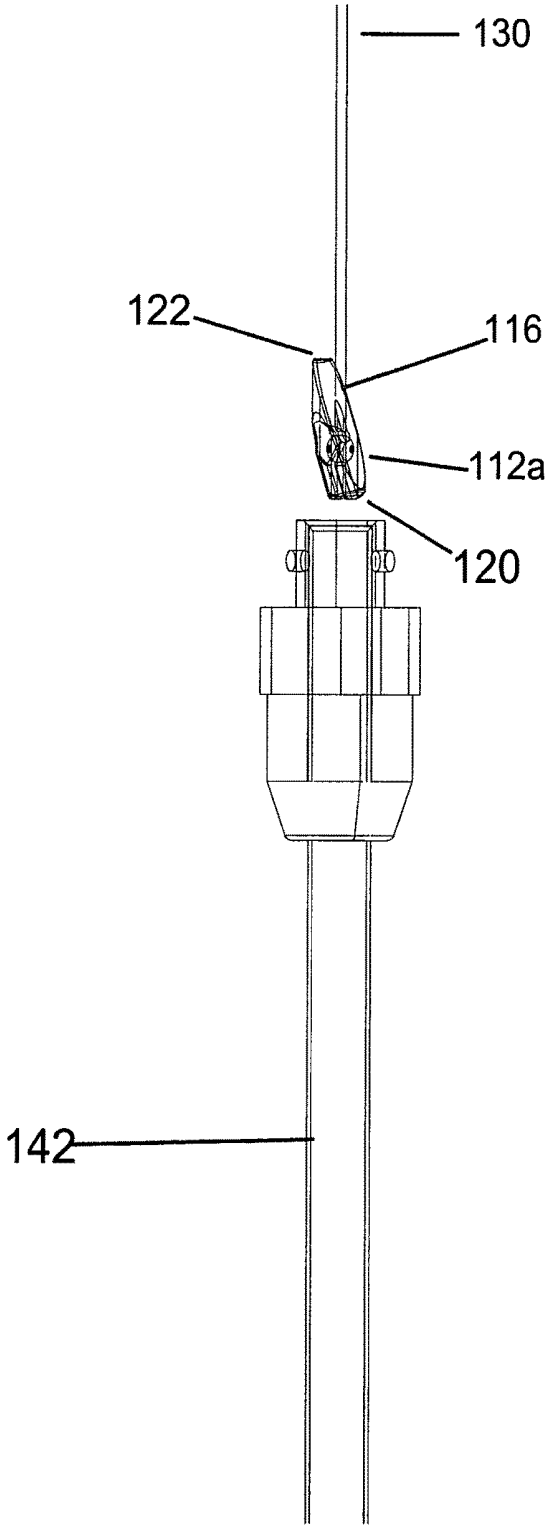


FIG. 13

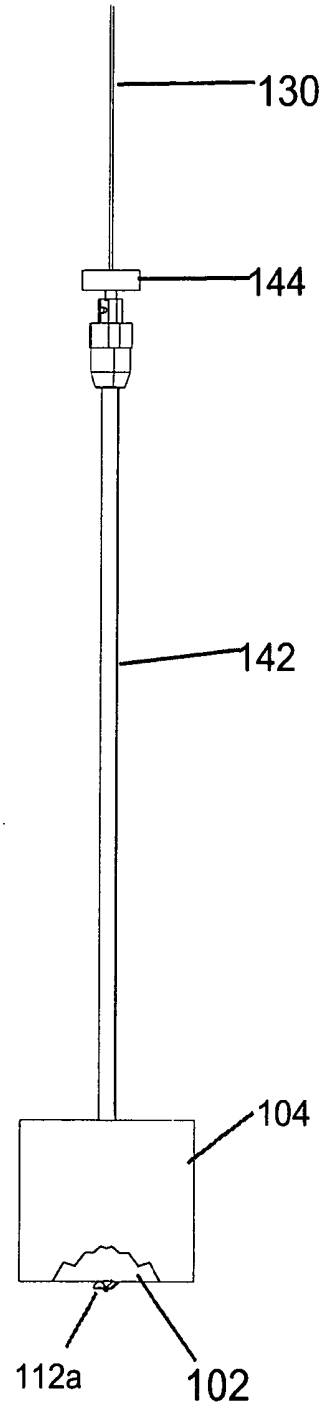


FIG. 14

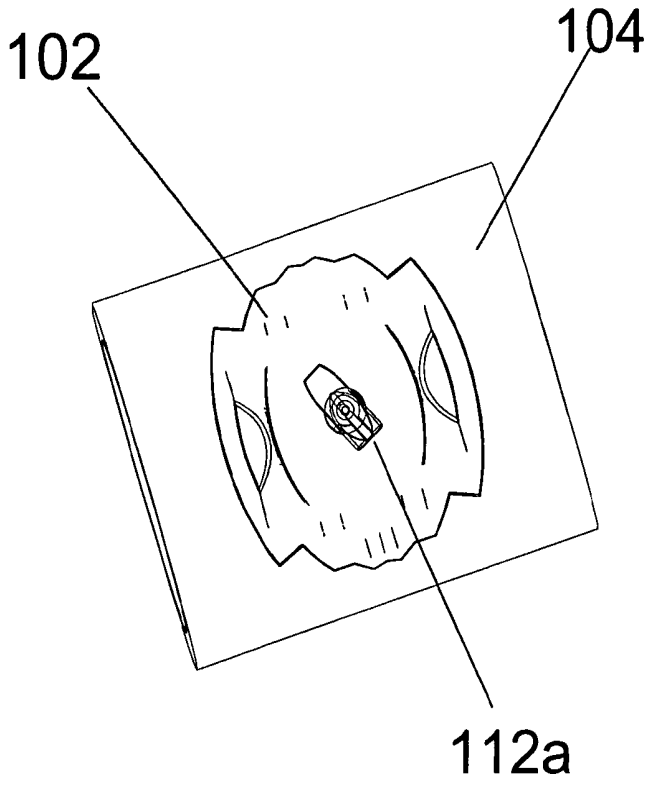


FIG. 15

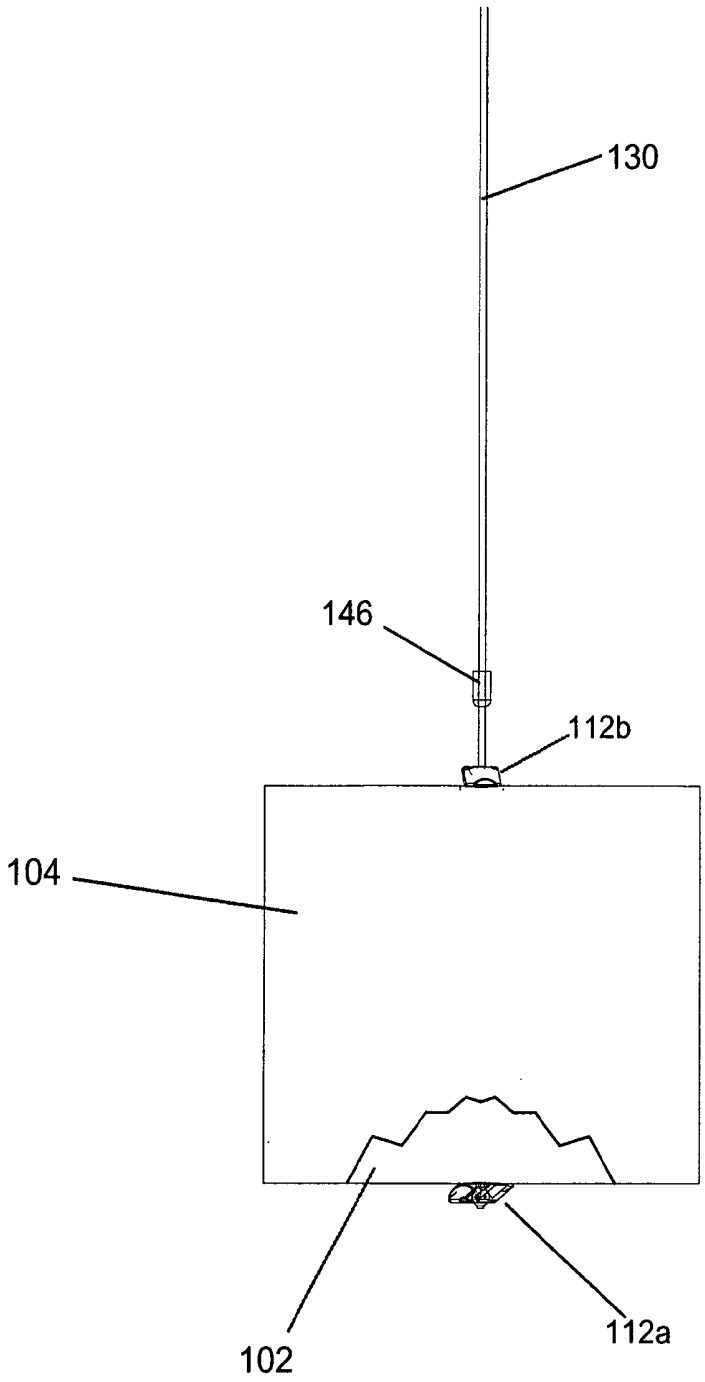


FIG. 16

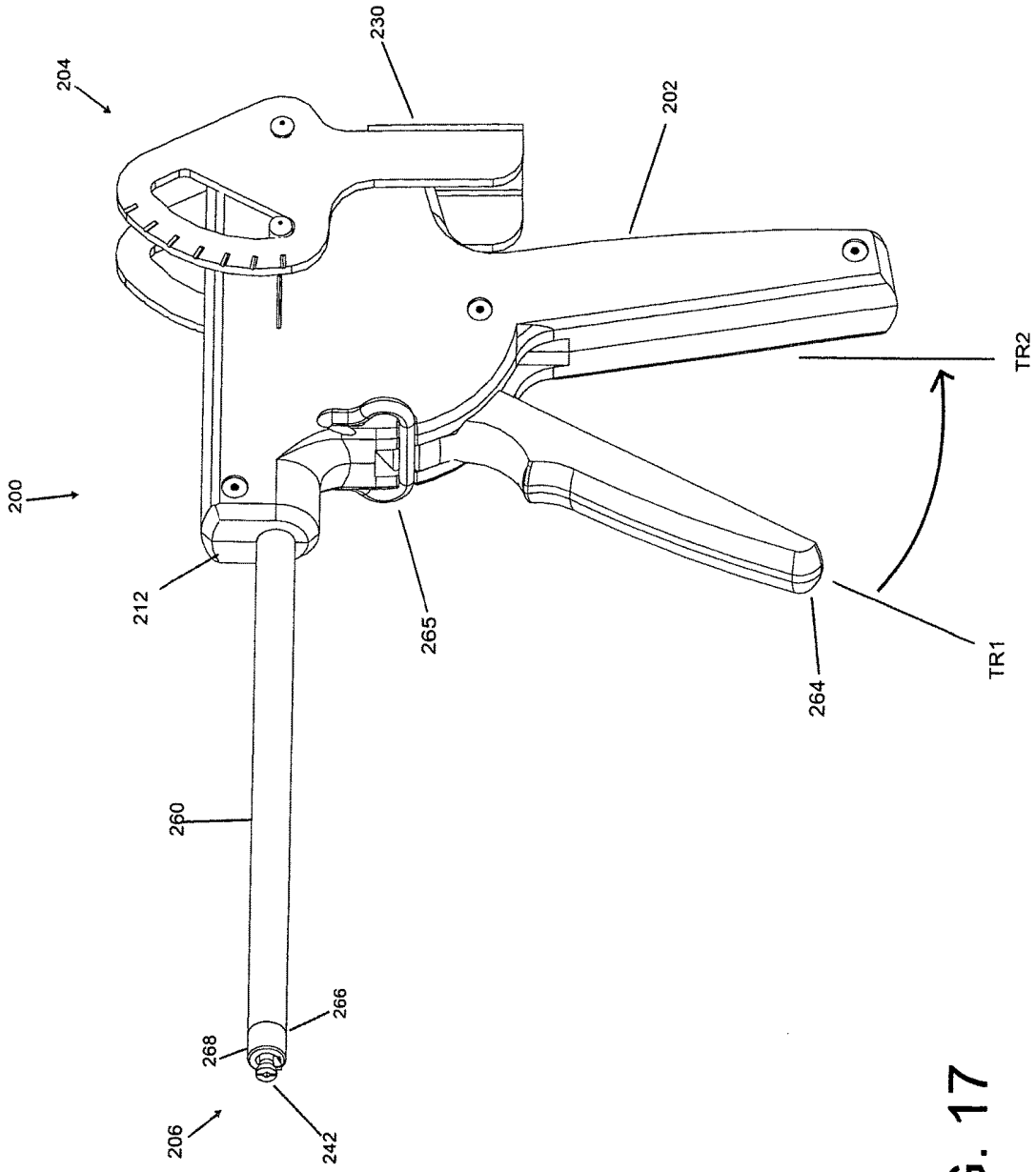
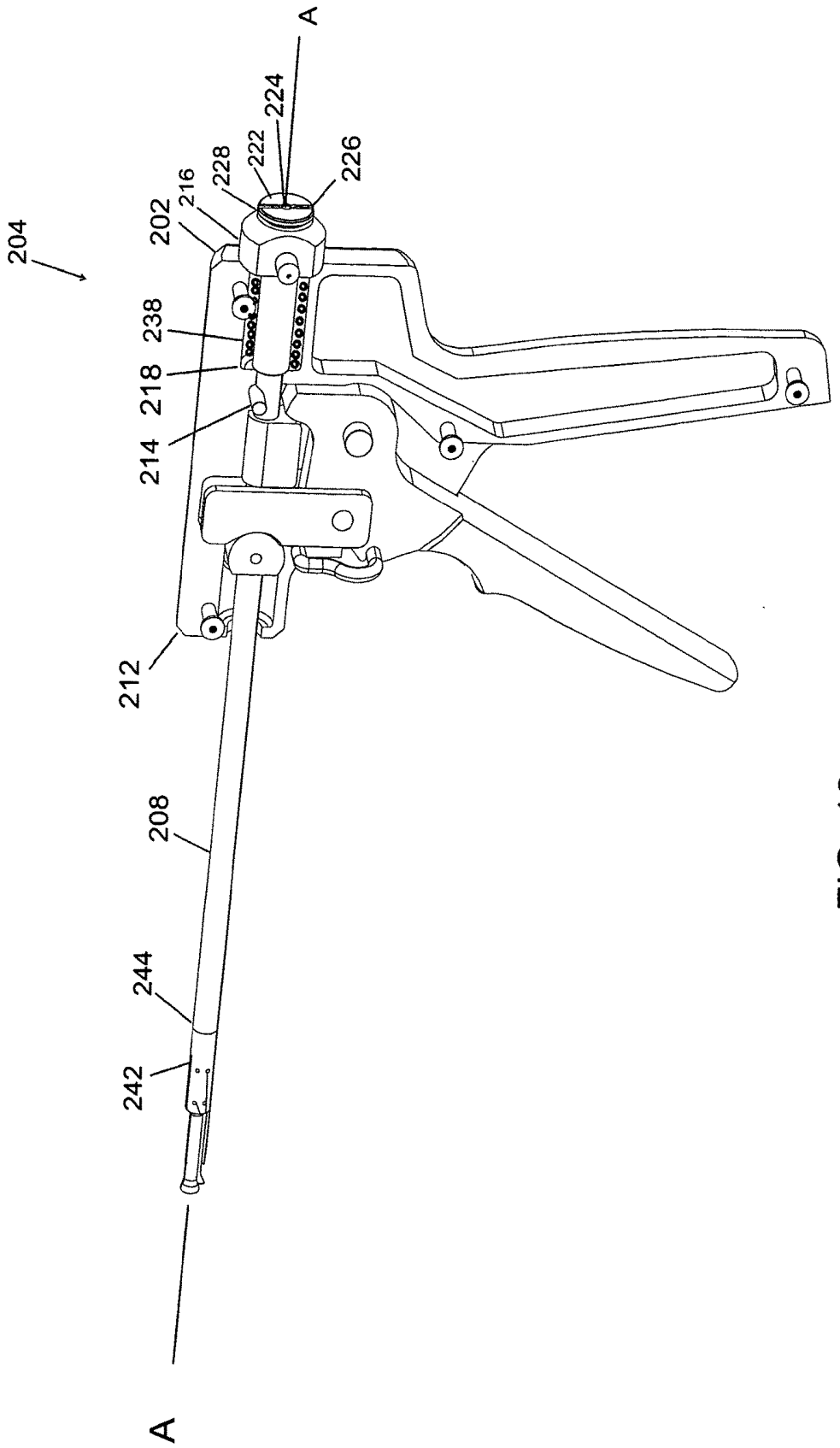


FIG. 17



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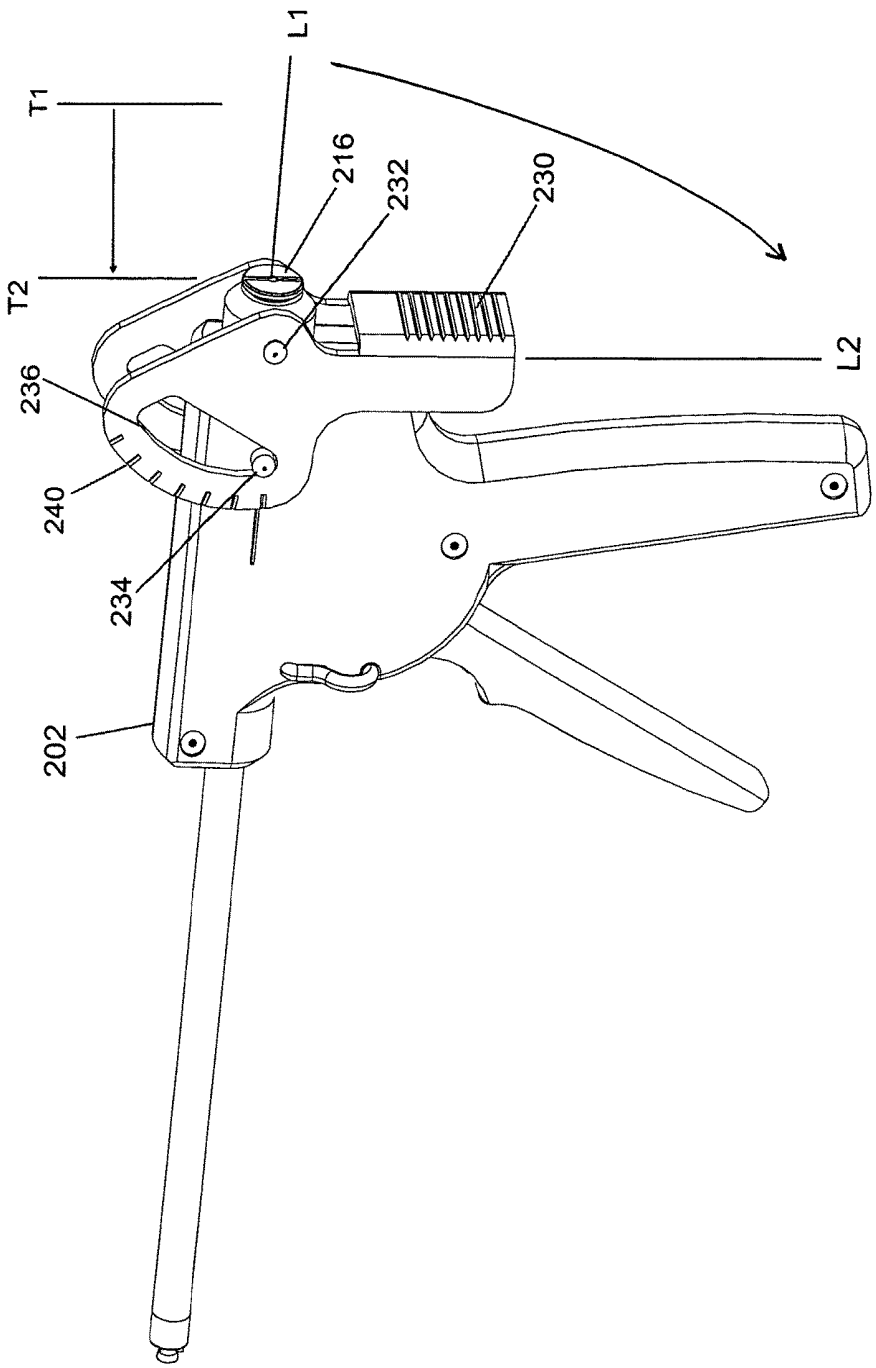

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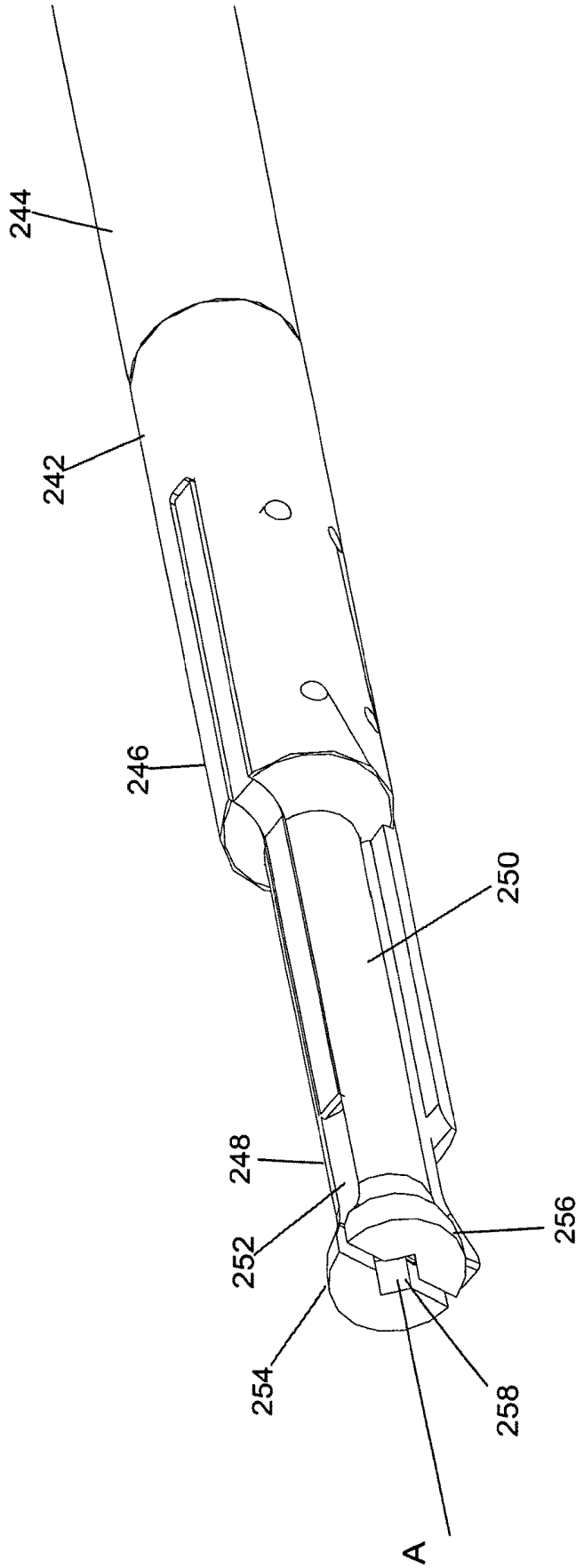


FIG. 20

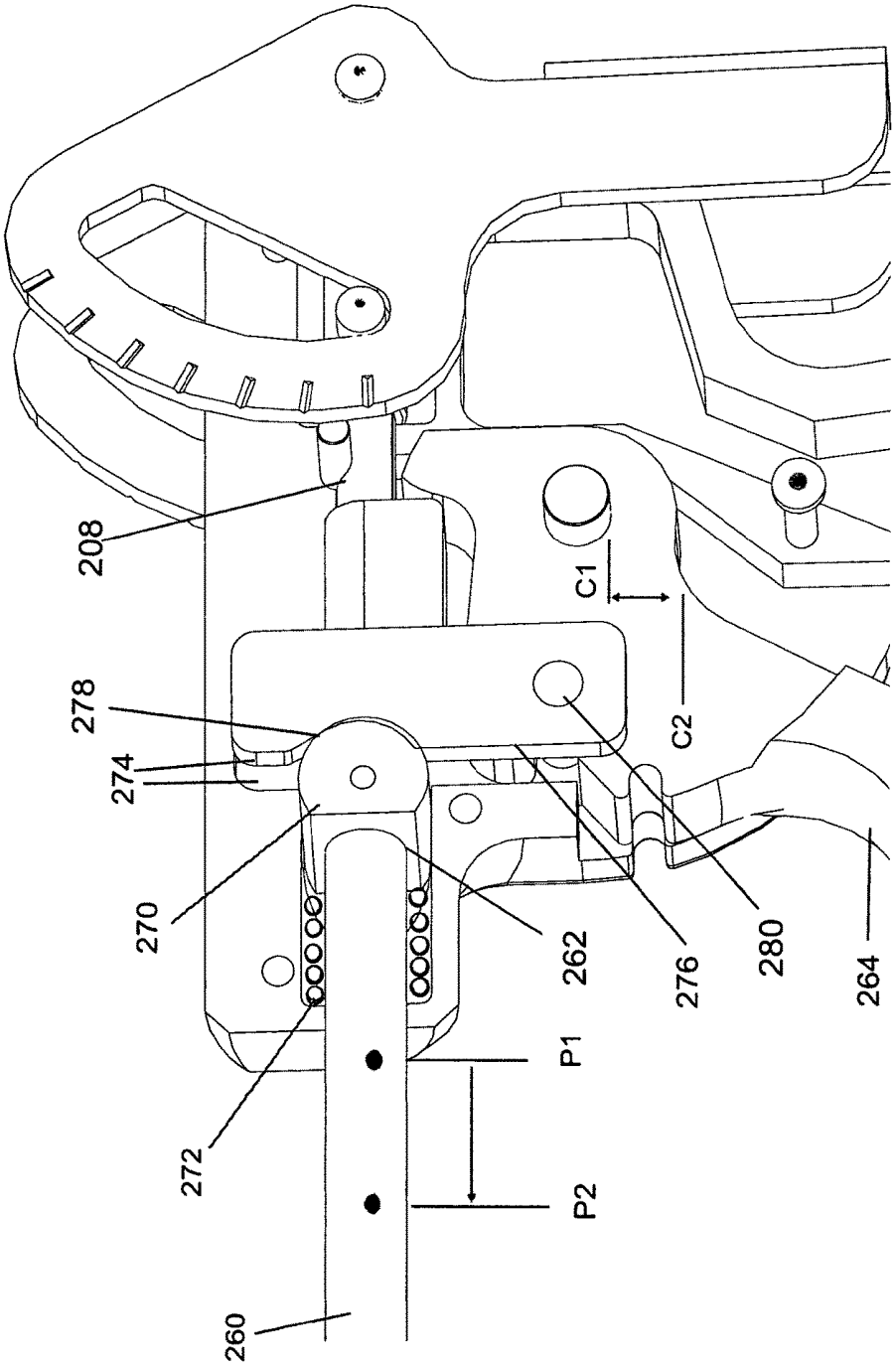


FIG. 21

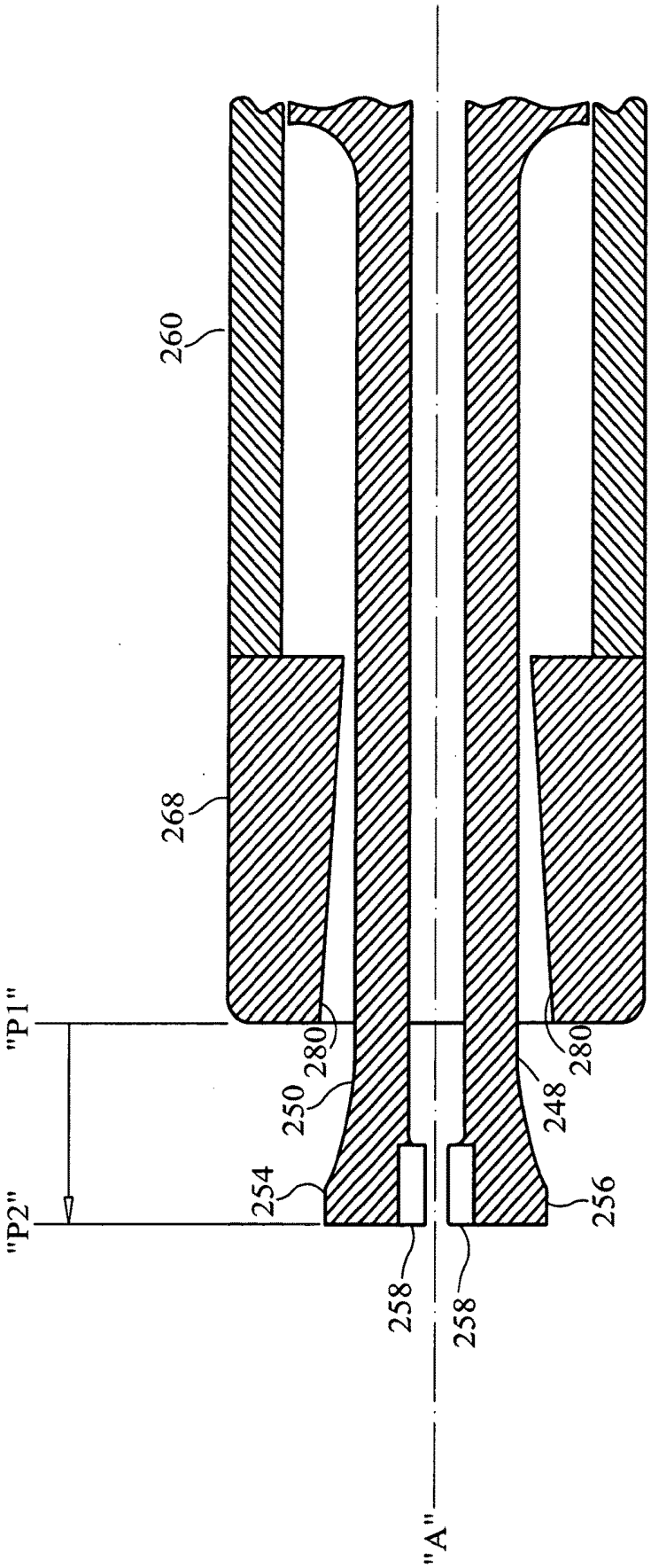
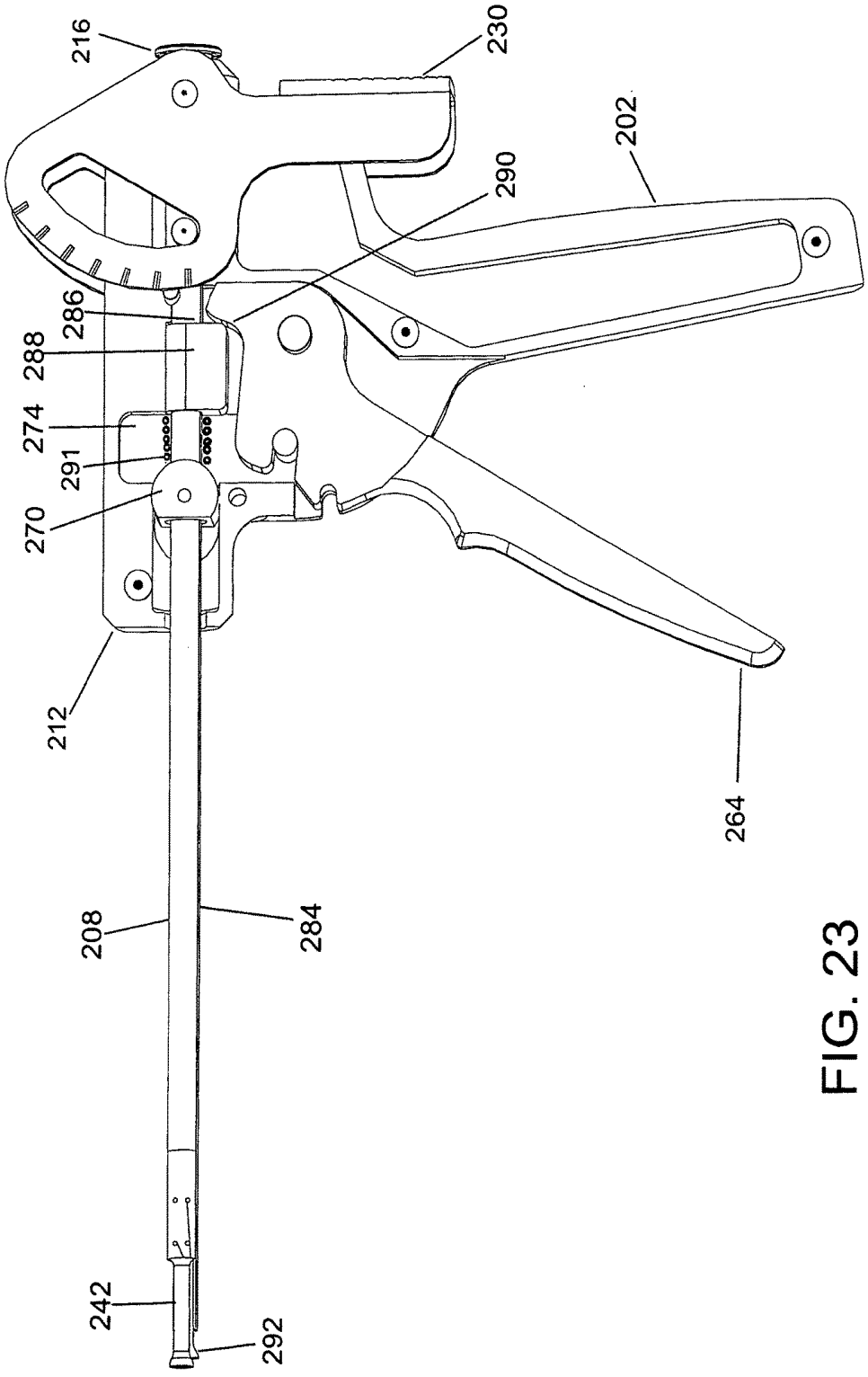


FIG. 22



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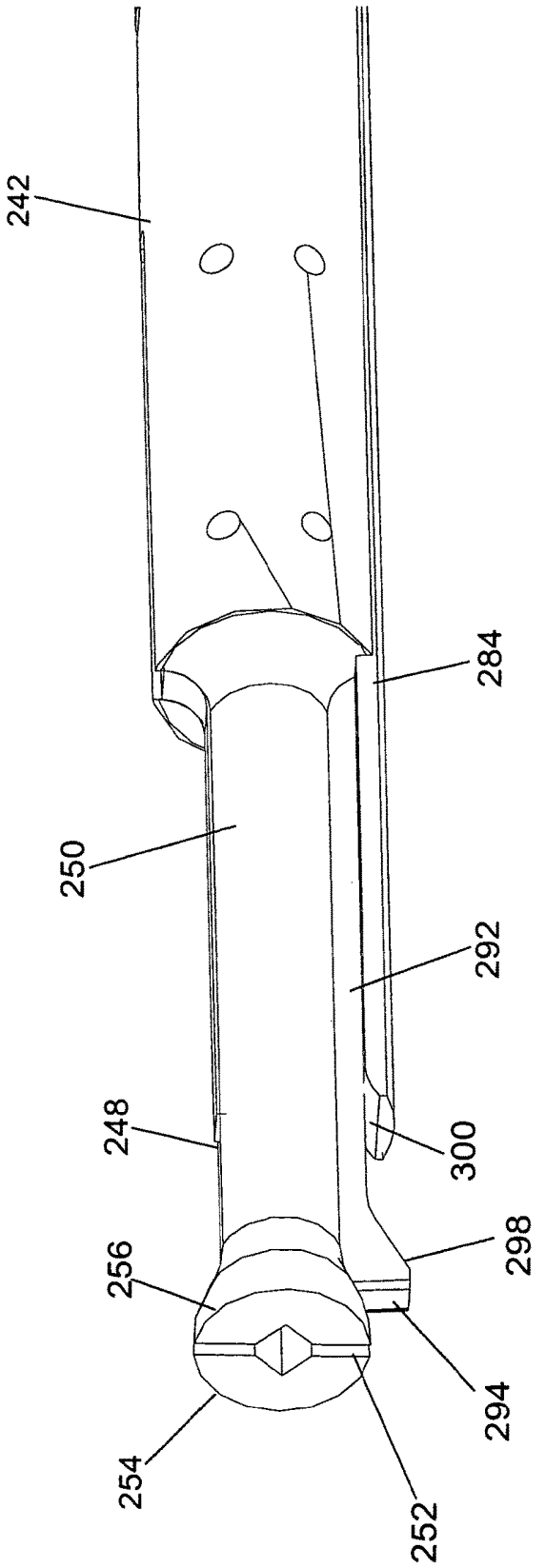


FIG. 24

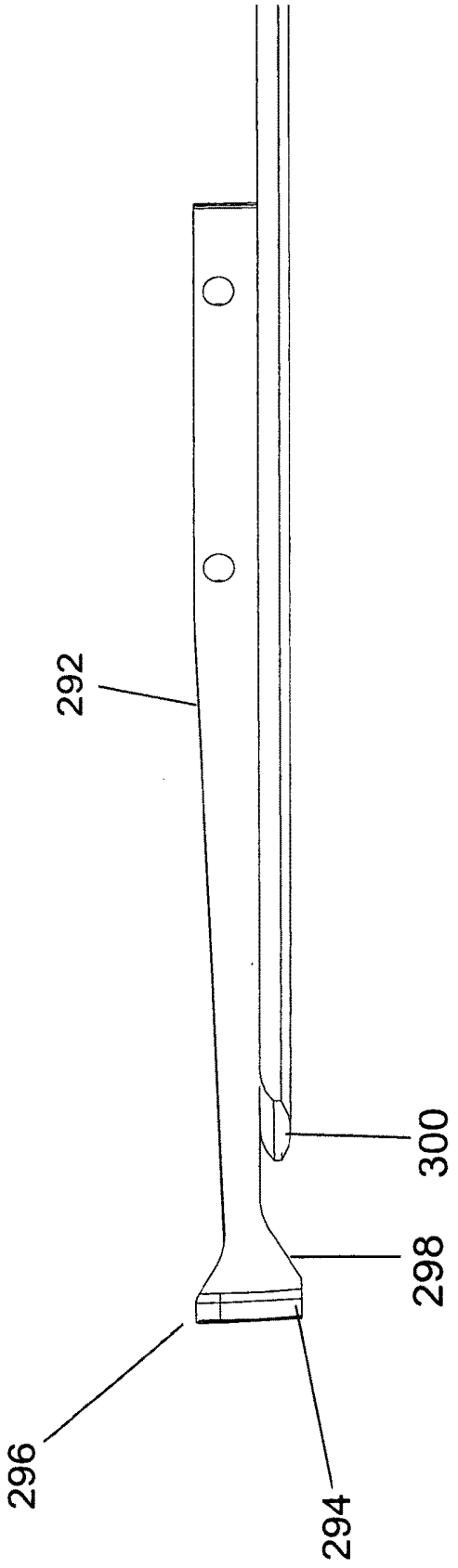
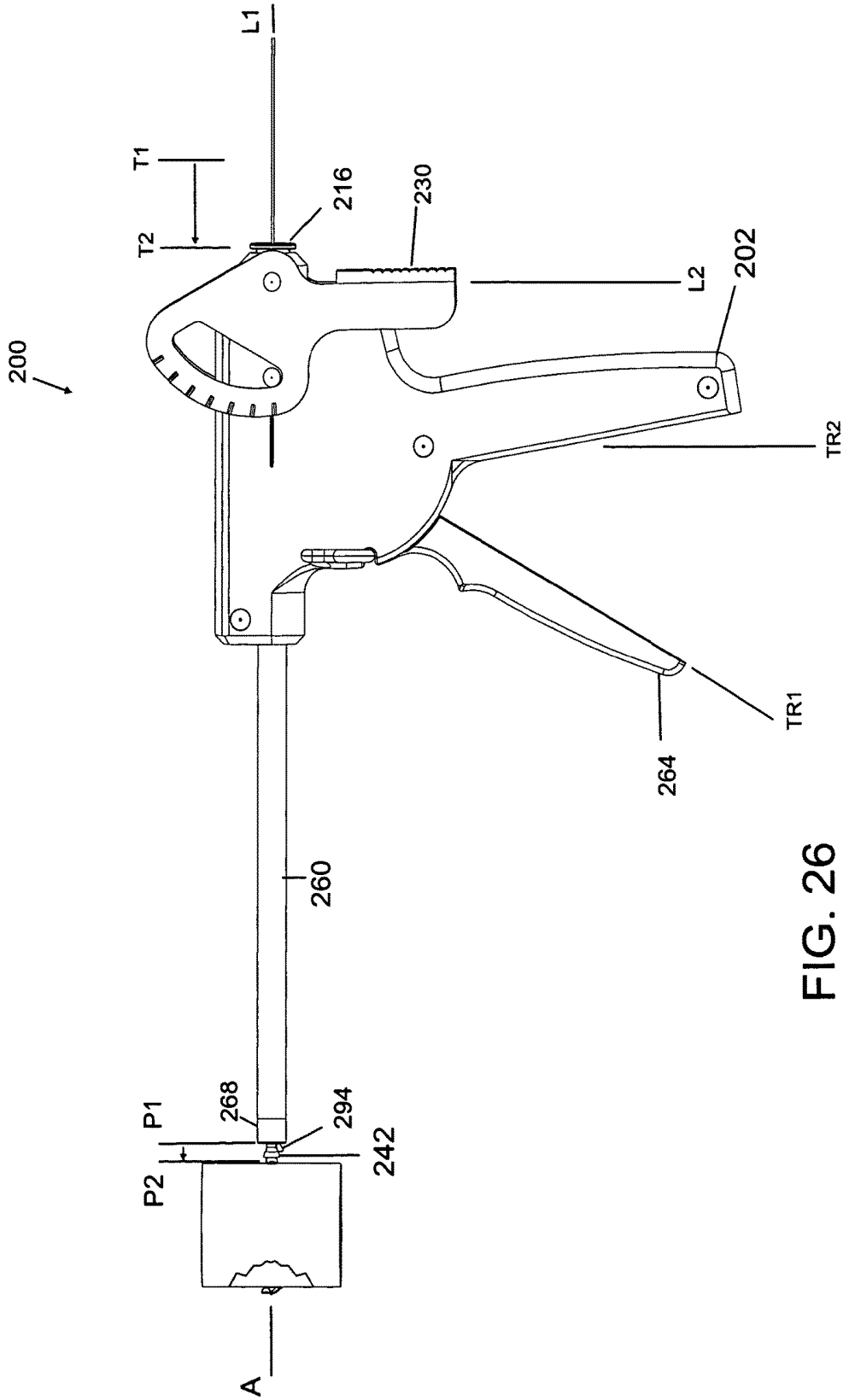


FIG.25



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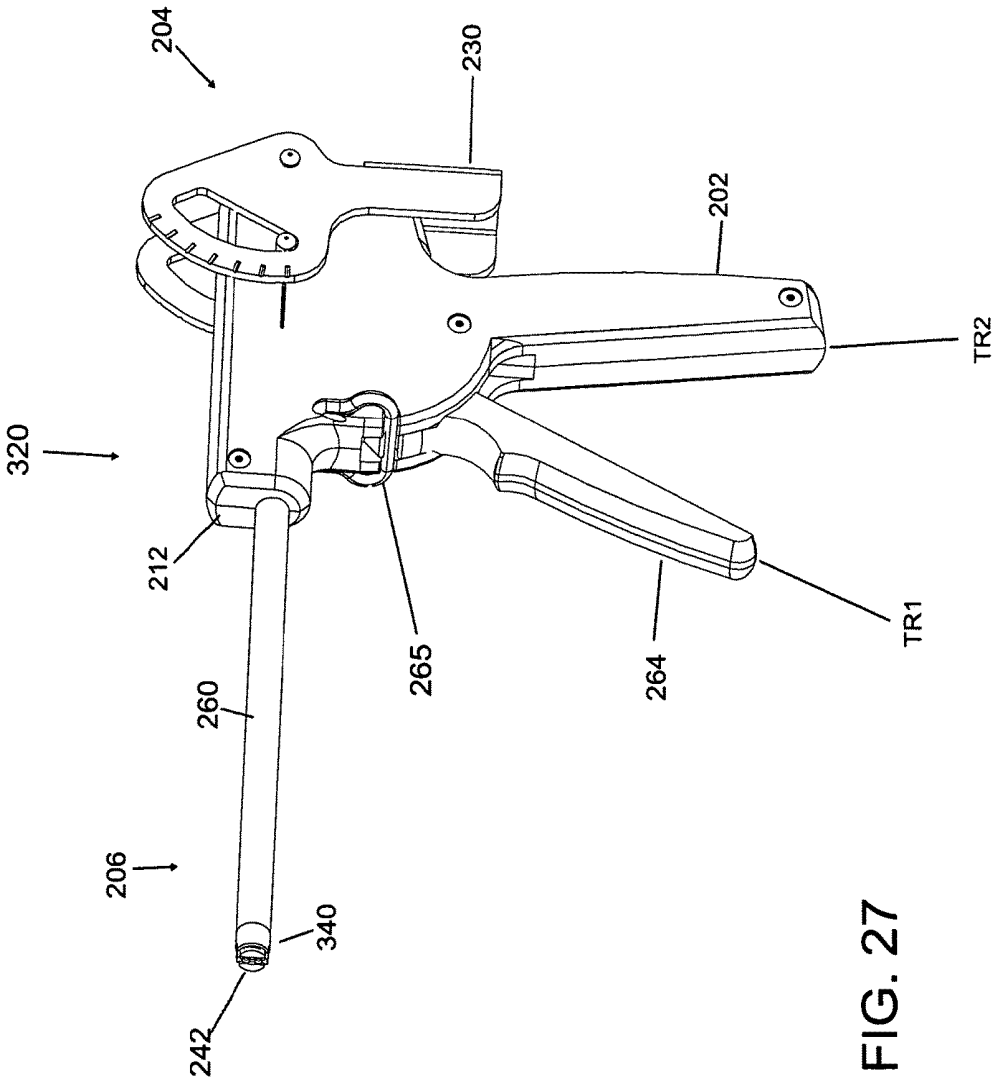


FIG. 27

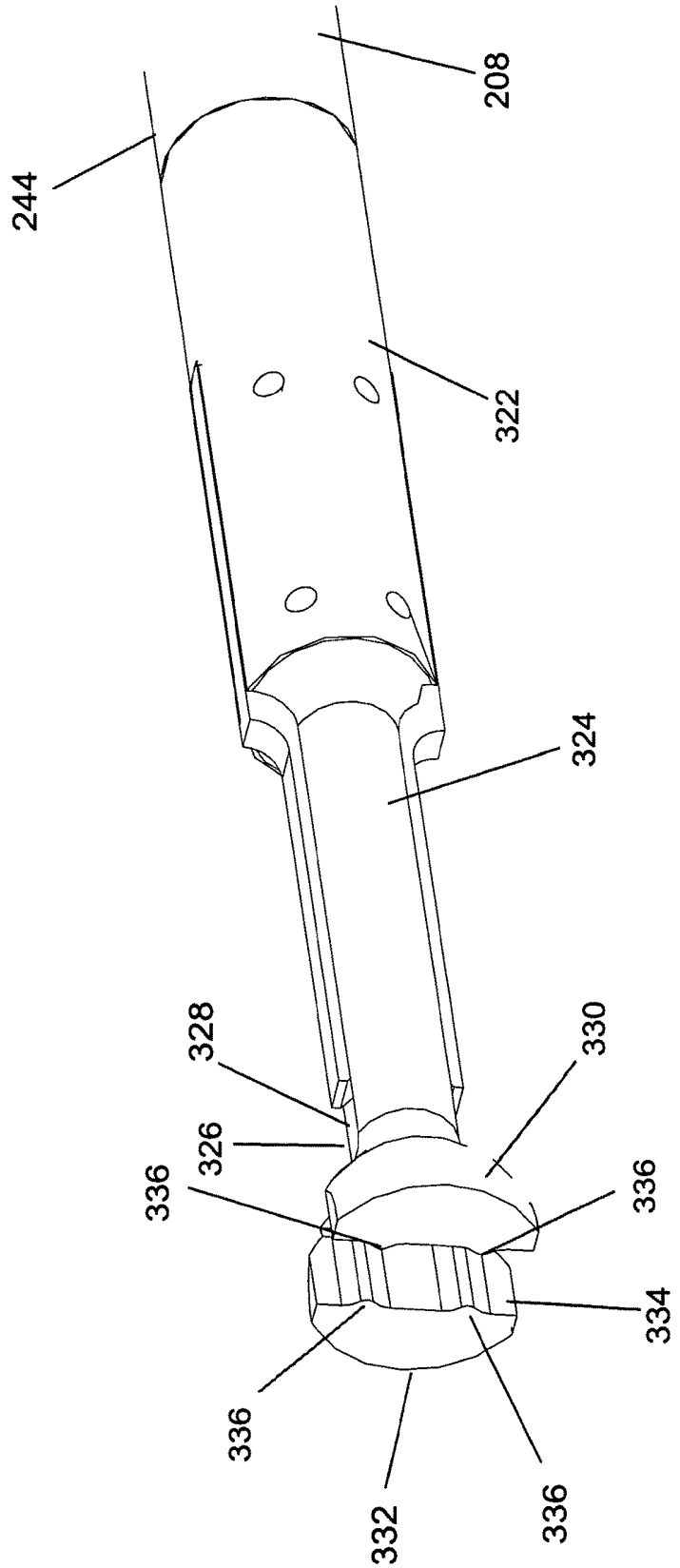
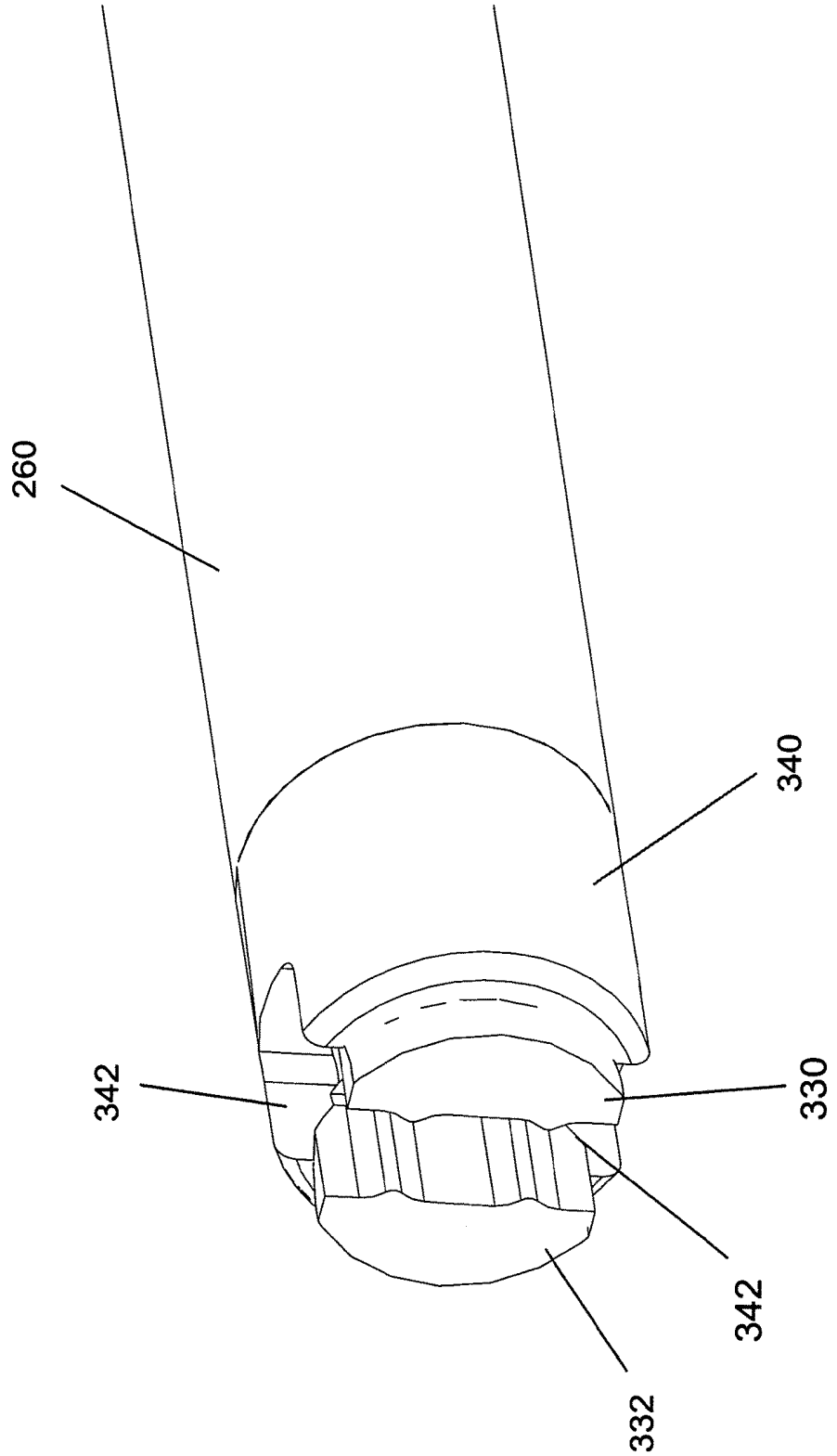


FIG. 28



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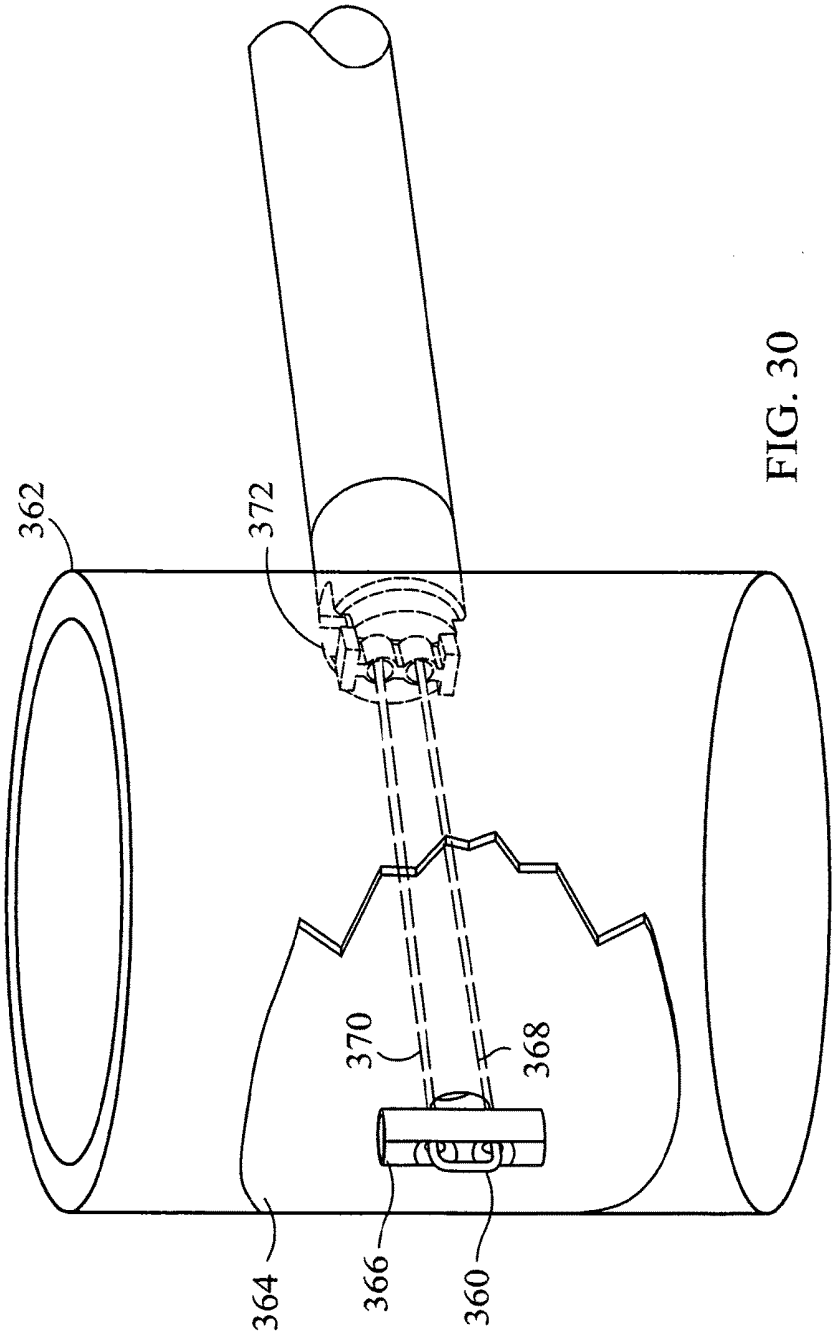
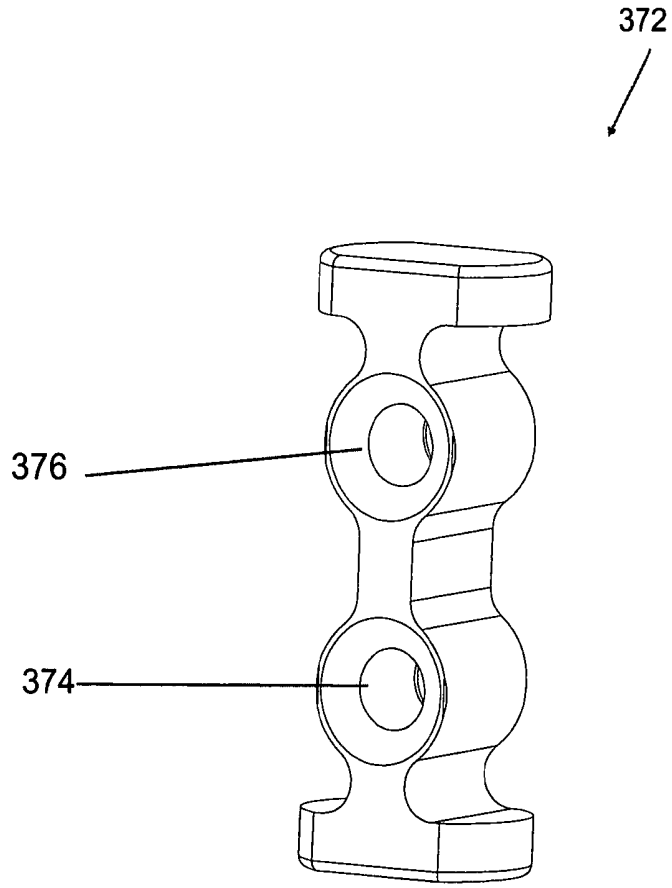


FIG. 30



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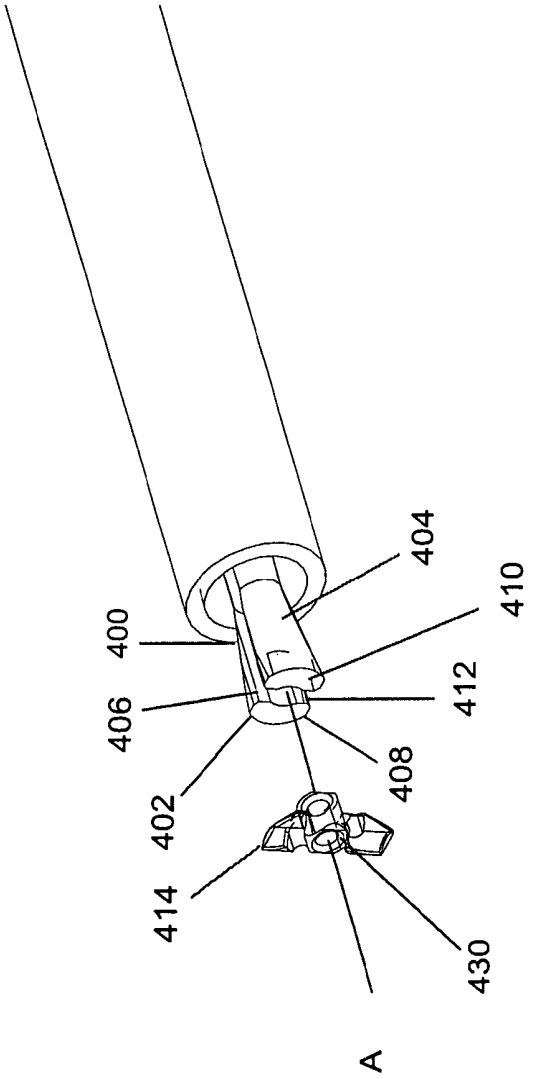


FIG. 32

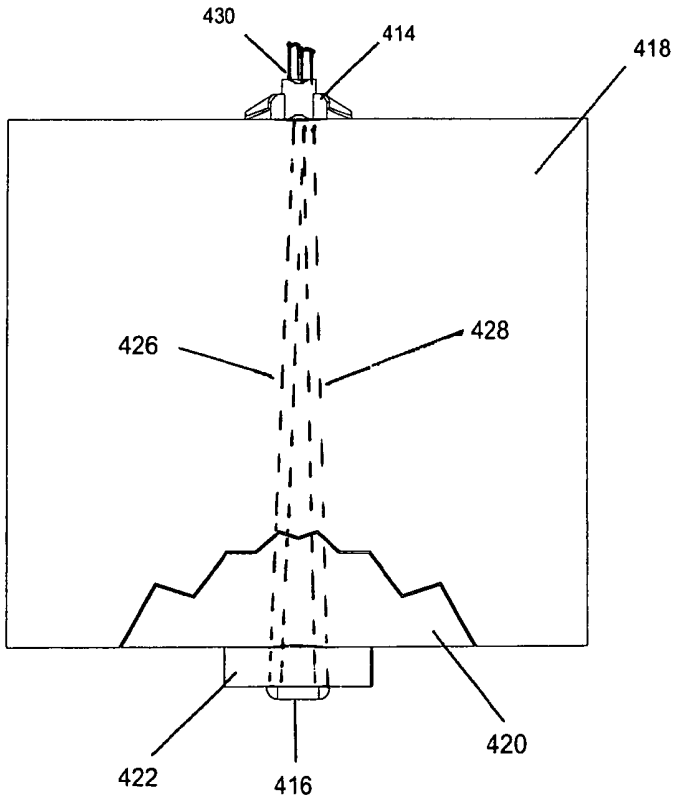


FIG. 33

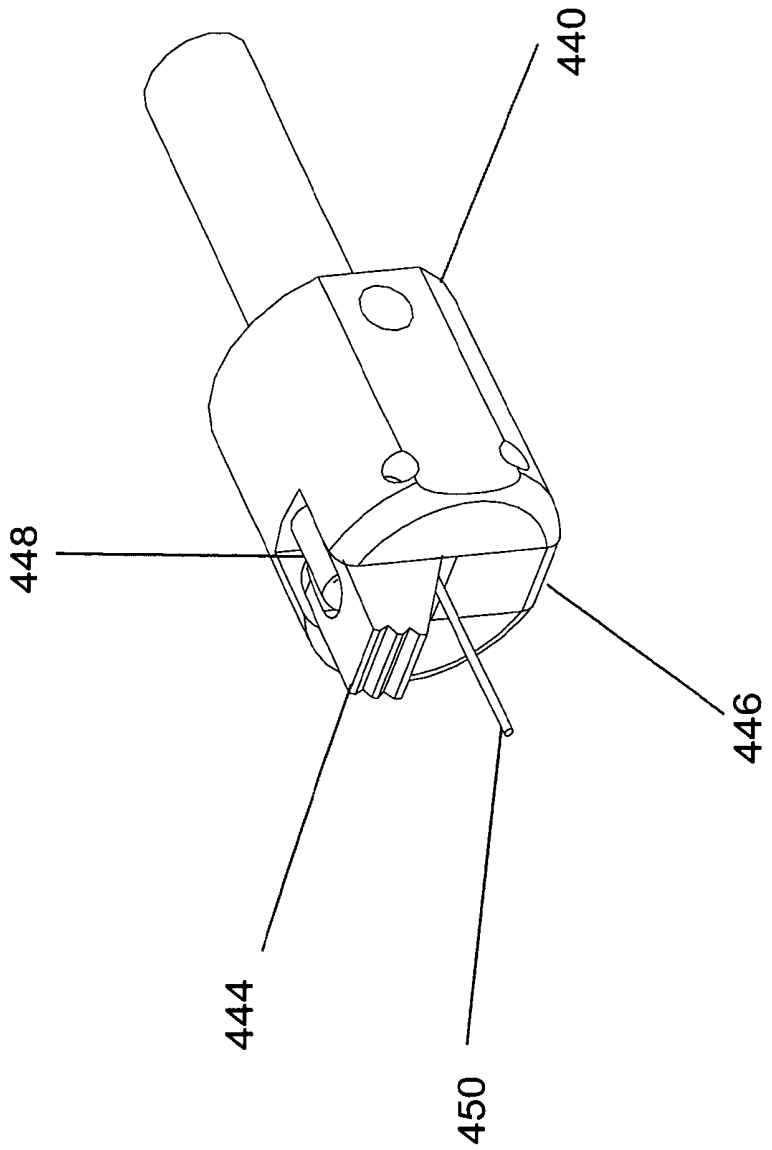


FIG. 34

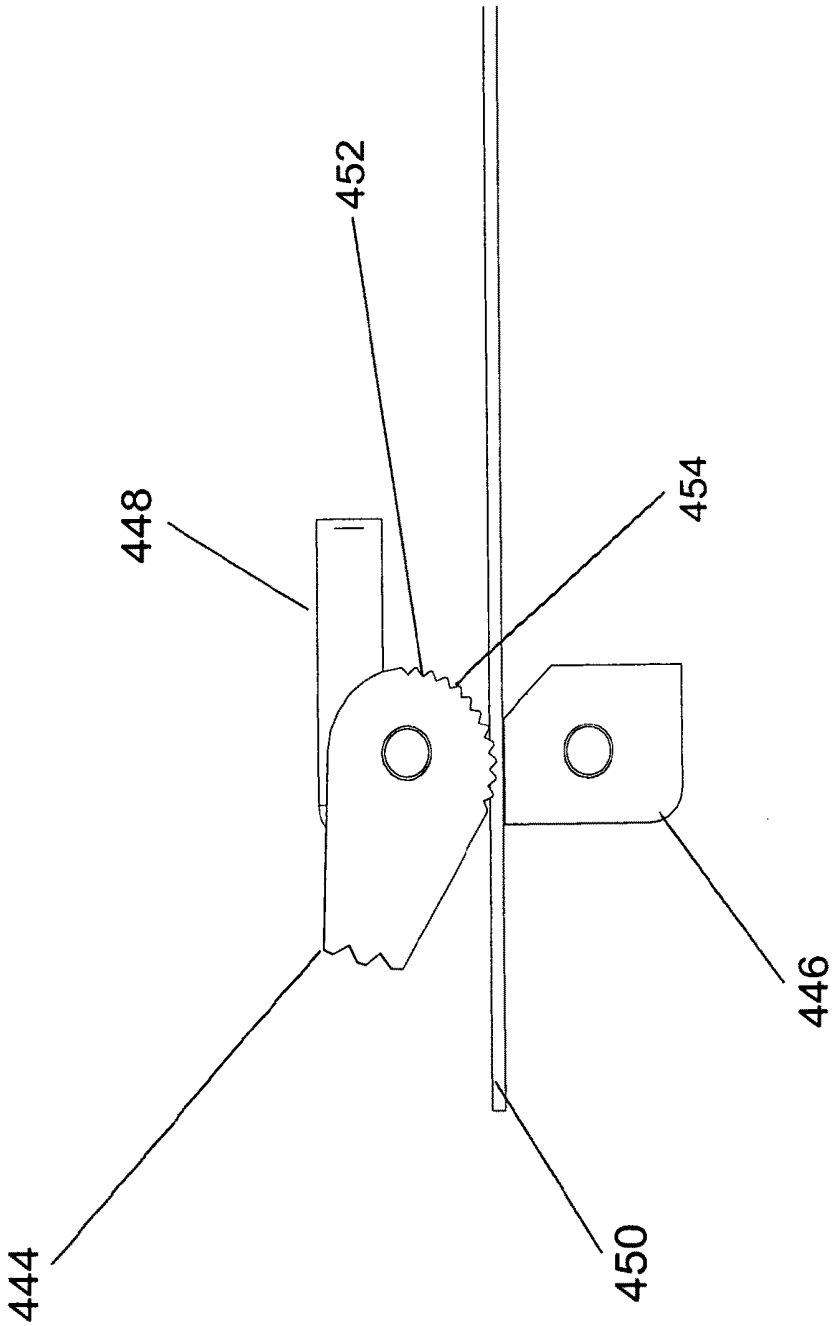
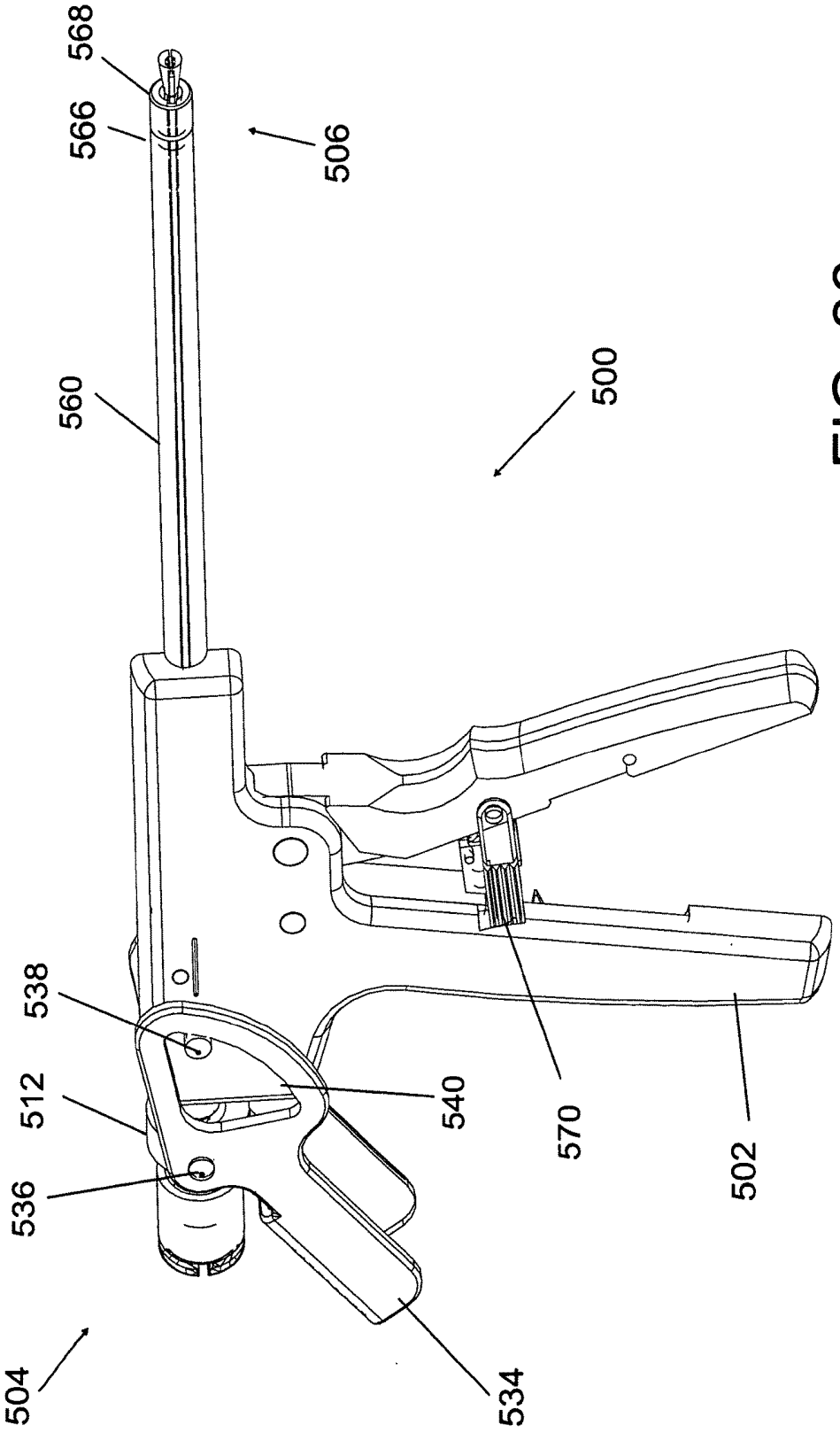


FIG. 35



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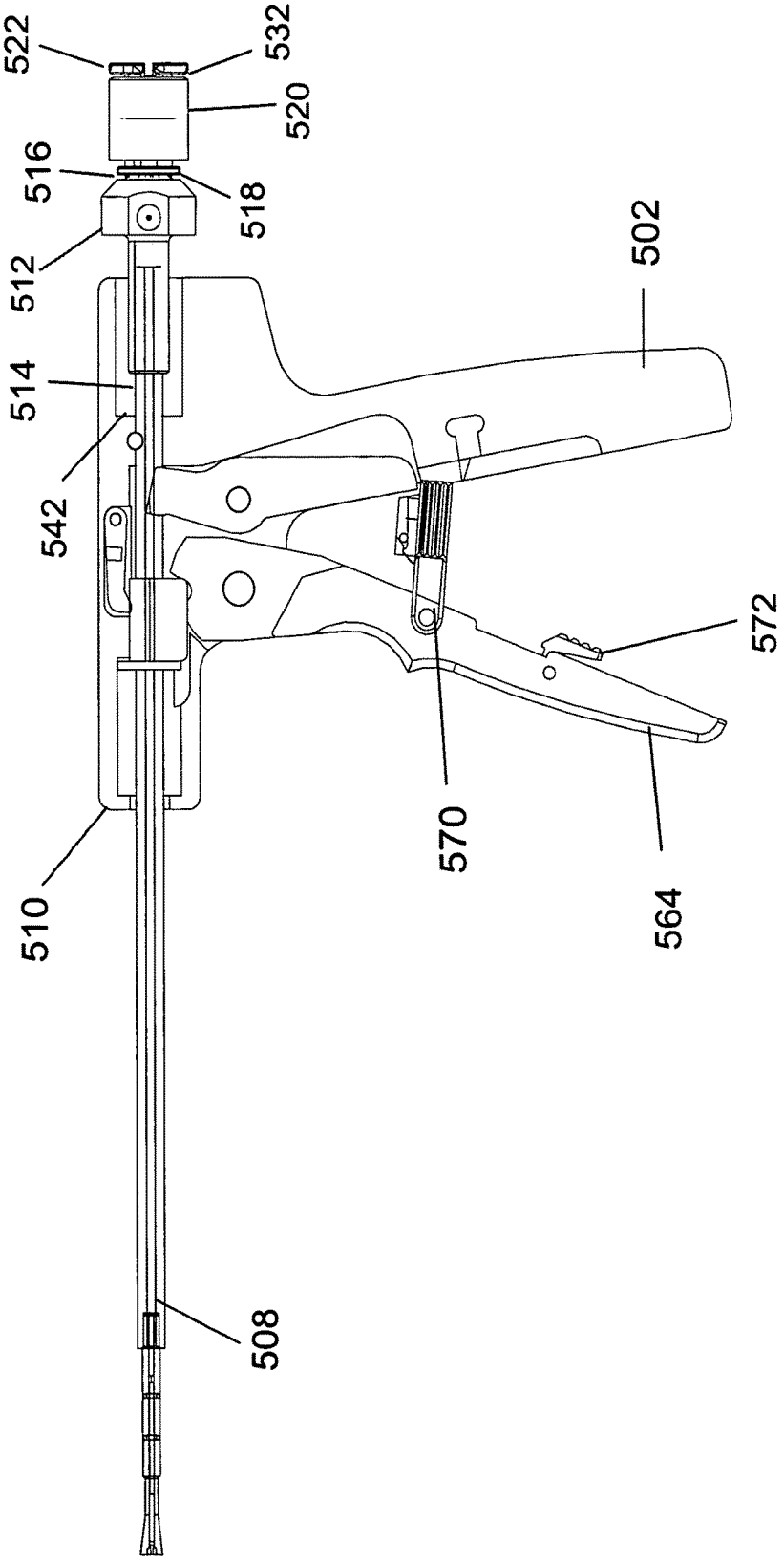

FIG. 37

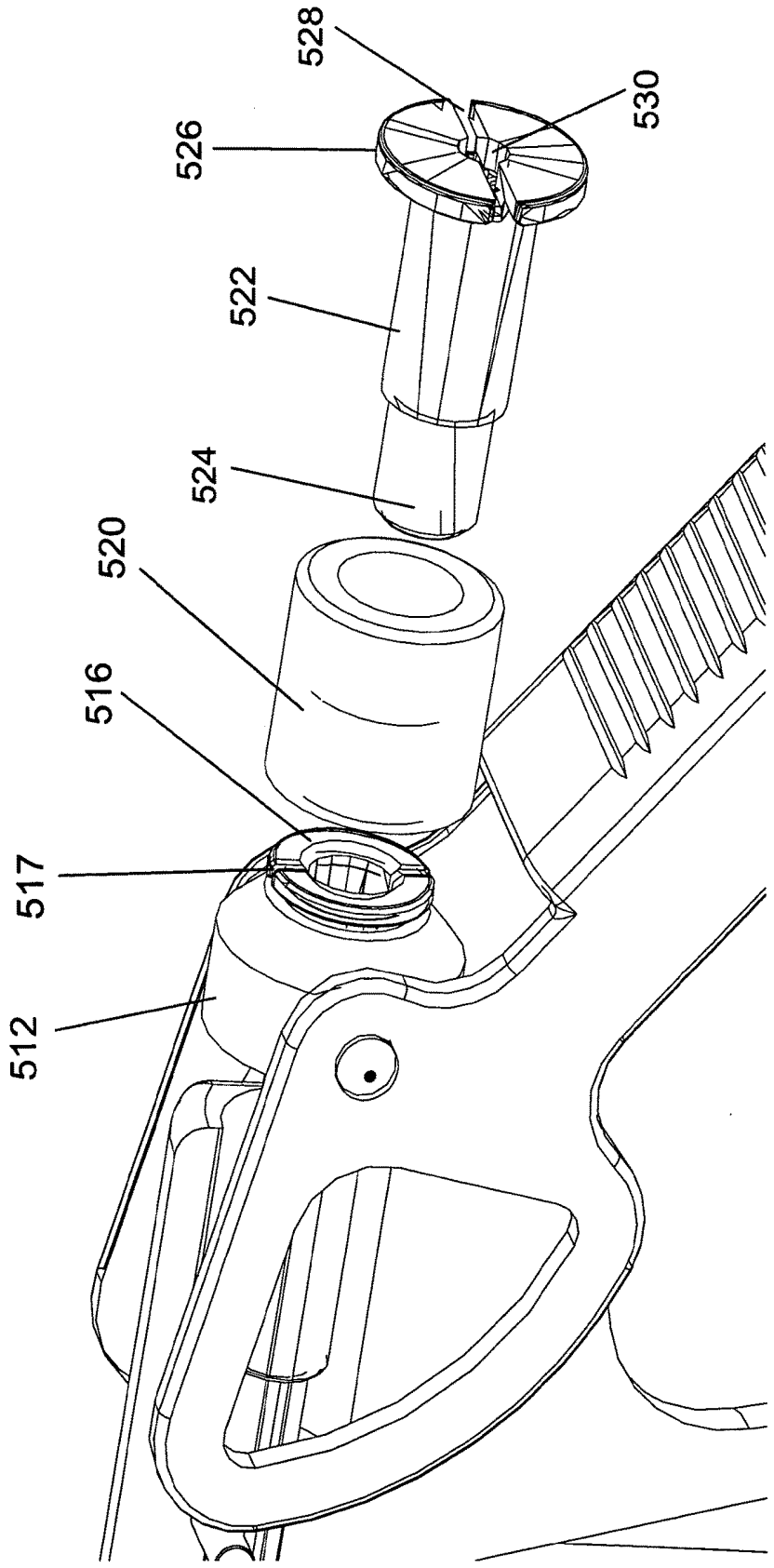

FIG. 38

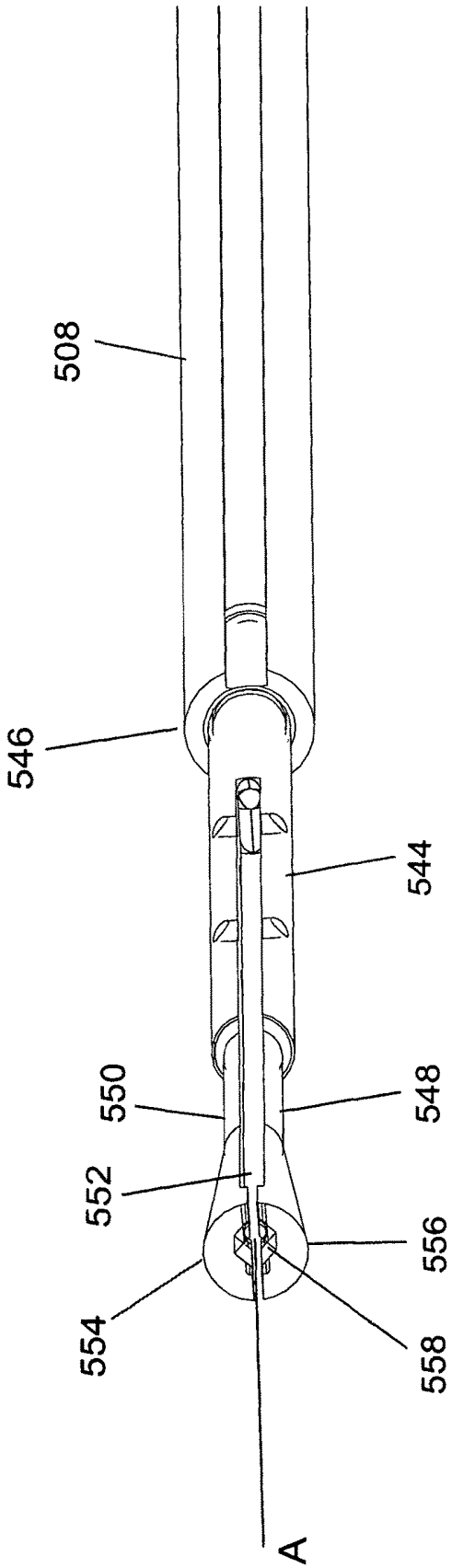

FIG. 39

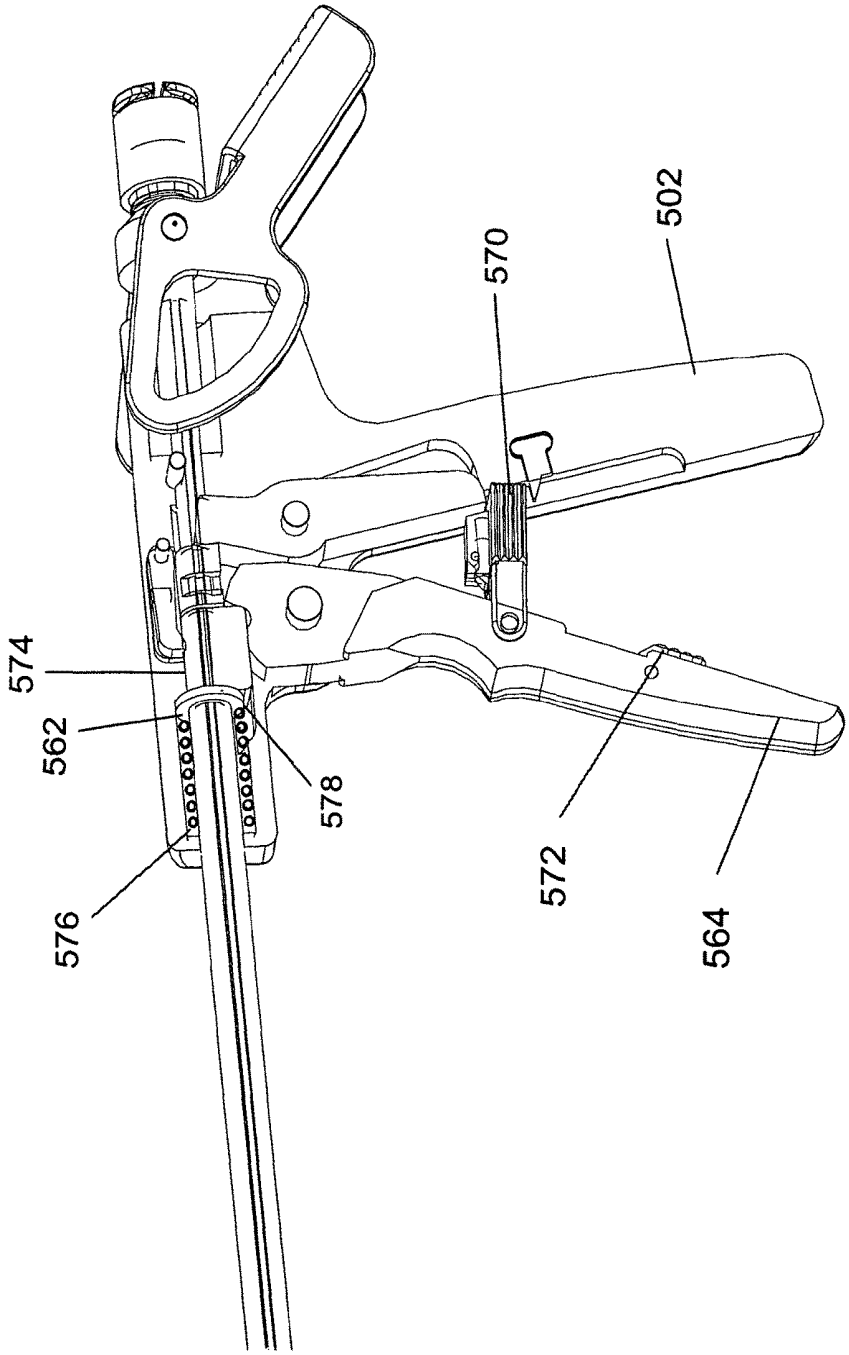

FIG. 40

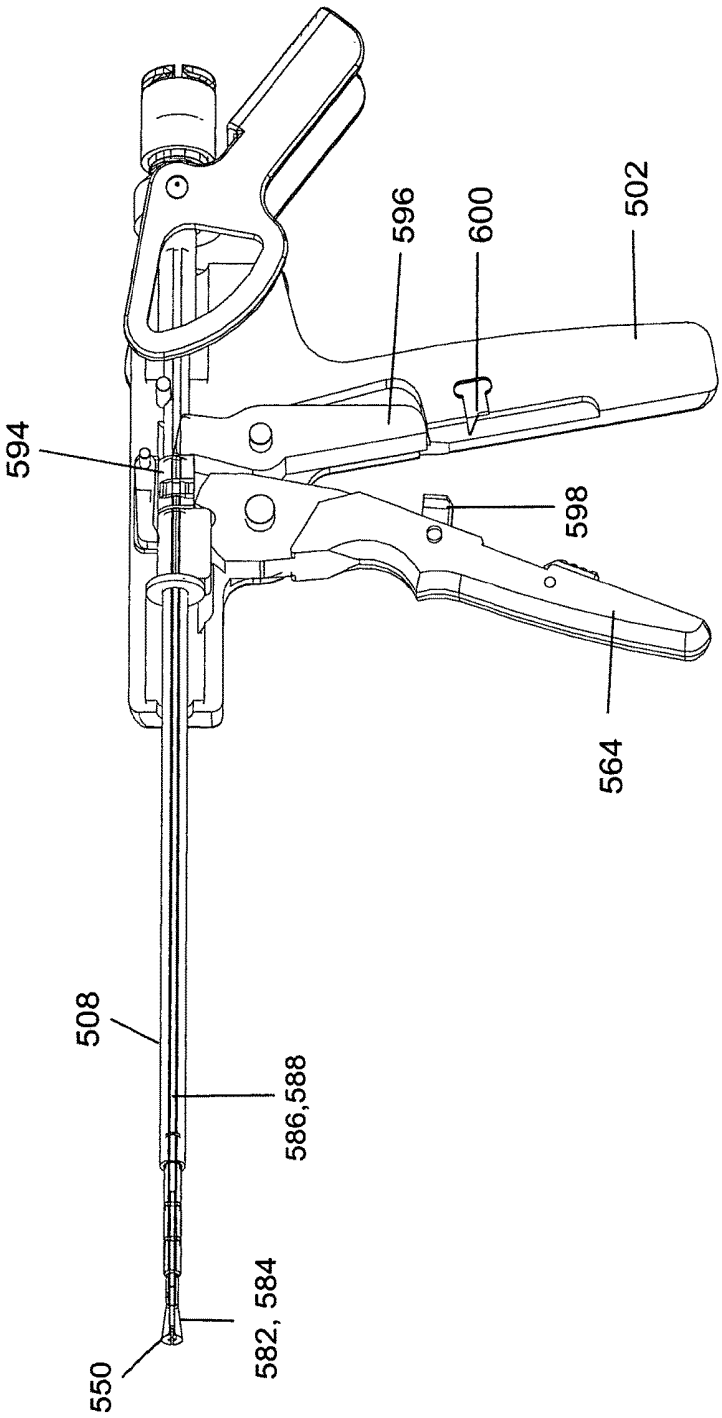

FIG. 41

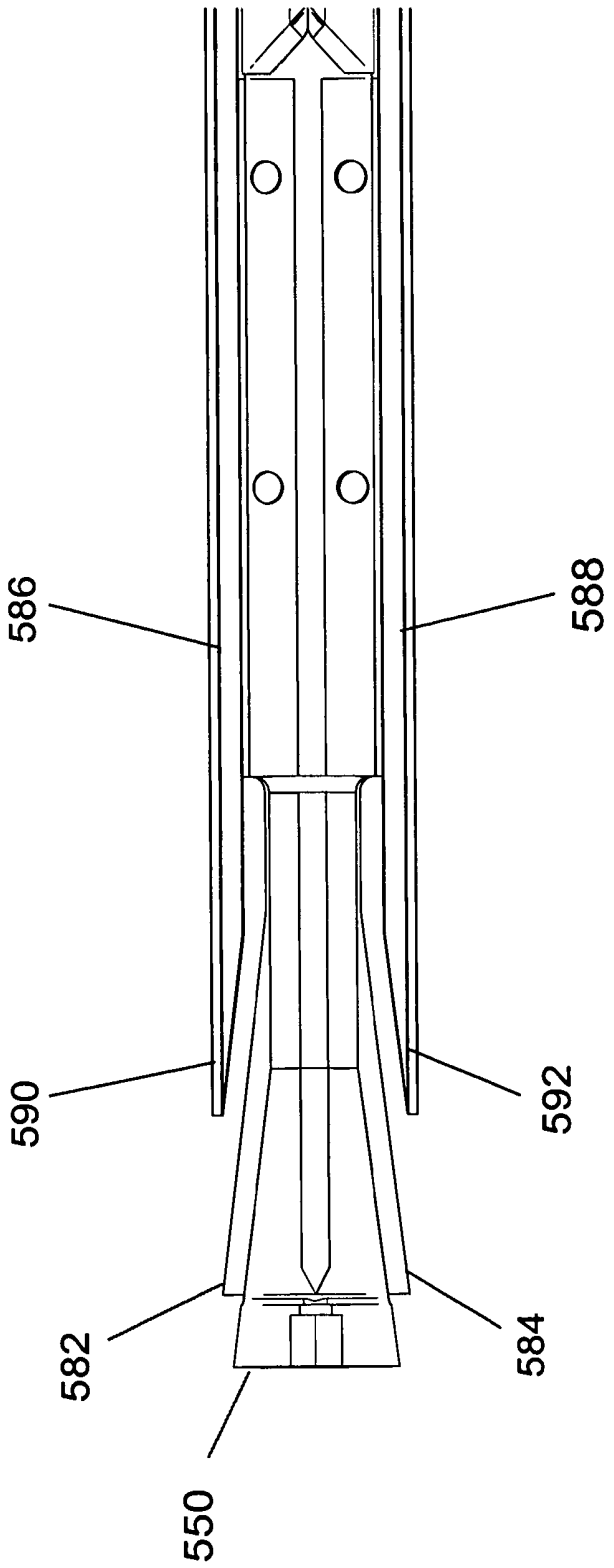

FIG. 42

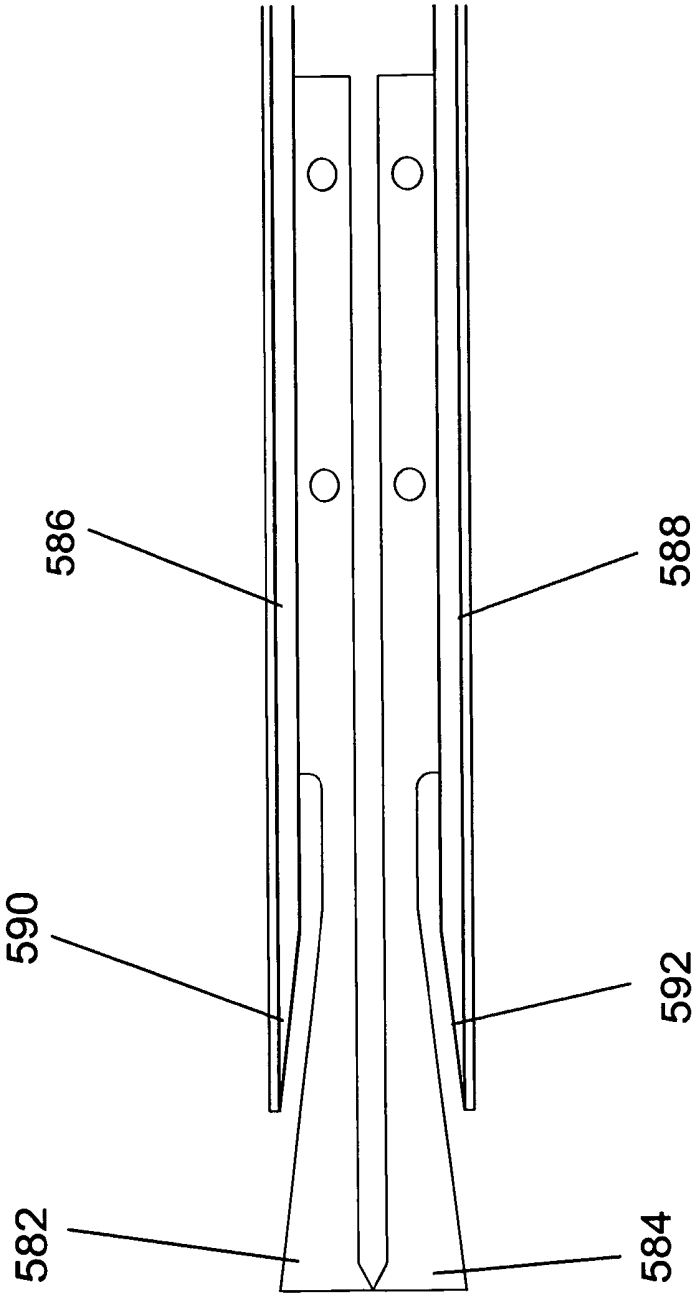

FIG. 43

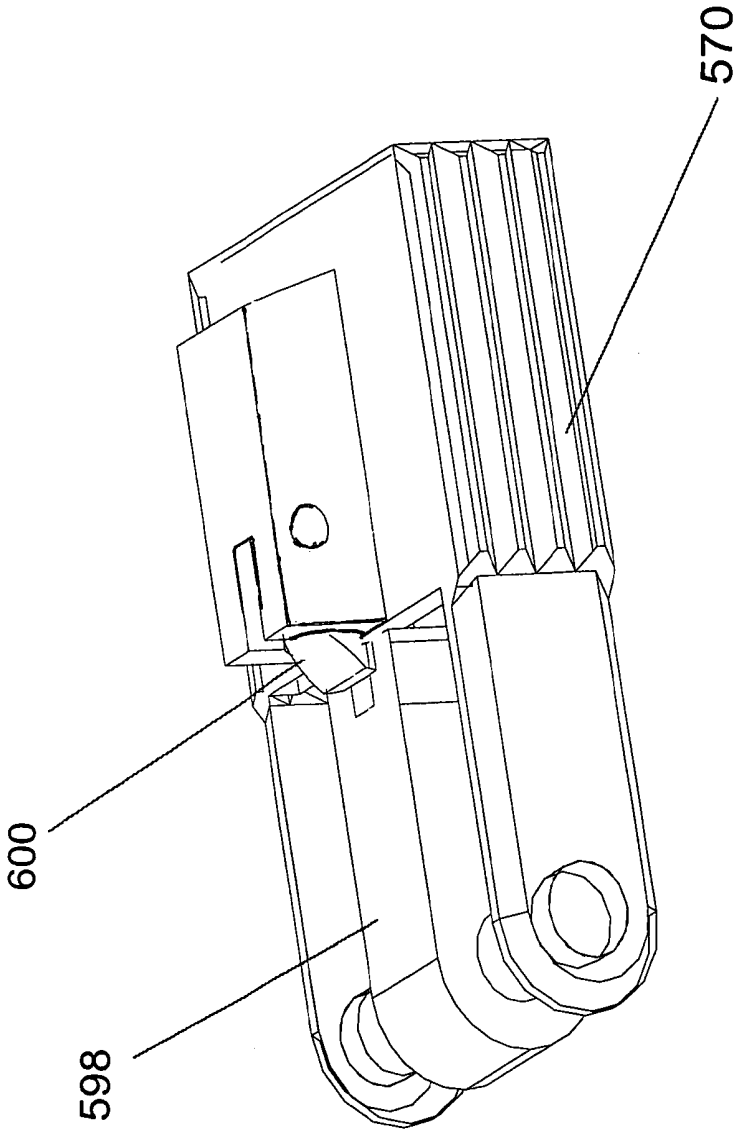

FIG. 44

TISSUE FIXATION SYSTEM AND METHOD

CROSS-REFERENCE TO RELATED APPLICATION

This Application claims the benefit of U.S. Provisional Patent Application No. 60/655,140, filed Feb. 22, 2005, entitled TISSUE FIXATION SYSTEM AND METHOD, the content of which is incorporated by reference in its entirety.

FIELD OF THE INVENTION

The invention relates to a system and method for fixation and stabilization of tissue. In particular, the invention relates to minimally invasive bone fracture fixation and stabilization.

BACKGROUND OF THE INVENTION

It is well-known in the medical arts that applying pressure to tissue helps during the healing process. Incised or torn soft tissue, for example, may be approximated with bandages, sutures, or staples. Proper and more rapid healing of broken or fractured bones likewise may be facilitated by applying constant pressure to the bone. For instance, physicians may insert pins, screws, or bolts in the area of the fracture in order to apply pressure to the fracture.

However, inserting screws through or around fractures can be complex and time-consuming. For example, the process of inserting a screw typically involves multiple steps conducted from multiple incisions or openings that provide access to the treated bone or tissue, including the steps of drilling holes, measuring the relevant distances to determine the appropriate screw selection, tapping the hole to establish threads, and screwing the screw into the hole.

In addition to the length and complexity of the process, bone screws also may lose their grip and strip out of the bone. In addition, currently available lag screws also typically provide only one side of cortex fixation and are generally not suited for percutaneous surgery. Moreover, when placing the screws in the bone, the physician may not accurately set the screw into the distal hole or may miss the distal hole completely, thereby resulting in the screw stripping the threads or breaking the bone.

Many devices and instruments have been disclosed to fasten soft and hard tissue for enhanced healing or tissue reconstruction. Examples of such devices include bone plates, bone wraps, external bone supports, and the like.

For example, U.S. Pat. No. 5,921,986, the contents of which are incorporated herein by reference, discloses a bone suture and associated methods for implantation and fracture fixation. The '986 Patent describes fasteners and anchors used in conjunction with an elongate fixation element, such as a suture. In some cases, it may be advantageous to use more rigid fixation elements.

Accordingly, a need exists for a tissue fixation instrument which can provide flexible or rigid fixation of tissue while accessing the tissue from a small skin portal.

SUMMARY OF THE INVENTION

The present invention relates to a tissue fixation system. The system comprises an elongate fastening member and a fastener moveable with respect to the elongate fastening member from a first orientation to a second orientation, the fastener having a body with a tissue contacting surface that includes a groove configured and dimensioned to receive a portion of the elongate member in the first orientation. The system can also include a second fastener or other means for maintaining tension in the elongate fastening member.

A biasing means can be provided to maintain the fastener in the first orientation. The biasing means can be an adhesive between the groove and the portion of the elongate fastening member received in the groove. The biasing means could also be a frangible connection between the groove and the portion of the elongate fastening member received in the groove.

The fastener body can have a free surface opposite the tissue contacting surface, with the free surface including a channel configured and dimensioned to receive a portion of the elongate member in the first orientation. The fastener body can also include a through bore extending from the tissue contacting surface through the free surface.

In one embodiment, the fastener body includes leading and trailing ends. The leading end can be tapered or otherwise shaped to facilitate insertion. The groove terminates at the through bore and extends toward one of the leading and trailing ends and the channel terminates at the through bore and extends toward the other of the leading and trailing ends. In an exemplary embodiment, the groove extends toward the leading end and the channel extends toward the trailing end.

The free surface of the fastener body can be provided with a well surrounding the through bore. The well can be configured and dimensioned to receive at least a portion of the stop. A distal end of the elongate fastening member can include a stop larger than the through bore.

The present invention also relates to a medical instrument or device for securing the fastener with respect to the elongate fastening member. The medical device tensions the elongate fastening member and crimps either the fastener or a bushing. Another aspect of the invention relates to methods of tissue fixation using the disclosed tissue fixation systems.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present invention, and the attendant advantages and features thereof, will be more readily understood by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

FIG. **1** shows a schematic illustration of a tissue fixation system according to the present invention utilized for fracture fixation;

FIG. **2** shows a perspective view of a fastener according to the present invention;

FIG. **3** shows a side view of the fastener of FIG. **2**;

FIG. **4** shows a bottom view of the fastener of FIG. **2**;

FIG. **5** shows a top view of the fastener of FIG. **2**;

FIG. **6** shows a fastener and elongate fastening member with the fastener in a first orientation with respect to the elongate fastening member;

FIG. **7** shows a front view of a fastener in the first orientation with respect to the elongate fastening member with the fastener rotated 180° compared to FIG. **6**;

FIG. **8** shows a back view of the fastener and elongate fastening member of FIG. **7**;

FIG. **9**A shows an elongate fastening member according to the present invention;

FIG. **9**B shows an elongate fastening member including expandable members;

FIG. **10** shows a fastener in a second orientation with respect to an elongate fastening member;

FIG. **11** shows a cannulated drill system used to create a passage through the tissue to be fixed;

FIG. **12** shows a sleeve having a lumen through which the fixation system can be passed;

FIG. **13** shows a distal fastener being inserted into the sleeve;

FIG. **14** shows a pushrod used to move the distal fastener through the sleeve;

FIG. **15** shows the distal fastener in the second orientation;

FIG. **16** shows a proximal fastener being used to maintain the tension in the elongate fastening member;

FIG. **17** depicts a front isometric view of the medical device of the present invention;

FIG. **18** depicts a rear partial isometric view showing the tensioning mechanism of the medical device of FIG. **17**;

FIG. **19** depicts a rear isometric view showing the tensioning mechanism of the medical device of FIG. **17**;

FIG. **20** depicts an isometric view of the crimping mechanism collett of the medical device of FIG. **17**;

FIG. **21** depicts a partial isometric view showing the handle portion of the crimping mechanism of the medical device of FIG. **17**;

FIG. **22** depicts a top sectional view of the crimping mechanism collett closer of the medical device of FIG. **17**;

FIG. **23** depicts a partial isometric view showing the cutting mechanism of the medical device of FIG. **17**;

FIG. **24** depicts a partial isometric view showing the collett portion of the cutting mechanism of FIG. **23**;

FIG. **25** depicts an isometric view showing the cutting arm of the cutting mechanism of FIG. **24**;

FIG. **26** depicts the medical device of FIG. **17** in use to secure a bone fracture;

FIG. **27** depicts a front isometric view of an alternative medical device of the present invention;

FIG. **28** depicts an isometric view of the crimping mechanism collett of the medical device of FIG. **27**;

FIG. **29** depicts an isometric view of the crimping mechanism collett closer of the medical device of FIG. **27**;

FIG. **30** depicts a sectional view of the medical device of FIG. **27** in use to secure a bone fracture;

FIG. **31** depicts an exemplary fastener for use with the medical device of FIG. **27**;

FIG. **32** depicts an alternative sectional view of the medical device of FIG. **27** in use to secure a bone fracture;

FIG. **33** depicts an alternative fastener for use with the medical device of FIG. **32**;

FIG. **34** depicts an alternative cable tensioner for the medical device of FIG. **17**;

FIG. **35** depicts a sectional view of the cable tensioner of FIG. **34**;

FIG. **36** depicts a front isometric view of the medical device of the present invention;

FIG. **37** depicts a side sectional view showing the tensioning mechanism of the medical device of FIG. **36**;

FIG. **38** depicts a rear exploded view showing the tensioning mechanism of the medical device of FIG. **36**;

FIG. **39** depicts an isometric view of the crimping mechanism collett of the medical device of FIG. **36**;

FIG. **40** depicts a partial isometric view showing the handle portion of the crimping mechanism of the medical device of FIG. **36**;

FIG. **41** depicts a partial isometric view showing the cutting mechanism of the medical device of FIG. **36**;

FIG. **42** depicts an isometric view of the cutting mechanism in the collett of the medical device of FIG. **36**;

FIG. **43** depicts the cutting wedge of the medical device of FIG. **36**; and

FIG. **44** depicts a safety lock of the medical device of FIG. **36**.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a tissue fixation system for dynamic and rigid fixation of tissue. The system can be utilized for the fixation and stabilization of body tissue, including soft tissue to soft tissue, soft tissue to bone, and bone to bone. The surgical system can additionally be used to affix implants and grafts to body tissue. The system can access and treat fractured, incised or torn tissue, or the like, from one access area (i.e., from only one opening to the tissue to be fastened) instead of requiring two or more openings. That is, the system is a linear fixation system that can be used with a single, small incision or portal in the skin or other soft tissue to gain access to the fractured bone. The fixation system may be an all-in-one system, packaged as a system kit, for creating a passage in tissue, positioning fasteners, and tensioning an elongate fastening member, like a suture, thread, cable, wire, rod, or pin. The individual components of the system can either be reusable or single use components.

Referring now to the drawing figures in which like reference designators refer to like elements, FIG. **1** shows an exemplary embodiment of a tissue fixation system **100** according to the present invention. A fractured portion **102** of a bone **104** is approximated by system **100**. Use of system **100** is not limited to any particular type of fracture. Furthermore, use of system **100** is not limited to fracture fixation. In other words, system **100** can be utilized for other tissue fixation applications (such as soft tissue) or similar clinical indications. Examples of such tissue includes, are not limited to, muscle, cartilage, ligament, tendon, skin, etc. Also, the tissue may be stomach tissue, and the system may be used during bariatric surgery, like stomach stapling. Additionally, the system **100** can be used for the fixation of implants to tissue.

In this regard, the present invention may be used in conjunction with any surgical procedure of the body. The repair, reconstruction, augmentation, and securing of tissue or an implant may be performed in connection with surgery of a joint, bone, muscle, ligament, tendon, cartilage, capsule, organ, skin, nerve, vessel, or other body part. For example, tissue may be repaired, reconstructed, augmented, and secured following intervertebral disc surgery, knee surgery, hip surgery, organ transplant surgery, bariatric surgery, spinal surgery, anterior cruciate ligament (ACL) surgery, tendon-ligament surgery, rotator cuff surgery, capsule repair surgery, fractured bone surgery, pelvic fracture surgery, avulsion fragment surgery, hernia repair surgery, and surgery of an intrasubstance ligament tear, annulus fibrosis, fascia lata, flexor tendons, etc. In one particular application, an anastomosis is performed over a balloon and the methods and devices of the present invention are used to repair the vessel.

Also, tissue may be repaired after an implant has been inserted within the body. Such implant insertion procedures include, but are not limited to, partial or total knee replacement surgery, hip replacement surgery, bone fixation surgery, etc. The implant may be an organ, partial organ grafts, tissue graft material (autogenic, allogenic, xenogeneic, or synthetic), collagen, a malleable implant like a sponge, mesh, bag/sac/pouch, collagen, or gelatin, or a rigid implant made of metal, polymer, composite, or ceramic. Other implants include breast implants, biodegradable plates, por-

cine or bovine patches, metallic fasteners, compliant bearing for medial compartment of the knee, nucleus pulpous prosthetic, stent, tissue graft, tissue scaffold, biodegradable collagen scaffold, and polymeric or other biocompatible scaffold. The scaffold may include fetal cells, stem cells, embryonal cells, enzymes, and proteins.

The present invention further provides flexible and rigid fixation of tissue. Both rigid and flexible fixation of tissue and/or an implant provides compression to enhance the healing process of the tissue. A fractured bone, for example, requires the bone to be realigned and rigidly stabilized over a period time for proper healing. Also, bones may be flexibly secured to provide flexible stabilization between two or more bones. Soft tissue, like muscles, ligaments, tendons, skin, etc., may be flexibly or rigidly fastened for proper healing. Flexible fixation and compression of tissue may function as a temporary strut to allow motion as the tissue heals. Furthermore, joints which include hard and soft tissue may require both rigid and flexible fixation to enhance healing and stabilize the range of motion of the joint. Flexible fixation and compression of tissue near a joint may provide motion in one or more desired planes. The fasteners described herein and incorporated by reference provide for both rigid and flexible fixation.

Although the invention is described primarily on a macroscopic level, it is also envisioned that the present invention can be used for microscopic applications. For example, in the repair of nerve tissue, individual cells or fibers may need to be repaired. Similarly, muscle repair may require tightening of individual muscle fibers.

System **100** includes a distal fastener **106** contacting fracture portion **102**, a proximal fastener **108** contacting bone **104**, and an elongate fastening member **110** extending through the fracture and coupling distal and proximal fasteners **106**, **108**. Tension is maintained in elongate fastening member **110** to press fasteners **106**, **108** against opposite sides of bone **104** with a desired force. This force presses fracture portion **102** against bone **104** firmly together to promote healing of the fracture. If desired, buttons or other force distributing members could be provided between fasteners **106**, **108** and the bone. Although FIG. **1** shows distal and proximal fasteners **106**, **108** as having the same construction, they could have differing construction. However, for convenience and practical purposes, it may be beneficial if distal and proximal fasteners **106** and **108** have substantially the same construction.

FIGS. **2-5** show an exemplary embodiment of a fastener **112** that can be used as part of system **100**, i.e. as either or both of distal and proximal fasteners **106**, **108**. Fastener **112** has a body **114** that is configured and dimensioned to facilitate implantation through minimally invasive procedures, e.g. through a cannula or sleeve. In particular, body **114** includes a tissue contacting surface **116** that is provided with groove **118** that receives a portion of elongate fastening member **110** when fastener **112** is in a first orientation with respect to elongate fastening member **110**. This is seen in FIG. **6**. The accommodation of elongate fastening member **110** within groove **118** helps to minimize the profile of the assembly of fastener **112** and elongate fastening member **110**. The reduced profile can be more readily passed through a cannula or sleeve. If desired, an adhesive can be provided within groove **118** to bias fastener **112** in the first orientation. Alternatively, a frangible connection can be provided between groove **118** and the portion of elongate fastening member **110**. This frangible connection keeps fastener **112** in the first orientation with respect to elongate fastening member **110** until it is broken.

Fastener **112** is provided with first and second ends **120**, **122**. As shown in FIG. **6**, first end **120** is the leading end and second end **122** is the trailing end. In this position, when fastener **112** is pivoted to a second orientation, like distal fastener **106** of FIG. **1**, tissue contacting surface **116** is in contact with the tissue. As shown in FIGS. **7** and **8**, second end **122** is the leading end and first end **120** is the trailing end. In this position, when fastener **112** is pivoted to the second orientation, like proximal fastener **108** of FIG. **1**, tissue contacting surface **116** is in contact with the tissue.

Fastener body **114** has a free surface **124** opposite tissue contacting surface **116**. Free surface **124** is provided with a channel **126** that receives a portion of elongate fastening member **110** when fastener **112** is in a first orientation with respect to elongate fastening member **110**. As shown in FIGS. **7** and **8**, fastener **112** is being slid along elongate fastening member **110**. In particular, a through bore **128** extends from tissue contacting surface **116** through free surface **124**. Through bore **128** is larger in diameter than elongate fastening member **110** so that fastener **112** freely slides along elongate fastening member **110**. A portion of elongate fastening member **110** fits within channel **126** on free surface **124** and a portion of elongate fastening member **110** fits within groove **118** on tissue contacting surface **116**.

Fastener body **114** is shown with first end **120** having a substantially flat profile and second end **122** having a tapered profile. In general, any suitable external configuration can be used for fastener **112**. Examples of fasteners may be found in U.S. Pat. Nos. 5,163,960; 5,403,348; 5,464,426; 5,549,630; 5,593,425; 5,713,921; 5,718,717; 5,782,862; 5,814,072; 5,814,073; 5,845,645; 5,921,986; 5,948,002; 6,010,525; 6,045,551; 6,159,234; 6,368,343; 6,447,516; 6,475,230; 6,592,609; 6,635,073; and 6,719,765. Other fastener types are disclosed in U.S. patent application Ser. Nos. 10/102,413; 10/228,855; 10/779,978; 10/780,444; and 10/797,685. The above cited patents and patent applications are hereby incorporated by reference.

Fastener **112** can be made of any biocompatible material suitable for a given application. For example, the fasteners may be, but are not limited to, degradable, biodegradable, bioerodible, bioabsorbable, mechanically expandable, hydrophilic, bendable, deformable, malleable, riveting, threaded, toggling, barbed, bubbled, laminated, coated, blocking, pneumatic, one-piece, multi-component, solid, hollow, polygon-shaped, pointed, self-introducing, and combinations thereof. Also, the fasteners may include metallic material, polymeric material, ceramic material, composite material, body tissue, synthetic tissue, hydrophilic material, expandable material, compressible material, heat bondable material, and combinations thereof. Examples of body tissue include bone, collagen, cartilage, ligaments, or tissue graft material like xenograft, allograft, and autograft. The fasteners may also be made from a porous matrix or mesh of biocompatible and bioresorbable fibers acting as a scaffold to regenerate tissue.

The fasteners may further be made of or have a coating made of an expandable material. The material could be compressed then allowed to expand. Alternatively, the material could be hydrophilic and expand when it comes in contact with liquid. Examples of such expandable materials are ePTFE and desiccated body tissue.

Moreover, the fasteners described herein and incorporated by reference may include therapeutic substances to promote healing. These substances could include antibiotics, hydroxyapatite, anti-inflammatory agents, steroids, antibiotics, analgesic agents, chemotherapeutic agents, bone morphogenetic protein (BMP), demineralized bone matrix, col-

lagen, growth factors, autogenetic bone marrow, progenitor cells, calcium sulfate, immo suppressants, fibrin, osteoinductive materials, apatite compositions, germicides, fetal cells, stem cells, enzymes, proteins, hormones, cell therapy substances, gene therapy substances, and combinations thereof. These therapeutic substances may be combined with the materials used to make the fasteners to produce a composite fastener. Alternatively, the therapeutic substances may be impregnated or coated on the fastener. Time-released therapeutic substances and drugs may also be incorporated into or coated on the surface of the fastener. The therapeutic substances may also be placed in a bioabsorbable, degradable, or biodegradable polymer layer or layers.

FIG. **9**A shows an exemplary embodiment of an elongate fastening member **130**. Elongate fastening member **130** includes a body **132** and has a stop **134** at a distal end. Body **132** can be selected for a given application. For example, if a rigid elongate fastening member **130** is needed, body **132** can be a rod or a tube. If a more flexible elongate fastening member **130** is needed, body **132** can be a suture. In general, a wire analogous to those used for cerclage of bone fractures is believed to provide a suitable combination of strength and flexibility. Although body **132** is shown as a single strand wire, the invention can be used with any type of surgical cable, such as a multi-strand cable.

Stop **134** can be made integral with body **132** or separate and then attached. Stop **134** is larger in diameter than through bore **128** in body **114** of fastener **112**. Thus, once stop **134** reaches through bore **128**, fastener **112** cannot be slid any further along elongate fastening member **130**. As shown in FIG. **5**, free surface **124** of fastener **112** is provided with a well **136** surrounding through bore **128**. Well **136** is configured and dimensioned to receive at least a portion of stop **134**. As shown in FIG. **10**, this helps reduce the profile of the assembly when fastener **112** is in a second orientation with respect to elongate fastening member **130**.

Referring to FIG. **9**B, in another embodiment, the elongated fastener member **130** includes expandable members **131**, positioned along the body **132**. Upon insertion into the tissue, the expandable members **131** expand to engage the surrounding tissue. For examples, the expandable members **131** can be barbs. The barbs **131** engage the surrounding tissue, maintaining the elongated fastener member's **130** position within the tissue.

The elongate fastening members of the present invention may be made of metallic material, non-metallic material, composite material, ceramic material, polymeric material, co polymeric material, or combinations thereof. The members may be degradable, biodegradable, bioabsorbable, or nonbiodegradable. Examples of suture materials that can be used for the elongate fastening members are polyethylene, polyester, cat gut, silk, nylon, polypropylene, linen, cotton, and copolymers of glycolic and lactic acid. Preferably, the members are flexible or bendable. They may be threadlike, monofilament, multifilament, braided, or interlaced. The members may have a coating of therapeutic substances or drugs. For example, the members may include antibiotics, hydroxyapatite, anti-inflammatory agents, steroids, antibiotics, analgesic agents, chemotherapeutic agents, bone morphogenetic protein, demineralized bone matrix, collagen, growth factors, autogenetic bone marrow, progenitor cells, calcium sulfate, immo suppressants, fibrin, osteoinductive materials, apatite compositions, fetal cells, stem cells, enzymes, proteins, hormones, and germicides.

The use of the tissue fixation system according to the present invention will now be described using fracture fixation as an example. If necessary, the fracture is reduced bringing fracture portion **102** into contact with bone **104** (FIG. **11**). The reduction can be achieved using any number of techniques.

As also shown in FIG. **11**, a drill system **138** is used to drill across the fracture, thereby creating a passage completely through bone **104**. Drill system **138** includes a drill bit **140** with a headpiece configured for attachment to a drill. A drill stop can be placed on the headpiece and prevents drill bit **140** from penetrating too far beyond the tissue to be drilled. Drill system **138** may be a cannulated drill system that fits over a k-wire or other similar guide wire. A cannula or sleeve **142** may encircle drill bit **140** or at least the shaft portion of drill bit **140**. As drill bit **140** creates a passage through bone **104**, sleeve **142** is positioned in the passage. Drill system **138** is used to create a passage in bone **104** from the proximal side of bone **104** to the distal side of bone **104**, then the drill and drill bit **140** are removed from sleeve **142** (FIG. **12**).

As shown in FIG. **13**, a distal fastener **112***a* is inserted into sleeve **142**. Distal fastener **112***a* is inserted in the first orientation with respect to elongate fastening member **130** with first end **120** as the leading end. In this configuration, tissue contacting surface **116** will be in contact with fracture portion **102** when distal fastener **112***a* is pivoted into the second orientation. This is best seen in FIGS. **14** and **15**, in which a pushrod **144** is used to advance distal fastener **112***a* and elongate fastening member **130** through sleeve **142**. Pushrod **144** also facilitates the pivoting of distal fastener **112***a* from the first orientation to the second orientation. This pivoting is not possible until distal fastener **112***a* has exited through sleeve **142**. Also, since the length of distal fastener **112***a* is larger than the passage created in bone **104**, pulling back on elongate fastening member **130** helps to ensure distal fastener **112***a* is in the second orientation and flush against fracture portion **102**.

As illustrated in FIG. **16**, sleeve **142** is removed from bone **104**. Fastener **112***a* is located on the distal side of bone **104**. Elongate fastening member **130** extends from fastener **112***a* through the bone passage and out the proximal opening of the bone or tissue passage. Any suitable means can be used to keep distal fastener **112***a* against fracture portion **102** with tension, where the tension can be measure and controlled in accordance with use. For example, elongate fastening member **130** can be deformed at the proximal end of the passage such that the deformed section rests against bone **104**. The deformation would depend on the nature of elongate fastening member **130**. If elongate fastening member **130** is a relatively flexible element, such as a suture, cable, or wire, then simply tying a knot in fastening member **130** could be sufficient to maintain the tension. If elongate fastening member **130** does not allow a knot, such as would be the case with a rod or tube, then mechanical deformation of elongate fastening member **130** to create an enlarged head could be sufficient to maintain the tension. U.S. Patent Application Publication No. US 2002/0016593, the contents of which are incorporated herein by reference, discloses mechanisms to mechanically deform an extension member and could be used to deform elongate fastening member **130**.

Alternatively, the elongated fastening member **130** can be deformed by an energy, such as thermal energy, to deform elongate fastening member **130** to create an enlarged head sufficient to maintain the tension.

In an exemplary embodiment, a proximal fastener **112***b* is used to secure distal fastener **112***a* and elongate fastening member **130**. In this embodiment, proximal fastener **112***b* is identical to distal fastener **112***a*. If not already pre-loaded, proximal fastener **112***b* is loaded onto elongate fastening

member **130**. Proximal fastener **112***b* is loaded as shown in FIGS. **7** and **8**, i.e. with second end **122** as the leading end so that after proximal fastener **112***b* is slid down against bone **104** and pivoted into the second orientation, tissue contacting surface **116** is in contact with bone **104**.

Elongate fastening member **130** is tensioned, and proximal fastener **112***b* is secured to elongate fastening member **130** to thereby approximate the fracture and stabilize bone **104**. The tension of elongate fastening member **130** pulls on distal and proximal fasteners **112***a*, **112***b* generally toward each other, thereby applying pressure to the fractured bone or tissue. In this regard, a bushing **146** can be used to secure proximal fastener **112***b* with the desired tension. Single or multiple elongated members **130** can be used to secure the fractured bone or tissue.

Although a number of mechanisms can be used to secure bushing **146**, an instrument or medical device particularly useful for this will now be described.

In this regard, the present invention also provides a medical device for securing a fastener against relative movement with respect to a cable. As previously disclosed, a cable and pair of oppositely spaced fasteners can be used to secure a bone fracture. The cable is passed through the bone and fracture; a first fastener secures the cable on a first side (fracture side) of the bone; and a second fastener is positioned about the cable on a second side of the bone, opposite the first fastener. A bushing is positioned onto the cable to secure the second fastener against the second side of the bone. A force is applied to the bushing, compressing the second fastener against the second side of the bone and providing a tension to the cable. The tension in the cable can be measured and controlled, for example, with the used of a sensor and spring element. The spring can apply the force to tension the cable, and the sensor can be used to measure the resulting tension. Alternatively, the sensor can measure the compression of the tissue to determine the tension. The bushing is crimped about the cable, securing the second fastener against the second side of the bone, such that a tension is provided through the cable between the first and second fasteners.

Referring to FIG. **17**, a medical device **200** is provided for securing the bushing to the cable. The medical device **200** includes a handle portion **202** having a tensioning mechanism **204**, tensioning the cable and applying a force to the bushing, and a crimping mechanism **206** for securing the bushing to the cable.

Referring also to FIGS. **18** and **19**, the tensioning mechanism **204** includes a collett holder **208** defining a longitudinal passage along a central longitudinal axis A. The collett holder **208** is affixedly positioned through a top portion **212** of the handle portion **202** with collett holder pin **214**. A cable tensioner **216** is slidably positioned on a first end **218** of the collett holder **208**. The cable tensioner **216** defines a cable passage longitudinally aligned with the longitudinal passage of the collett holder **208**. An end portion **222** of the cable tensioner **216** includes a cable aperture **224** for threading the cable there through. A radial groove **226** and circumferential groove **228** are provided on the end portion **222** of the cable tensioner **216**, such that the cable can be wrapped about the circumferential groove **228** of the cable tensioner **216**, thereby preventing relative movement between the cable and the cable tensioner **216**.

A cable tension lever **230** is pivotally connected to the cable tensioner **216** with a lever pin **232**. The cable tension lever **230** is adjustably positioned on the handle portion **202** with body pins **234**, wherein a body pin **234** is mirrorly positioned on opposite sides of the handle portion **202**. The body pins **234** are engaged in the cable tension lever **230** arcuate lever slots **236**, such that cable tension lever **230** and cable tensioner **216** are movably connected to the handle portion **202**.

In use, as the cable tension lever **230** is pivoted about the cable tensioner **216** from a first lever position L**1** to a second lever position L**2**, the body pins **234** traverse the arcuate lever slots **236**, resulting in a translation of the cable tensioner **216** along the first end **218** of the collett holder **208** from a first tensioner position T**1** to a second tensioner position T**2**. A tension bias member **238** is interposed between the cable tensioner **216** and the handle portion **202**, biasing the cable tensioner **216** into the first tensioner position T**1**. The cable tension lever **230** includes tension indicating markings **240** along each of the arcuate lever slots **236**. The tension markings **240** indicate the tension to be applied to the cable.

Referring also to FIG. **34** an alternative cable tensioner **440** is provided. Cable tensioner **440** is slidably positioned on a first end **218** of the collett holder **208**. The cable tensioner **440** defines a cable passage longitudinally aligned with the longitudinal passage of the collett holder **208**. An end portion **442** of the cable tensioner **440** includes a cleat **444** and a cleat stop **446**. The cleat **444** is pivotally mounted to the cable tensioner **440**, including a bias member **448** biasing the cleat **444** into a closed position. A cable **450** is threadable between the cleat **446** and the cleat stop **448**, where in the closed position the cleat **446** imparts a force onto the cable **450**, securing the cable **450** in the cable tensioner **440**.

The bias member **448** biases the cleat **444** such that in the closed position the cable can be further drawn through the cable tensioner **440**, for example, to position the fastener proximal to the tissue while removing any initial slack from the cable **450**. However, the cleat **444** prevents the cable **450** from being drawn back through the cable tensioner **440**. For example, the cleat **444** can include an arcuate contact surface **452** such that the force imparted on the cable **450** in the closed position increases as the tension on the cable **450** increases, preventing the cable **450** from being drawn back through the cable tensioner **440**. The cleat arcuate surface **452** can further include a plurality of teeth **454**, which can be utilized to grip cable **450**.

Referring to FIGS. **18** and **20**, a collett **242** is affixed to a second end portion **244** of the collett holder **208**, opposite the cable tensioner **216**. The collett **242** defines a collett passage longitudinally aligned with the longitudinal passage of the collett holder **208** along the central longitudinal axis A. An end portion of the collett **242** is bisected, forming first and second collett arms **248** and **250**. A gap portion **252** is provided between the first and second collett arms **248** and **250**. Each of the first and second collett arms **248** and **250** includes force application end portions **254** and **256**. The force application end portions **254** and **256** combine to form a bushing aperture **258** configured to received the bushing therein. The collett **242** is made of a semi-rigid material, such that the first and second collett arms **248** and **250** can be moved from an open to a closed position, closing the gap **252** between the force application end portions **254** and **256**.

In use, the tensioning mechanism **204** is used to tension the cable. The cable can include a single or multiple filaments. The cable is inserted through the medical device **200** along the central longitudinal axis A, through the collett **242**, collett holder **208**, and the cable tensioner **216**, positioning the bushing in the bushing aperture **258** and extending the cable through the cable aperture **224**. To tension the cable, the cable tension lever **230** is actuated from the first lever

position L1 to the second lever position L2, sliding the cable tensioner **216** along the collett holder **208** from the first tensioner position T1, into the handle portion **202** against the tension bias member **238**, to the second tensioner position T2. The cable is positioned through the radial groove **226** and wrapped about the circumferential groove **228** on the end portion **222** of the cable tensioner **216**, securing the cable to the cable tensioner **216**. The cable tension lever **230** is released, such that tension bias member **238** biases the cable tensioner **216** from the second tensioner position T2 towards the first tensioner position T1. The movement of the cable tensioner **216** towards the first tensioner position T1 applies a tension to the cable, forcing the bushing into the second fastener. The applied tension can be selected by actuating the cable tension lever **230** to the desired tension marking **240**.

Referring again to FIGS. **17** and **21**, the crimping mechanism **206** includes an outer tube **260** slidingly positioned over the collett holder **208**. The outer tube **260** includes a first end **262** operably connected to a trigger **264** and a second end **266** connected to a collett closer **268**. The trigger **264** is pivotally mounted in the handle portion **202**, such that the trigger **264** can be actuated from a first trigger position TR1 to a second trigger position TR2. A locking mechanism **265** prevents the trigger **264** from being actuated. The locking mechanism **265** is rotated to disengage the trigger **264**, allowing actuation of the trigger **264**.

The operable connection between the first end of the outer tube **262** and the trigger **264** includes an outer tube ferrule **270** slidably positioned about the collett holder **208** and affixed to the first end of the outer tube **262**. A tube bias member **272** is interposed between the handle portion **202** and the outer tube ferrule **270**, such that the tube bias member **272** biases the outer tube ferrule **270** and the outer tube **260** into a first tube position P1. A pair of crimp cams **274** are pivotally connected to the handle portion **202** on opposite sides of the trigger **264**. The crimp cams **274** each include first edges **276** having an arcuate section **278** for engaging the outer tube ferrule **270**, where the crimp cams **274** are translatable with respect to the handle portion **202** from a first cam position C1 to a second cam position C2.

An actuation of the trigger **264** from a first trigger position TR1 to a second trigger position TR2 translated the crimp cams **274** with respect to the handle portion from a first cam position C1 to a second cam position C2 position. The arcuate sections **278** of the crimp cams **274** engage the outer tube ferrule **270**, translating the outer tube ferrule **270** and the outer tube **260** along the collett holder **208** from the first tube position P1 to a second tube position P2. As the trigger **264** is released, the tube bias member **272** biases the outer tube ferrule **270** and the outer tube **260** from the second tube position P2 to the first tube position P1. Simultaneously, the crimp cams **274** and the trigger **264** are moved to the first cam position C1 and the first trigger position TR1.

Referring to FIGS. **17** and **22**, the collett closer **268** is positioned on the outer tube **260** proximal to the force application end portions **254** and **256** of the first and second collett arms **248** and **250**. As the outer tube **260** is moved from the first tube position P1 to the second tube position P2, the collett closer **268** is moved over the force application end portions **254** and **256**. The collett closer **268** includes inner tapered surfaces **280**, such that the inner tapered surfaces **280** apply compressive forces to the force application end portions **254** and **256** as the collett closer **268** is moved over the force application end portions **254** and **256**, closing the gap **252** there between.

In use, the trigger **264** is actuated from the first trigger position TR1 to the second trigger position TR2. The actuation of the trigger **264** slides the outer tube **260** along the collett holder **208** from the first tube position P1 to the second tube position P2, moving collett closer **268** about the force application end portions **254** and **256** of the first and second collett arms **248** and **250**. The inner tapered surfaces **280** of the collett closer **268** apply compressive forces to the first and second force application end portions **254** and **256**, closing the gap **252** there between. The trigger **264** is released, allowing the tube bias member **272** to bias the outer tube **260** from the second tube position P2 to the first tube position P1, moving the collett closer **268** from the force application end portions **254** and **256**.

Referring to FIGS. **23-25**, the crimping mechanism **206** can further include a cutting mechanism. The cutting mechanism includes a cut off cam **284** slidingly positioned along a bottom portion of the collett holder **208**. The cut off cam **284** includes a first end portion **286** positioned through the outer tube ferrule **270**. A cut off cam ring **288** is slidably positioned about the collett holder **208**, engaging the first end portion **286** of the cut off cam **284**. The cut off cam ring **288** is positioned proximal to the trigger **264**, such that as the trigger **264** is actuated from the first trigger **264** position TR1 to the second trigger **264** position TR2, a top portion **290** of the trigger **264** engages the cut off cam ring **288**, sliding the cut off cam ring **288** and cut off cam **284** along the collett holder **208**. A cut off bias member **291** is interposed between the outer tube ferrule **270** and the cut off cam ring **288**.

A cut off arm **292** is connected to the collett **242**, at least partially positioned in the gap **252** between the first and second collett arms **248** and **250**. The cut off arm **292** includes a cutting head portion **294** positioned proximal to the first and second force application end portions **254** and **256**, at least partially positioned in the gap **252**, interposed between the first and second collett arms **248** and **250**. The cutting head portion **294** includes a cutting edge **296**, for cutting the cable, and a lower angular surface **298** for engagement by a second end portion **300** of the cut off cam **284**.

In use, the trigger **264** is actuation from the first trigger position TR1 to the second trigger position TR2. The actuation of the trigger **264** results in the top portion **290** of the trigger **264** engaging the cut off cam ring **288**, sliding the cut off cam ring **288** and cut off cam **284** along the collett holder **208**. The second end portion **300** of the cut off cam **284** engages the angular surface **298** of the cutting head **294**, forcing the cutting edge **296** into the cable, cutting the cable. The trigger **264** is released, allowing the cut off bias member **291** to bias the cut off cam **284** from the cutting head **294**.

Referring to FIG. **26**, in a method of use, the cable is passed through the bone and fracture, where a first fastener secures the cable on a first side (fracture side) of the bone and a second fastener is positioned about the cable on a second side of the bone, opposite the first fastener. A bushing is positioned onto the cable to secure the second fastener against the second side of the bone.

The cable is inserted through the medical device **200** along the central longitudinal axis "A", through the collett **242**, collett holder **208**, and the cable tensioner **216**, positioning the bushing in the bushing aperture **258** and extending the cable through the cable aperture **224**. To tension the cable, the cable tension lever **230** is actuated from the first lever position L1 to the second lever position L2, sliding the cable tensioner **216** along the collett holder **208** from the first tensioner position T1, into the handle portion **202** against the

tension bias member **238**, to the second tensioner position T**2**. The cable is positioned through the radial groove **226** and wrapped about the circumferential groove **228** on the end portion **222** of the cable tensioner **216**, securing the cable to the cable tensioner **216**. The cable tension lever **230** is released, such that tension bias member **238** biases the cable tensioner **216** from the second tensioner position T**2** towards the first tensioner position T**1**. The movement of the cable tensioner **216** towards the first tensioner position T**1** applies a tension to the cable, pressing the bushing against the second fastener. The applied tension can be selected by actuating the cable tension lever **230** to the desired tension marking **240**.

The trigger **264** is actuated from the first trigger position TR**1** to the second trigger position TR**2**. The actuation of the trigger **264** slides the outer tube **260** along the collett holder **208** from the first tube position P**1** to the second tube position P**2**, moving collett closer **268** about the force application end portions **254** and **256** of the first and second collett arms **248** and **250**. The inner tapered surfaces **280** of the collett closer **268** apply compressive forces to the first and second force application end portions **254** and **256**, compressing the first and second force application end portions **254** and **256** about the bushing positioned in the bushing aperture **258**. The compressive forces crimp the bushing about the cable, securing the bushing to the cable.

Simultaneously, the actuation of the trigger **264** results in the top portion **290** of the trigger **264** engaging the cut off cam ring **288**, sliding the cut off cam ring **288** and cut off cam **284** along the collett holder **208**. The second end portion **300** of the cut off cam **284** engages the angular surface **298** of the cutting head **294**, forcing the cutting edge **296** into the cable, cutting the cable.

In another embodiment a medical device **320** of the present invention secures a fastener against relative movement with respect to a suture, with the fastener itself being deformed. Medical device **320** is substantially similar to medical device **200** and like reference number shall be used to indicate like items.

Referring to FIGS. **27** and **28**, medical device **320** includes collett **322**. As with collett **242**, previously disclosed and illustrated, collett **322** is affixed to the second end portion **244** of the collett holder **208**, opposite the cable tensioner **216**. The collett **322** defines a collett passage longitudinally aligned with the longitudinal passage of the collett holder **208**, along the central longitudinal axis A. An end portion of the collett **322** is bisected, forming first and second collett arms **324** and **326**. A gap portion **328** is provided between the first and second collett arm **324** and **326**. Each of the first and second collett arms **324** and **326** includes force application end portions **330** and **332**. The force application end portions **330** and **332** combine to form a fastener aperture **334** configured to receive the fastener therein. The force application end portions **330** and **332** each include opposing compressive members **336** for compressing the fastener about the suture.

Referring to FIGS. **27** and **29**, medical device **320** includes collett closer **340**. The collett closer **340** is positioned on the outer tube **260** proximal to the force application end portions **330** and **332** of the first and second collett arms **324** and **326**. The collett closer **340** includes slotted sections **342** configured for receiving end portions of the fastener therein. As the outer tube **260** is moved from the first tube position P**1** to the second tube position P**2**, the collett closer is moved over the force application end portions **330** and **332**. Similar to collett closer **268**, the collett closer **340** includes inner tapered surfaces **280** (See FIG. **22**), such that the inner tapered surfaces **280** apply compressive forces to the force application end portions **330** and **332** as the collett closer **340** is moved over the force application end portions **330** and **332**, closing the gap **328** there between.

Referring to FIGS. **30** and **31**, in a method of use suture **360** is inserted through the bone **362** and fracture **364**, where the suture **360** is threaded through a fastener **366** on a first side (fracture side) of the bone **362**. The suture **360** is reinserted through the fracture **364** and bone **362**, such that first and second ends **368** and **370** of the suture **360** extend from the bone **362**. The first and second ends of the suture **368** and **370** are threaded through a fastener **372**, where the first end of the suture **368** is threaded through a first aperture **374** in the fastener **372** and the second end of the suture **370** is threaded through a second aperture **376** in the fastener **372**.

Referring also to FIG. **26**, the ends of the suture **368** and **370** are inserted through the medical device **320** along the central longitudinal axis A, through the collett **322**, collett holder **208**, and the cable tensioner **216**, positioning the fastener **372** in the fastener aperture **334** and extending the ends of the suture **368** and **370** through the cable aperture **224**. To tension the suture **360**, the cable tension lever **230** is actuated from the first lever position L**1** to the second lever position L**2**, sliding the cable tensioner **216** along the collett holder **208** from the first tensioner position T**1**, into the handle portion **202** against the tension bias member **238**, to the second tensioner position T**2**. The suture ends **368** and **370** are positioned through the radial groove **226** and wrapped about the circumferential groove **228** on the end portion **222** of the cable tensioner **216**, securing the suture **360** to the cable tensioner **216**. The cable tension lever **230** is released, such that tension bias member **238** biases the cable tensioner **216** from the second tensioner position T**2** towards the first tensioner position T**1**. The movement of the cable tensioner **216** towards the first tensioner position T**1** applies tension to the suture **360**, compressing the fastener **372** against the bone **362**. The applied tension can be selected by actuating the cable tension lever **230** to the desired tension marking **240**.

The trigger **264** is actuation from the first trigger position TR**1** to the second trigger position TR**2**. The actuation of the trigger **264** slides the outer tube **260** along the collett holder **208** from the first tube position P**1** to the second tube position P**2**, moving collett closer **340** about the force application end portions **330** and **332** of the first and second collett arms **324** and **326**. The inner tapered surfaces **280** of the collett closer **340** apply compressive forces to the first and second force application end portions **330** and **332**, compressing compressive members **336** of the first and second force application end portions **330** and **332** into the first and second fastener apertures **374** and **376**. The compressive forces crimp the first and second fastener apertures **374** and **376** about the suture ends **368** and **370**, securing the fastener **372** to the suture ends **368** and **370**.

Simultaneously, the actuation of the trigger **264** results in the top portion **290** of the trigger **264** engaging the cut off cam ring **288**, sliding the cut off cam ring **288** and cut off cam **284** along the collett holder **208**. The second end portion **200** of the cut off cam **283** engages the angular surface **298** of the cutting head **294**, forcing the cutting edge **296** into the suture ends **268** and **270**, cutting the suture ends **368** and **370**.

Referring to FIG. **32**, similar to FIGS. **18** and **20**, a collett **400** is affixed to a second end portion **244** of the collett holder **208**, opposite the cable tensioner **216**. The collett **400**

defines a collett passage longitudinally aligned with the longitudinal passage of the collett holder **208** along the central longitudinal axis A. An end portion of the collett **400** is bisected, forming first and second collett arms **402** and **404**. A gap portion **406** is provided between the first and second collett arms **402** and **404**. Each of the first and second collett arms **402** and **404** includes force application end portions **408** and **410**. The force application end portions **408** and **410** combine to form a bushing aperture **412** configured to received the bushing therein **414**. The collett **400** is made of a semi-rigid material, such that the first and second collett arms **402** and **404** can be moved from an open to a closed position, closing the gap **406** between the force application end portions **408** and **410**.

Referring also to FIG. **33**, in a method of use, suture **416** is inserted through the bone **418** and fracture **420**, where the suture **416** is threaded through a fastener **422** on a first side (fracture side) of the bone **424**. The suture **416** is reinserted through the fracture **420** and bone **418**, such that first and second ends **426** and **428** of the suture **416** extend from the bone **418**. The first and second ends of the suture **426** and **428** are threaded through a fastener **414**, where the first and second ends **426** and **428** of the suture **416** is threaded through an aperture **430** in the fastener **414**.

Referring also to FIGS. **26** and **29**, the ends of the suture **426** and **428** are inserted through the medical device **320** along the central longitudinal axis A, through the collett **400**, collett holder **208**, and the cable tensioner **216**, positioning the fastener **414** in the fastener aperture **412** and extending the ends of the suture **426** and **428** through the cable aperture **224**. To tension the suture **416**, the cable tension lever **230** is actuated from the first lever position L**1** to the second lever position L**2**, sliding the cable tensioner **216** along the collett holder **208** from the first tensioner position T**1**, into the handle portion **202** against the tension bias member **238**, to the second tensioner position T**2**. The suture ends **426** and **428** are positioned through the radial groove **226** and wrapped about the circumferential groove **228** on the end portion **222** of the cable tensioner **216**, securing the suture **360** to the cable tensioner **216**. The cable tension lever **230** is released, such that tension bias member **238** biases the cable tensioner **216** from the second tensioner position T**2** towards the first tensioner position T**1**. The movement of the cable tensioner **216** towards the first tensioner position T**1** applies tension to the suture **416**, compressing the fastener **414** against the bone **418**. The applied tension can be selected by actuating the cable tension lever **230** to the desired tension marking **240**.

The trigger **264** is actuated from the first trigger position TR**1** to the second trigger position TR**2**. The actuation of the trigger **264** slides the outer tube **260** along the collett holder **208** from the first tube position P**1** to the second tube position P**2**, moving collett closer **340** about the force application end portions **408** and **410** of the first and second collett arms **402** and **404**. The inner tapered surfaces **280** of the collett closer **340** apply compressive forces to the first and second force application end portions **408** and **410**. The compressive forces crimp the aperture **430** about the suture ends **426** and **428**, securing the fastener **414** to the suture ends **426** and **428**.

Referring to FIG. **36**, a medical device **500** is provided for securing the bushing to the cable. The medical device **500** includes a handle portion **502** having a tensioning mechanism **504**, tensioning the cable and applying a force to the bushing, and a crimping mechanism **506** for securing the bushing to the cable.

Referring also to FIGS. **37** and **38**, the tensioning mechanism **504** includes a collett holder **508** defining a longitudinal passage along a central longitudinal axis A. The collett holder **508** is affixedly positioned through a top portion **510** of the handle portion **502**. A cable tensioner **512** is slidably positioned on a first end **514** of the collett holder **508**. The cable tensioner **512** defines a cable passage longitudinally aligned with the longitudinal passage of the collett holder **508**. An end portion **516** of the cable tensioner **512** includes a cable aperture for threading the cable there through. A radial groove and circumferential groove **518** are provided on the end portion **516** of the cable tensioner **512**, such that the cable can be wrapped about the circumferential groove **518** of the cable tensioner **512**, thereby preventing relative movement between the cable and the cable tensioner **512**.

In an exemplary embodiment, the cable tensioner **512** can include a retention bushing **520** and a tension insert **522**. The tension insert **522** defines a cable passage longitudinally aligned with the longitudinal passage of the cable tensioner **512**. The retention bushing **520** is positioned about a portion of the tension insert **522**, where an end portion **524** is threaded into the end portion **516** of the cable tensioner **512**. An opposite end portion **526** of the tension insert **522** includes a cable aperture **528** for threading the cable there through. A radial groove **530** is provided on the end portion **526** of the cable tensioner **512** and the retention bushing **520** and the tension insert **522** combine to form a circumferential groove **532**, such that the cable can be wrapped about the circumferential groove **532**, thereby preventing relative movement between the cable and the cable tensioner **512**.

A cable tension lever **534** is pivotally connected to the cable tensioner **512** with a lever pin **536**. The cable tension lever **534** is adjustably positioned on the handle portion **502** with body pins **538**, wherein a body pin **538** is mirrorly positioned on opposite sides of the handle portion **502**. The body pins **538** are engaged in the cable tension lever **536** arcuate lever slots **540**, such that cable tension lever **534** and cable tensioner **512** are movably connected to the handle portion **502**.

In use, as the cable tension lever **534** is pivoted about the cable tensioner **512** from a first lever position L**1** to a second lever position L**2**, the body pins **538** traverse the arcuate lever slots **540**, resulting in a translation of the cable tensioner **512** along the first end **514** of the collett holder **508** from a first tensioner position T**1** to a second tensioner position T**2**. A tension bias member **542** is interposed between the cable tensioner **512** and the handle portion **502**, biasing the cable tensioner **512** into the first tensioner position T**1**.

Referring to FIGS. **37** and **39**, a collett **544** is affixed to a second end portion **546** of the collett holder **508**, opposite the cable tensioner **512**. The collett **544** defines a collett passage longitudinally aligned with the longitudinal passage of the collett holder **508** along the central longitudinal axis A. An end portion of the collett **544** is bisected, forming first and second collett arms **548** and **550**. A gap portion **552** is provided between the first and second collett arms **548** and **550**. Each of the first and second collett arms **548** and **550** includes force application end portions **554** and **556**. The force application end portions **554** and **556** combine to form a bushing aperture **558** configured to received the bushing therein. The collett **544** is made of a semi-rigid material, such that the first and second collett arms **548** and **550** can be moved from an open to a closed position, closing the gap **552** between the force application end portions **554** and **556**.

In use, the tensioning mechanism **504** is used to tension the cable. The cable can include single or multiple filaments.

The cable is inserted through the medical device **500** along the central longitudinal axis A, through the collett **544**, collett holder **508**, and the cable tensioner **512**, positioning the bushing in the bushing aperture **558** and extending the cable through the cable aperture **530**. To tension the cable, the cable tension lever **354** is actuated from the first lever position L1 to the second lever position L2, sliding the cable tensioner **512** along the collett holder **508** from the first tensioner position T1, into the handle portion **502** against the tension bias member **542**, to the second tensioner position T2. The cable is positioned through the radial groove **528** and wrapped about the circumferential groove **532** on the between the retention bushing **520** and the tension insert **522**, securing the cable to the cable tensioner **512**. The cable tension lever **534** is released, such that tension bias member **542** biases the cable tensioner **512** from the second tensioner position T2 towards the first tensioner position T1. The movement of the cable tensioner **512** towards the first tensioner position T1 applies a tension to the cable, forcing the bushing into the second fastener. The applied tension can be selected by actuating the cable tension lever **534** to the desired tension.

Referring to FIGS. **36** and **40**, the crimping mechanism **506** includes an outer tube **560** slidingly positioned over the collett holder **508**. The outer tube **560** includes a first end **562** operably connected to a trigger **564** and a second end **566** connected to a collett closer **568**. The trigger **264** is pivotally mounted in the handle portion **502**, such that the trigger **564** can be actuated from a first trigger position TR1 to a second trigger position TR2. A locking mechanism **570** prevents the trigger **564** from being actuated. The locking mechanism **570** is disengaged by rotating it away from the handle, where the locking mechanism is secured to the trigger with the locking pawl **572**. (See also FIG. **37**).

The operable connection between the first end of the outer tube **562** and the trigger **564** includes an outer tube ferrule **574** slidably positioned about the collett holder **408** and affixed to the first end of the outer tube **562**. A tube bias member **576** is interposed between the handle portion **502** and the outer tube ferrule **574**, such that the tube bias member **576** biases the outer tube ferrule **574** and the outer tube **560** into a first tube position P1. A tube washer **578** can be provided between the tube ferrule **574** and the bias member **576**.

An actuation of the trigger **564** from a first trigger position TR1 to a second trigger position TR2 translates the outer tube ferrule **574** along the collett holder **208** from the first tube position P1 to a second tube position P2. In the second tube position P2 a tube pawl **580** engages the outer tube ferrule **574**, hold the outer tube ferrule in the second tub position P2.

Referring to FIGS. **36** and **42**, the collett closer **568** is positioned on the outer tube **560** proximal to the force application end portions **554** and **556** of the first and second collett arms **548** and **550**. As the outer tube **560** is moved from the first tube position P1 to the second tube position P2, the collett closer **568** is moved over the force application end portions **554** and **556**. The collett closer **568** includes inner tapered surfaces **582**, such that the inner tapered surfaces **580** apply compressive forces to the force application end portions **554** and **556** as the collett closer **568** is moved over the force application end portions **554** and **556**, closing the gap **552** there between.

In use, the trigger **564** is actuated from the first trigger position TR1 to the second trigger position TR2. The actuation of the trigger **564** slides the outer tube **560** along the collett holder **508** from the first tube position P1 to the second tube position P2, moving collett closer **568** about the force application end portions **554** and **556** of the first and second collett arms **548** and **550**. The inner tapered surfaces **580** of the collett closer **568** apply compressive forces to the first and second force application end portions **554** and **556**, closing the gap **552** there between.

Referring to FIGS. **41-43**, the crimping mechanism **506** can further include a cutting mechanism. The cutting mechanism includes a pair of cut off cams **582** and **584** positioned in the collett gap **552**. A pair of wedges **586** and **588** are slidingly positioned along and on opposite sides of the collett **550** and the collett holder **508**. Each of the wedges **586** and **588** include tapered ends **590** and **592** positioned proximal to the cut off arms, such that when the wedges are moved from a first wedge position W1 to a second wedge position W2, the tapered ends **590** and **592** compress the cut off cams **582** and **584** together, cutting the cable.

The handle **502** further includes a wedge pusher **594** slidingly positioned about the collett holder **508**, adjacent to second ends **594** and **596** of wedges **586** and **588**. The wedge pusher **594** is slidable from a first position to a second position, such that the wedges **586** and **588** are moved from the first wedge position W1 to the second wedge position W2. A rocker **596** is pivotally connected to the handle **502**, such that an actuation of the rocker **596** from a first rocker position R1 to a second rocker position R2, slides the wedge pusher **594** from the first position to the second position, moving wedges **586** and **588** from the first wedge position W1 to the second wedge position W2

Referring to FIGS. **41** and **44**, the locking mechanism **570** includes a rocker kicker **598** pivotally affixed therein. The rocker kicker **598** is biasedly connected to the locking mechanism **570**, being held in a closed position by a pin **600**. When the trigger **564** is actuated from the first trigger position TR1 to the second trigger position TR2, the release **602** engages the pin **600**, releasing the rocker kicker **590**.

The trigger **564** is released, allowing the trigger **564** to move from the second trigger position TR2 to the first trigger position TR1. To actuate the cutting mechanism, the trigger is again moved from the first trigger position TR1 to the second trigger position TR2, such that the rocker kicker **598** engages the rocker **596**, pivoting the rocker **596** from the first rocker position R1 to the second rocker position. The rocker **596** slides the wedge pusher **594** from the first position to the second position, moving wedges **586** and **588** from the first wedge position W1 to the second wedge position W2, such that, the tapered ends **590** and **592** compress the cut off cams **582** and **584** together, cutting the cable. The trigger **564** can then be released, releasing the crimped fastener.

It is also contemplated that the system and medical device of the present invention may be disposable or may be sterilized after use and reused.

The methods and devices of the present invention may be used in conjunction with any surgical procedure of the body. The repair, reconstruction, augmentation, and securing of tissue or an implant may be performed in connection with surgery of a joint, bone, muscle, ligament, tendon, cartilage, capsule, organ, skin, nerve, vessel, or other body part. For example, tissue may be repaired, reconstructed, augmented, and secured following intervertebral disc surgery, knee surgery, hip surgery, organ transplant surgery, bariatric surgery, spinal surgery, anterior cruciate ligament (ACL) surgery, tendon-ligament surgery, rotator cuff surgery, capsule repair surgery, fractured bone surgery, pelvic fracture surgery, avulsion fragment surgery, hernia repair surgery, and surgery of an intrasubstance ligament tear, annulus fibrosis,

fascia lata, flexor tendons, etc. In one particular application, an anastomosis is performed over a balloon and the methods and devices of the present invention are used to repair the vessel.

Also, tissue may be repaired after an implant has been inserted within the body. Such implant insertion procedures include, but are not limited to, partial or total knee replacement surgery, hip replacement surgery, bone fixation surgery, etc. The implant may be an organ, partial organ grafts, tissue graft material (autogenic, allogenic, xenogeneic, or synthetic), collagen, a malleable implant like a sponge, mesh, bag/sac/pouch, collagen, or gelatin, or a rigid implant made of metal, polymer, composite, or ceramic. Other implants include biodegradable plates, porcine or bovine patches, metallic fasteners, compliant bearings for one or more compartments of the knee, nucleus pulpous prosthetic, stent, tissue graft, tissue scaffold, biodegradable collagen scaffold, and polymeric or other biocompatible scaffold. The scaffold may include fetal cells, stem cells, embryonal cells, enzymes, and proteins.

The present invention further provides flexible and rigid fixation of tissue. Both rigid and flexible fixation of tissue and/or an implant provides compression to enhance the healing process of the tissue. A fractured bone, for example, requires the bone to be realigned and rigidly stabilized over a period time for proper healing. Also, bones may be flexibly secured to provide flexible stabilization between two or more bones. Soft tissue, like muscles, ligaments, tendons, skin, etc., may be flexibly or rigidly fastened for proper healing. Flexible fixation and compression of tissue may function as a temporary strut to allow motion as the tissue heals. Furthermore, joints which include hard and soft tissue may require both rigid and flexible fixation to enhance healing and stabilize the range of motion of the joint. Flexible fixation and compression of tissue near a joint may provide motion in one or more desired planes. The fasteners described herein and incorporated by reference provide for both rigid and flexible fixation.

It is contemplated that the devices and methods of the present invention be applied using minimally invasive incisions and techniques to preserve muscles, tendons, ligaments, bones, nerves, and blood vessels. A small incision(s) may be made adjacent the damaged tissue area to be repaired, and a tube, delivery catheter, sheath, cannula, or expandable cannula may be used to perform the methods of the present invention. U.S. Pat. No. 5,320,611 entitled, Expandable Cannula Having Longitudinal Wire and Method of Use, discloses cannulas for surgical and medical use expandable along their entire lengths. The cannulas are inserted through tissue when in an unexpanded condition and with a small diameter. The cannulas are then expanded radially outwardly to give a full-size instrument passage. Expansion of the cannulas occurs against the viscoelastic resistance of the surrounding tissue. The expandable cannulas do not require a full depth incision, or at most require only a needle-size entrance opening.

Also, U.S. Pat. Nos. 5,674,240; 5,961,499; and 6,338,730 disclose cannulas for surgical and medical use expandable along their entire lengths. The cannula has a pointed end portion and includes wires having cores which are enclosed by jackets. The jackets are integrally formed as one piece with a sheath of the cannula. The cannula may be expanded by inserting members or by fluid pressure. The cannula is advantageously utilized to expand a vessel, such as a blood vessel. An expandable chamber may be provided at the distal end of the cannula. The above mentioned patents are hereby incorporated by reference.

In addition to using a cannula with the methods of the present invention, an introducer may be utilized to position fasteners at a specific location within the body. U.S. Pat. No. 5,948,002 entitled Apparatus and Method for Use in Positioning a Suture Anchor, discloses devices for controlling the placement depth of a fastener. Also, U.S. patent application Ser. No. 10/102,413 discloses methods of securing body tissue with a robotic mechanism. The above-mentioned patent and application are hereby incorporated by reference. Another introducer or cannula which may be used with the present invention is the VersaStep® System by Tyco® Healthcare.

The present invention may also be utilized with minimally invasive surgery techniques disclosed in U.S. patent application Ser. No. 10/191,751 and U.S. Pat. Nos. 6,702,821 and 6,770,078. These patent documents disclose, inter alia, apparatus and methods for minimally invasive joint replacement. The femoral, tibial, and/or patellar components of a knee replacement may be fastened or locked to each other and to adjacent tissue using fasteners disclosed herein and incorporated by reference. Furthermore, the methods and devices of the present invention may be utilized for repairing, reconstructing, augmenting, and securing tissue or implants during and "on the way out" of a knee replacement procedure. For example, the anterior cruciate ligament and other ligaments may be repaired or reconstructed; quadriceps mechanisms and other muscles may be repaired. The patent documents mentioned above are hereby incorporated by reference.

In addition, intramedullary fracture fixation and comminuted fracture fixation may be achieved with the devices and methods of the present invention. For example, a plate or rod may be positioned within or against the fractured bone. A fastener may be driven through or about the bone and locked onto the plate, rod, or another fastener.

It is further contemplated that the present invention may be used in conjunction with the devices and methods disclosed in U.S. Pat. No. 5,329,846 entitled, Tissue Press and System, and U.S. Pat. No. 5,269,785 entitled, Apparatus and Method for Tissue Removal. For example, an implant secured within the body using the present invention may include tissue harvested, configured, and implanted as described in the patents. The above-mentioned patents are hereby incorporated by reference.

Furthermore, it is contemplated that the methods of the present invention may be performed under indirect visualization, such as endoscopic guidance, computer assisted navigation, magnetic resonance imaging, CT scan, ultrasound, fluoroscopy, X-ray, or other suitable visualization technique. The implants, fasteners, fastener assemblies, and sutures of the present invention may include a radiopaque material for enhancing indirect visualization. The use of these visualization means along with minimally invasive surgery techniques permits physicians to accurately and rapidly repair, reconstruct, augment, and secure tissue or an implant within the body. U.S. Pat. Nos. 5,329,924; 5,349,956; and 5,542,423 disclose apparatus and methods for use in medical imaging. Also, the present invention may be performed using robotics, such as haptic arms or similar apparatus. The above-mentioned patents are hereby incorporated by reference.

All references cited herein are expressly incorporated by reference in their entirety.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described herein above. In addition, unless mention was made above to the contrary, it should be noted

that all of the accompanying drawings are not to scale. A variety of modifications and variations are possible in light of the above teachings without departing from the scope and spirit of the invention. Therefore, it will be understood that the appended claims are intended to cover all such modifications and embodiments which come within the spirit and scope of the present invention.

What is claimed is:

1. A tissue fixation system comprising:

an elongate member;

an anchor positionable on the elongate member and movable from a first orientation to a second orientation, the anchor having a body with a surface configured to contact a first tissue;

a fastener positionable along the elongate member and having a body with a surface configured to contact a second tissue;

a cannulated drill system comprised of a removably connected drill and an attached outer sleeve configured to pass together through the first tissue and the second tissue as the drill creates a passage through the first tissue and the second tissue, wherein the removably connected drill is configured to be removed from the outer sleeve, wherein the anchor positioned in the first orientation on the elongate member is configured to be inserted into and advanced through the outer sleeve;

a pushrod, configured to advance the anchor positioned on the elongate member in the outer sleeve through the outer sleeve, wherein the anchor is configured to pivot from the first orientation to the second orientation and contact the first tissue after passage through the outer sleeve; and

a medical instrument configured to secure the fastener to the elongate member, the medical instrument comprising:

a handle;

a tubular member coupled to the handle, the tubular member including first and second ends and defining a longitudinal passage along a central longitudinal axis through which the elongate member is configured to be passed through the tubular member;

a tensioning mechanism disposed in the handle for tensioning the elongate member to a desired tension by actuating the tensioning mechanism when the elongate member is secured in the tensioning mechanism, wherein the tensioning mechanism is comprised in part of a pivotably attached lever to apply tension to the elongate member, and a sensor and a spring element to measure and control the tension in the elongate member;

a crimping mechanism positionable in at least a portion of the first end on the tubular member for securing the fastener about the elongate member, wherein the fastener is positionable in the crimping mechanism;

a trigger mechanism disposed in the handle for activating the crimping mechanism, the trigger mechanism comprised in part by a pivotably attached trigger, wherein actuation of the trigger activates the crimping mechanism,

wherein the pivotably attached lever of the tensioning mechanism and the pivotably attached trigger of the trigger mechanism pivot about parallel axes; and

a cutting mechanism configured to cut off the excess elongate member simultaneous to the crimping mechanism securing the fastener about the elongate member,

wherein securing the fastener about the elongate member secures the anchor against the first tissue.

2. The tissue fixation system of claim **1**, wherein at least a portion of one of the elongate member, anchor, fastener, cannulated insertion device, and medical instrument are passed through at least one of tube, delivery catheter, sheath, cannula or expandable cannula in a minimally invasive incision.

3. The tissue fixation system of claim **1**, wherein surgery utilizing at least a portion of the system can be performed with a surgical robot.

4. The tissue fixation system of claim **1**, wherein the system can be used in at least one of repair, reconstruction, augmentation, and securing of at least one of a tissue or an implant.

5. The tissue fixation system of claim **4**, wherein the implant includes harvested, configured, and implanted tissue.

6. The tissue fixation system of claim **1**, wherein at least one of the first tissue and second tissue includes at least one of bone, muscle, ligament, tendon, cartilage, joint, capsule, organ, skin, nerve, vessel, or stomach tissue.

7. The tissue fixation system of claim **1**, wherein the system is utilized in at least one of minimally invasive joint replacement surgery, intervertebral disc surgery, knee surgery, hip surgery, organ transplant surgery, bariatric surgery, spinal surgery, anterior cruciate ligament surgery, tendon-ligament surgery, rotator cuff surgery, capsule repair surgery, fractured bone surgery, pelvic fracture surgery, avulsion fragment surgery, and hernia repair surgery.

8. The tissue fixation system of claim **1**, wherein the elongate member is at least one of a suture, a thread, a cable, a wire, and a pin.

9. The tissue fixation system of claim **1**, wherein the drill system is configured to drill through bone tissue.

10. The tissue fixation system of claim **1**, wherein the system is configured to be used with at least one of endoscopic guidance, computer assisted navigation, magnetic resonance imaging, CT scan, ultrasound, fluoroscopy, and X-ray indirect visualization techniques.

11. The tissue fixation system of claim **1**, wherein the fastener is comprised of an anchor and a bushing.

12. The tissue fixation system of claim **1**, wherein the system is configured to secure at least one of a plate and rod within or on a fractured bone.

13. A tissue fixation system for fixation of a first tissue member to a second tissue member, comprising:

an elongate member positionable though the first and second tissue members and including first and second ends, such that the first and second tissue members are interposed between the first and second ends of the elongate member;

an anchor positionable on the first end of the elongate member, adjacent to the first tissue member;

a fastener positionable on the second end of the elongate member, adjacent to the second tissue member;

a medical instrument configured to secure the fastener to the elongate member, the medical instrument comprising:

a handle;

a tubular member coupled to the handle, the tubular member including first and second ends and defining a longitudinal passage along a central longitudinal axis through which the elongate member is configured to be passed through the tubular member;

a tensioning mechanism disposed in the handle for tensioning the elongate member to a desired tension

by actuating the tensioning mechanism when the elongate member is secured in the tensioning mechanism, wherein the tensioning mechanism is comprised in part of a pivotably attached lever to apply tension to the elongate member, and a sensor and a spring element to measure and control the tension in the elongate member;

a crimping mechanism positionable in at least a portion of the first end on the tubular member for securing the fastener about the elongate member, wherein the fastener is positionable in the crimping mechanism;

a trigger mechanism disposed in the handle for activating the crimping mechanism, the trigger mechanism comprised in part by a pivotably attached trigger, wherein actuation of the trigger activates the crimping mechanism; and

a cutting mechanism configured to cut off the excess elongate member,

wherein the pivotably attached lever of the tensioning mechanism and the pivotably attached trigger of the trigger mechanism pivot about parallel axes, and

wherein the tension provided through the elongate member between the anchor and fastener, affixes the first tissue member to the second tissue member.

14. A tissue fixation system of claim **13**, wherein the system is configured to secure a plate on a fractured bone.

15. The tissue fixation system of claim **13**, wherein surgery utilizing at least a portion of the system can be performed with a surgical robot.

16. The tissue fixation system of claim **13**, wherein the system can be used in at least one of repair, reconstruction, augmentation, and securing of at least one of tissue or an implant.

17. The tissue fixation system of claim **13**, wherein at least one of the first tissue and second tissue includes at least one of bone, muscle, ligament, tendon, cartilage, joint, capsule, organ, skin, nerve, vessel, or stomach tissue.

18. The tissue fixation system of claim **13**, wherein the system is utilized in at least one of minimally invasive joint replacement surgery, intervertebral disc surgery, knee surgery, hip surgery, organ transplant surgery, bariatric surgery, spinal surgery, anterior cruciate ligament surgery, tendon-ligament surgery, rotator cuff surgery, capsule repair surgery, fractured bone surgery, pelvic fracture surgery, avulsion fragment surgery, and hernia repair surgery.

19. The tissue fixation system of claim **13**, wherein the cutting of the excess elongate member occurs simultaneous to the crimping mechanism securing the fastener about the elongate member.

20. The tissue fixation system of claim **13**, wherein the elongate member is at least one of a suture, a thread, a cable, a wire, and a pin.

* * * * *

专利名称(译)	组织固定系统和方法		
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当前申请(专利权)人(译)	P科技有限责任公司		
[标]发明人	BONUTTI PETER M PHILLIPS GLEN A CRAINICH LAWRENCE		
发明人	BONUTTI, PETER M. PHILLIPS, GLEN A. CRAINICH, LAWRENCE		
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其他公开文献	US20160008043A1		
外部链接	Espacenet USPTO		

摘要(译)

提供组织固定系统用于组织的动态和刚性固定。与诸如电缆，电线，缝合线，杆或管等细长紧固构件连接的紧固件移动通过组织相对侧之间的通道。紧固件设置有凹槽，该凹槽容纳紧固构件的至少一部分，以减小通过通道移动期间的轮廓。然后旋转紧固件以改变其方向。然后可以将第二紧固件与紧固构件连接。在紧固构件中保持张力的同时，紧固件被固定以防止相对运动。这可以通过使紧固构件，第一或第二紧固件或抵靠第二紧固件放置的衬套变形来完成。