US009282973B2

(12) **United States Patent**
Hughett, Sr. et al.

(10) **Patent No.: US 9,282,973 B2**
(45) **Date of Patent: Mar. 15, 2016**

(54) **CLIP DEPLOYMENT TOOL AND ASSOCIATED METHODS**

(75) Inventors: **James David Hughett, Sr.**, Liberty Township, OH (US); **Keith Edward Martin**, Mason, OH (US); **Kenneth Lance Miller**, Hamilton, OH (US); **Michael Dolgin**, Cincinnati, OH (US)

(73) Assignee: **AtriCure, Inc.**, Mason, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 870 days.

(21) Appl. No.: **13/355,169**

(22) Filed: **Jan. 20, 2012**

(65) **Prior Publication Data**

US 2013/0190777 A1 Jul. 25, 2013

(51) **Int. Cl.**

A61B 17/128	(2006.01)
A61B 17/122	(2006.01)
A61B 17/00	(2006.01)
A61B 17/29	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 17/1285*** (2013.01); ***A61B 17/1227*** (2013.01); *A61B 2017/00867* (2013.01); *A61B 2017/2946* (2013.01)

(58) **Field of Classification Search**

CPC A61B 17/1227; A61B 17/1285; A61B 2017/00867; A61B 17/128

USPC 606/139, 142, 157

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,060,724 A	11/1936	Carroll
2,371,978 A	3/1945	Perham
3,032,039 A	5/1962	Beaty
3,496,932 A	2/1970	Prisk et al.
3,682,180 A	8/1972	McFarlane
3,854,482 A	12/1974	Laugherty et al.
3,856,016 A	12/1974	Davis
3,856,017 A	12/1974	Perisse et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP	1 600 108 A3	3/2006
WO	WO 98/18389	5/1998

(Continued)

OTHER PUBLICATIONS

Lynch et al, Recanalization of the Left Atrial Appendage Demonstrated by Transesophageal Echocardiography, Ann Torac Surg, 1997; 63:1774-5, Published by Elsevier Science Inc., © 1997 The Society of Thoracic Surgeons, USA.

(Continued)

Primary Examiner — Jonathan W Miles

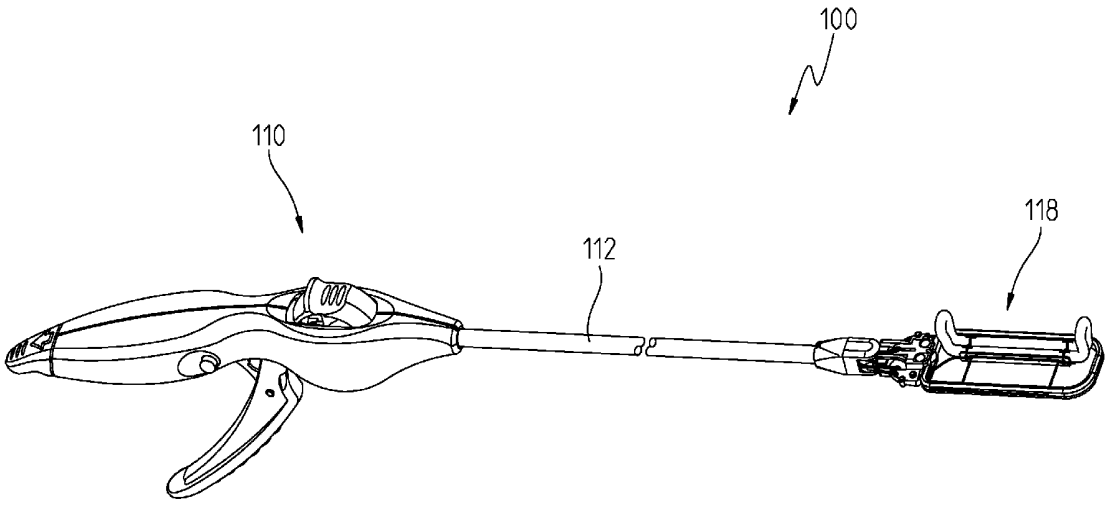
Assistant Examiner — Lucas Paez

(74) *Attorney, Agent, or Firm* — Porter Wright Morris & Arthur LLP; Ryan Willis

(57) **ABSTRACT**

A laparoscopic device comprising: (a) a housing operatively coupled to a first control and a second control; (b) an end effector operatively coupled to the first control, the end effector comprising a first component and a second component selectively repositionable with respect to one another within an X-Y plane, the end effector also including a third component selectively repositionable with respect to the second component within an Y-Z plane; (c) a laparoscopic conduit extending between the housing and the end effector; and, (d) an occlusion clip deployment device operatively coupled to the end effector and the second control.

18 Claims, 36 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

3,856,018 A 12/1974 Perisse et al.
3,954,108 A 5/1976 Davis
4,226,239 A 10/1980 Polk et al.
4,274,415 A 6/1981 Kanamoto et al.
4,493,319 A 1/1985 Polk et al.
4,552,128 A 11/1985 Haber
4,788,966 A 12/1988 Yoon
4,791,707 A 12/1988 Tucker
4,869,268 A 9/1989 Yoon
4,917,677 A 4/1990 McCarthy
4,950,284 A 8/1990 Green et al.
5,026,379 A 6/1991 Yoon
5,100,416 A 3/1992 Oh et al.
5,119,804 A 6/1992 Anstadt
5,171,250 A 12/1992 Yoon
5,217,030 A 6/1993 Yoon
5,217,473 A 6/1993 Yoon
5,258,000 A 11/1993 Gianturco
5,282,829 A 2/1994 Hermes
5,290,299 A 3/1994 Fain et al.
5,306,234 A 4/1994 Johnson
5,309,927 A 5/1994 Welch
5,334,209 A 8/1994 Yoon
5,336,252 A 8/1994 Cohen
5,342,373 A 8/1994 Stefanchik et al.
5,366,459 A 11/1994 Yoon
5,425,740 A 6/1995 Hutchinson, Jr.
5,439,156 A 8/1995 Grant et al.
5,445,167 A 8/1995 Yoon et al.
5,452,733 A 9/1995 Sterman et al.
5,540,706 A * 7/1996 Aust et al. 606/170
5,549,628 A 8/1996 Cooper et al.
5,582,616 A 12/1996 Bolduc et al.
5,609,599 A 3/1997 Levin
5,620,452 A 4/1997 Yoon
5,643,291 A * 7/1997 Pier et al. 606/143
5,665,100 A 9/1997 Yoon
5,667,518 A 9/1997 Pannell
5,681,330 A 10/1997 Hughett et al.
5,683,405 A 11/1997 Yacoubian et al.
5,728,121 A 3/1998 Bimbo et al.
5,758,420 A 6/1998 Schmidt et al.
5,762,255 A 6/1998 Chrisman et al.
5,782,397 A 7/1998 Koukline
5,782,844 A 7/1998 Yoon et al.
5,810,851 A 9/1998 Yoon
5,810,882 A 9/1998 Bolduc et al.
5,824,008 A 10/1998 Bolduc et al.
5,830,221 A 11/1998 Stein et al.
5,833,700 A 11/1998 Fogelberg et al.
5,843,121 A 12/1998 Yoon
5,865,791 A 2/1999 Whayne et al.
5,893,863 A 4/1999 Yoon
5,919,202 A 7/1999 Yoon
5,921,997 A * 7/1999 Fogelberg et al. 606/158
5,922,001 A 7/1999 Yoon
5,922,002 A 7/1999 Yoon
5,964,772 A 10/1999 Bolduc et al.
5,984,917 A 11/1999 Fleischman et al.
5,984,938 A 11/1999 Yoon
5,984,939 A 11/1999 Yoon
6,042,563 A 3/2000 Morejohn et al.
6,074,418 A 6/2000 Buchanan et al.
6,088,889 A 7/2000 Luther et al.
6,096,052 A 8/2000 Callister et al.
6,099,550 A 8/2000 Yoon
6,152,144 A 11/2000 Lesh et al.
6,165,183 A 12/2000 Kuehn et al.
6,231,561 B1 5/2001 Frazier et al.
6,270,516 B1 8/2001 Tanner et al.
6,280,415 B1 8/2001 Johnson
6,290,674 B1 9/2001 Roue et al.
6,296,656 B1 10/2001 Bolduc et al.
6,299,612 B1 10/2001 Ouchi
6,312,447 B1 11/2001 Grimes
6,330,964 B1 12/2001 Kayan et al.
6,387,105 B1 5/2002 Gifford, III et al.
6,402,765 B1 6/2002 Monassevitch et al.
6,416,554 B1 7/2002 Alferness et al.
6,428,548 B1 8/2002 Durgin et al.
6,436,088 B2 8/2002 Frazier et al.
6,447,542 B1 9/2002 Weadock
6,450,391 B1 9/2002 Kayan et al.
6,485,407 B2 11/2002 Alferness et al.
6,488,689 B1 12/2002 Kaplan et al.
6,491,701 B2 12/2002 Tierney et al.
6,491,706 B1 12/2002 Alferness et al.
6,506,149 B2 1/2003 Peng et al.
6,508,829 B1 1/2003 Levinson et al.
6,514,265 B2 2/2003 Ho et al.
6,578,585 B1 6/2003 Stachowski et al.
6,579,304 B1 6/2003 Hart et al.
6,584,360 B2 6/2003 Francischelli et al.
6,607,504 B2 8/2003 Haarala et al.
6,607,542 B1 8/2003 Wild
6,610,074 B2 8/2003 Santilli
6,638,297 B1 * 10/2003 Huitema 606/219
6,645,196 B1 11/2003 Nixon et al.
6,652,515 B1 11/2003 Maguire et al.
6,676,684 B1 1/2004 Morley et al.
6,746,461 B2 6/2004 Fry
6,770,081 B1 8/2004 Cooper et al.
6,793,664 B2 9/2004 Mazzocchi et al.
6,849,075 B2 2/2005 Bertolero et al.
6,849,078 B2 2/2005 Durgin et al.
6,896,684 B2 5/2005 Monassevitch et al.
6,911,032 B2 6/2005 Jugenheimer et al.
6,955,643 B2 10/2005 Gellman et al.
6,981,628 B2 * 1/2006 Wales 227/178.1
7,008,401 B2 3/2006 Thompson et al.
7,113,831 B2 9/2006 Hooven
7,118,582 B1 10/2006 Wang et al.
7,169,164 B2 1/2007 Borillo et al.
7,226,458 B2 6/2007 Kaplan et al.
7,318,829 B2 1/2008 Kaplan et al.
7,344,543 B2 3/2008 Sra
7,424,965 B2 * 9/2008 Racenet et al. 227/180.1
7,644,848 B2 1/2010 Swayze et al.
7,645,285 B2 * 1/2010 Cosgrove et al. 606/151
7,896,895 B2 * 3/2011 Boudreaux et al. 606/157
8,172,870 B2 * 5/2012 Shipp 606/205
8,795,325 B2 * 8/2014 Taylor et al. 606/205
2001/0005787 A1 6/2001 Oz et al.
2001/0039434 A1 11/2001 Frazier et al.
2001/0039435 A1 11/2001 Roue et al.
2002/0013605 A1 1/2002 Bolduc et al.
2002/0022860 A1 2/2002 Borillo et al.
2002/0026214 A1 2/2002 Tanner
2002/0026216 A1 2/2002 Grimes
2002/0032454 A1 3/2002 Durgin et al.
2002/0035374 A1 3/2002 Borillo et al.
2002/0049457 A1 4/2002 Kaplan et al.
2002/0055750 A1 5/2002 Durgin et al.
2002/0058967 A1 5/2002 Jervis
2002/0062130 A1 5/2002 Jugenheimer et al.
2002/0065524 A1 5/2002 Miller et al.
2002/0077660 A1 6/2002 Kayan et al.
2002/0099390 A1 7/2002 Kaplan et al.
2002/0103492 A1 8/2002 Kaplan et al.
2002/0111637 A1 8/2002 Kaplan et al.
2002/0111641 A1 8/2002 Peterson et al.
2002/0111647 A1 8/2002 Khairkhahan et al.
2002/0169377 A1 11/2002 Khairkhahan et al.
2002/0177859 A1 11/2002 Monassevitch et al.
2002/0177862 A1 11/2002 Aranyi et al.
2003/0009441 A1 1/2003 Holsten et al.
2003/0018362 A1 1/2003 Fellows et al.
2003/0023248 A1 1/2003 Parodi
2003/0023266 A1 1/2003 Borillo et al.
2003/0055422 A1 3/2003 Lesh
2003/0158464 A1 8/2003 Bertolero
2004/0030335 A1 2/2004 Zenati et al.
2004/0064138 A1 4/2004 Grabek
2004/0073241 A1 4/2004 Barry et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0097982	A1	5/2004	Jugenheimer et al.	
2004/0215216	A1	10/2004	Gannoe et al.	
2005/0085808	A1	4/2005	Nakao	
2005/0149068	A1	7/2005	Williams et al.	
2005/0149069	A1	7/2005	Bertolero et al.	
2005/0203561	A1	9/2005	Palmer et al.	
2006/0020271	A1	1/2006	Stewart et al.	
2006/0084974	A1	4/2006	Privitera et al.	
2006/0161147	A1	7/2006	Privitera et al.	
2006/0161149	A1	7/2006	Privitera et al.	
2007/0108252	A1*	5/2007	Racenet et al.	227/176.1
2007/0149988	A1	6/2007	Michler et al.	
2008/0033457	A1	2/2008	Francischelli et al.	
2008/0125795	A1	5/2008	Kaplan et al.	
2009/0012545	A1	1/2009	Williamson, IV et al.	
2009/0069823	A1	3/2009	Foerster et al.	
2009/0253961	A1	10/2009	Le et al.	
2010/0004663	A1	1/2010	Murphy et al.	
2010/0204716	A1	8/2010	Stewart et al.	
2011/0152922	A1	6/2011	Jeong	
2012/0035622	A1	2/2012	Kiser et al.	

FOREIGN PATENT DOCUMENTS

WO	WO 99/62409	A1	12/1999
WO	WO 01/35832	A2	5/2001
WO	WO 01/97696	A1	12/2001
WO	WO 03/011150	A1	2/2003
WO	WO 03/096881	A2	11/2003
WO	WO 2007/009099	A2	1/2007
WO	PCT/US2006/027553		1/2008
WO	PCT/US2012/051002		8/2012
WO	PCT/US2012/051002		10/2012
WO	PCT/US13/22600		4/2013

OTHER PUBLICATIONS

Hoit et al, Altered Left Atrial Compliance After Atrial Appendectomy, AHA Circulation Research, vol. 72, No. 1, Jan. 1993, pp. 167-175, From University of Cincinnati Medical Center, Department of Internal Medicine, Cincinnati, Ohio, USA.

Landymore, et al, Staple Closure of the Left Atrial Appendage, The Canadian Journal of Surgery, vol. 27, No. 2, Mar. 1984, pp. 144-145, From Victoria General Hospital, Dept. of Surgery,Div. of Cardiovascular Surgery, Halifax, NS.

Robin et al, Strangulation of the Left Atrial Appendage through a Congenital Partial Pericardial Defect, CHEST, 67:3, Mar. 1975, pp. 354-355, From Dept. of Cariology, Hutzel Hospital Medical Unit, Wayne State University, Detroit, MI, USA.

Tabata, et al, Role of Left Atrial Appendage in Left Atrial Reservoir Function as Evaluated by Left Atrial Appendage Clamping During Cardiac Surgery, American Journal of Cardiology, vol. 81, Feb. 1, 1998, pp. 327-332, © 1998 Excerpta Medica, Inc., USA.

Aytac, et al, Intrapericardial aneurysm of the left atrial appendix, J. Cardiovas. Surg., 21, 1980, pp. 509-511, USA.

Lindsay, M.D., Bruce D., Obliteration of the Left Atrial Appendage: A Concept Worth Testing, Ann Thorac Surg 1996;61:515, © 1996 The of Society Thoracic Surgeons, Published by Elsevier Science, Inc. ,USA.

Landymore, M.D., R. W., Stapling of Left Atrial Appendage, To the Editor: , Ann Thorac Surg 1989;47:794, © 1989 The Society of Thoracic Surgeons, USA.

Disesa, et al, Ligation of the Left Atrial Appendage Using an Automatic Surgical Stapler, Accepted for publication Jul. 26, 1988, Div. of Cardiac Surgery, Brigham and Women's Hospital, Boston, MA.

Wakabayashi, MD., Akio, Expanded applications of diagnostic and therapeutic thoracoscopy, J. Thorac Cardiovasc Surg 1991;102:721-3, from Dept. of Surgery, University of Californaia, Irvine, Irvine, CA.

Thomas, TV, Left atrial appendage and valve replacement, Am Heart Journal, vol. 84, No. 6, Dec. 1972, pp. 838-839, USA.

Coselli, et al, Congenital Intrapericardial Aneurysmal Dilatation of the Left Atrial Appendage, Case Reports: The Annals of Thoracic Surgery, vol. 39, No. 5, May 1985, pp. 466-468, From Dept. of Surgery, Baylor College of Medicine, Houston TX.

Coffin, M.D., Laurence H., Use of the Surgical Stapler to Obliterate the Left Atrial Appendage, Surgery, Gynecology & Obsterics, Jun. 1985, vol. 160, pp. 565-566, From Div., of Thoracic and Cardiac Surgery, Univ of Vermont College of Medicine, Burlington, VT.

Katz, et al, Surgical Left Atrial Appendage Ligation is Frequently Incomplete: A Transesophageal Echocardiographic Study, J Am College of Cardiology, vol. 36, No. 2, pp. 468-471, Aug. 2000, © 2000 American College of Cardiology, Published by Elsevier Science, Inc., USA.

Ganeshakrishnan, et al, Congenital Intrapericardial Aneurysm of the Left-Atrial Appendage, Case Report: Thorac. cardiovasc. Surgeon 40 (1992), 382-384, © Georg Thieme Verlag Stuttgart, New York, USA.

Unknown, surgical procedure report to track prior art with regards to a minimimally invasive left atrial appendage exclusion, Jan. 1, 2007, USA.

Stollberger, et. al, Elimination of the Left Atrial Appendage to Prevent Stroke or Embolism?, Opinions/Hypotheses, CHEST/ 124 / 6/ Dec. 2003, pp. 2356-2362, © American College of Chest Physicians, USA.

Cox, et al, Five-Year Experience with the Maze Procedure for Atrial Fibrillation, Ann Thorac Surg 1993; 56:814-24, Presented at the Twenty-ninth Annual Meeting of The Society of Thoracic Surgeons, San Antonio, TX, Jan. 25-27, 1993, © 1993 The Society of Thoracic Surgeons, USA.

Stollberger, et al, Is left atrial appendage occlusion useful for prevention of stroke or embolism in atrial fibrillation?, Z Kardiol 91:376-379 (2002), © Steinkopff Verlag 2002, Germany.

Riley, et al, Mitral Valve Repair, CTSNET Experts' Techniques, doc 5729, pp. 1-7, © 2004 Cardiothoracic Surgery Network, USA.

Johnson, et al, The left atrial appendage: our most lethal human attachment! Surgical implications, EU J Cardio-thor Surg 17 (2000) 718-722, Presented at the 13th Annual Meeting of the European Association for Cardio-thor Surg 17 (2000) 718-722, Presented at the 13th Annual Meeting of The European Association for Cardio-thoracic Surgery, Glasgow, Scotland, UK, Sep. 5-8, 1999, © 2000 Elsevier Science B.V.

Blackshear, et al, Thoracoscopic Extracardiac Obliteration of the Left Atrial Appendage for Stroke Risk Reduction in Atrial Fibrillation, JACC, vol. 42, No. 7, 2003, Oct. 1, 2003:1249-52, © 2003 American College of Cardiology Foundation, Published by Elsevier Inc., USA.

Odell, et al, Thoracoscopic Obliteration of the Left Atrial Appendage: Potential for Stroke Reduction?, Ann Thorac Surg 1996;61:565-9, © 1996 The Society of Thoracic Surgeons, Published by Elsevier Science Inc., USA.

Blackshear, et al, Appendage Obliteration to Reduce Stroke in Cardiac Surgical Patients with Atrial Fibrillation, Ann Thorac Surg 1996;61:755-9, © 1996 The Society of Thoracic Surgeons, Published by Elsevier Science Inc., USA.

Gillinov, et al, Stapled excision of the left atrial appendage, J Thorac Cardiovasc Surg 2005;129:679-80, © 2005 The American Association for Thoracic Surgery, USA.

Stollberger, et al, Stroke Prevention by Means of Left Atrial Appendage Strangulation?, To the Editor:, J Thorac Cardiovasc Surg 2010, p. 732, USA.

Kamohara et al, Evaluation of a novel device for left atrial appendage exclusion: The second-generation atrial exclusion device, J Thorac Cardiov Surg 2006;132:340-46, © 2006 American Association for Thoracic Surgery, USA.

Kamohara et al, A novel device for left atrial appendage exclusion, J Thorac Cardiov Surg 2005;130:1639-44, © 2005 American Association for Thoracic Surgery, USA.

Stollberger et al, Leave the left atrial appendage untouched for stroke prevention!, To the Editor:, J Thorac Cardiov Surg, vol. 134, No. 2, Aug. 2007, pp. 549-550, © 2007 American Association for Thoracic Surgery, USA.

Wudel et al, Video-Assisted Epicardial Ablation and Left Atrial Appendage Exclusion for Atrial Fibrillation: Extended Follow-up,

(56) **References Cited**

OTHER PUBLICATIONS

Ann Thorac Surg, Aug. 14, 2007, pp. 1-5, © 2007 The Society of Thoracic Surgeons, Published by Elsevier Inc., USA.

Salzberg, et al, Surgical left atrial appendage occulsion: evaluation of a novel device with magnetic resonance imaging, EU J Cardio-thor Surg 34 (2008) 766-770, © 2008 European Association for Cardio-Thoracic Surgery, Published by Elsevier B.V.

Salzberg, et al, Left atrial appendage clip occlusion: Early clinical results, J Thorac Cardiov Surg, vol. 139, No. 5, pp. 1269-1274, © 2010 The American Association for Thoracic Surgery, USA.

Unknown, Endowrist Instruments and Accessories Catalog, Intuitive Surgical, Sunnyvale, California, Sep. 2005.

Kamohara et al, Impact of left atrial appendage exclusion on left atrial function, J Thorac Cardiov Surg 2007;133:174-81, © 2007 American Association for Thoracic Surgery, USA.

Fumoto et al, A novel device for left atrial appendage exclusion: The third-generation atrial exclusion device, J Thorac Cardiov Surg 2008;136:1019-27, © 2008 American Association for Thoracic Surgery, USA.

Lipkin et al, Aneurysmal dilation of left atrial appendage diagnosed by cross sectional echocardiography and surgically removed, Br Heart J 1985; 53:69-71, National Heart Hospital, London, UK.

Cohn et al, Right thoracotomy, femorofemoral bypass, and deep hypothermia for re-replacement of the mitral valve, Ann Thorac Surg 1989;48:69-71, © 1989 Society of Thoracic Surgeons, USA.

Al-Saady et al, Left atrial appendage: structure, function, and role in thrombo-boembolism, Heart 1999;82:547-555, St. George's Hosp Med School, London UK.

Kaymaz et al, Location, Size and Morphological Characteristics of Left Atrial Thrombi as Assessed by Echocardiography in Patients with Rheumatic Mitral Valve Disease, Eur. J Echocardiography, vol. 2, Issue 4, Dec. 2001, pp. 270-276, © 2001 The European Society of Cardiology.

Rosenzweig et al, Thromboembolus from a Ligated Left Atrial Appendage, J Am Soc Echocardiography, vol. 14, pp. 396-398, May 2001, © 2001 American Society of Echocardiography, USA.

Hondo et al, The Role of the Left Atrial Appendage; A Volume Loading Study in Open-chest Dogs, Jpn Heart J, Mar. 1995, pp. 225-234, Japan.

Veinot et al, Anatomy of the Normal Left Atrial Appendage: A Quantitative Study of Age-Related Changes . . . , ahajournals 1997; 96: 3112-3115, USA.

Halperin et al, Obliteration of the Left Atrial Appendage for Prevention of Thromboembolis, J Am Coll of Cardiol, 2003;42:1259-1261, USA.

Unknown, Transesophageal Echocardiographic Correlates of Thromboembolism in High Risk Patients with Nonvalvular Atrial Fibrillation, The American College of Physicians, Apr. 1998, pp. 639-647, © 1998 American College of Physicians, USA.

Omari et al, Effect of right atrial appendectomy on the release of atrial natriuretic hormone, J Thorac Cardiovasc Surg 1991; 102:272-279, USA.

Mole et al, Desmoid Tumour in Thoractomy Scar 5 Years After Excision of a Left Giant Atrial Appendage Aneurysm in Female with a Family History of Gardner's Syndrome, Thorac Cardiovasc Surg 40 (1991) pp. 300-302, © 1992 Georg Thieme Verlag Stuttgart, New York.

Crystal et al, Left Atrial Appendage Occlusion Study (LAA0S): A randomized clinical trial of left atrial appendage occlusion during routine coronary artery bypass graft surgery for long-term stroke prevention, Am Heart J 2003; 145:174-178, © 2003 Mosby, Inc., USA.

Garcia-Fernadez et al, Role of left atrial appendage obliteration in stroke reduction in patients with mitral valve prosthesis: A transeophageal echocardiographic study, J Am Coll Cardiol 2003;42:1253-1258, © 2003 American College of Cardioldgy Foundation, USA.

Burke et al, Improved Surgical Approach to Left Atrial Appendage Aneurysm, J Cardi Surg, 1992, vol. 7, No. 2, pp. 104-107, USA.

Fisher et al, Large Gradient Across a Partially Ligated Left Atrial Appendage, J Am Soc Echocardiography, vol. 11, No. 12, pp. 1163-1165, © 1998 American Society of Echocardiography, USA.

Grundeman et al, Experimental videothoracoscopic cannulation of the left atrial appendix, Surg Endosc (1993) 7:511-513, © 1993 Springer-Verlag New York, Inc., USA.

* cited by examiner

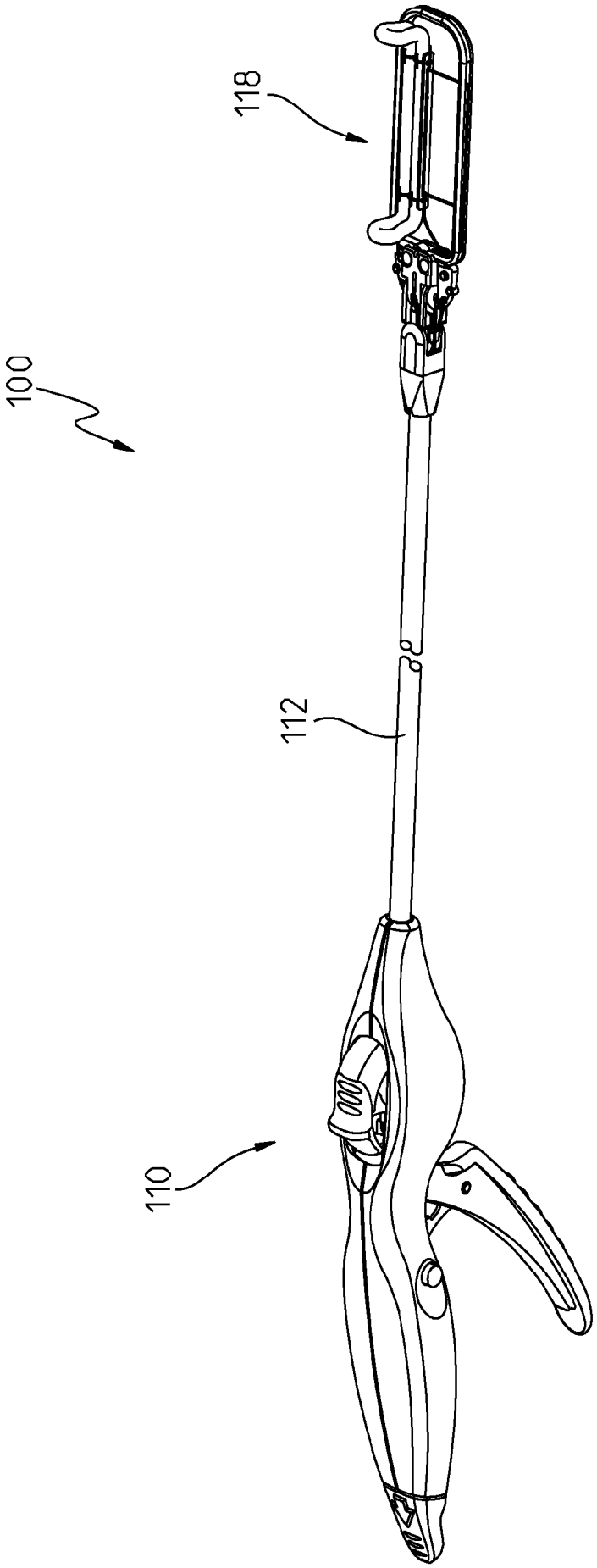


Fig. 1

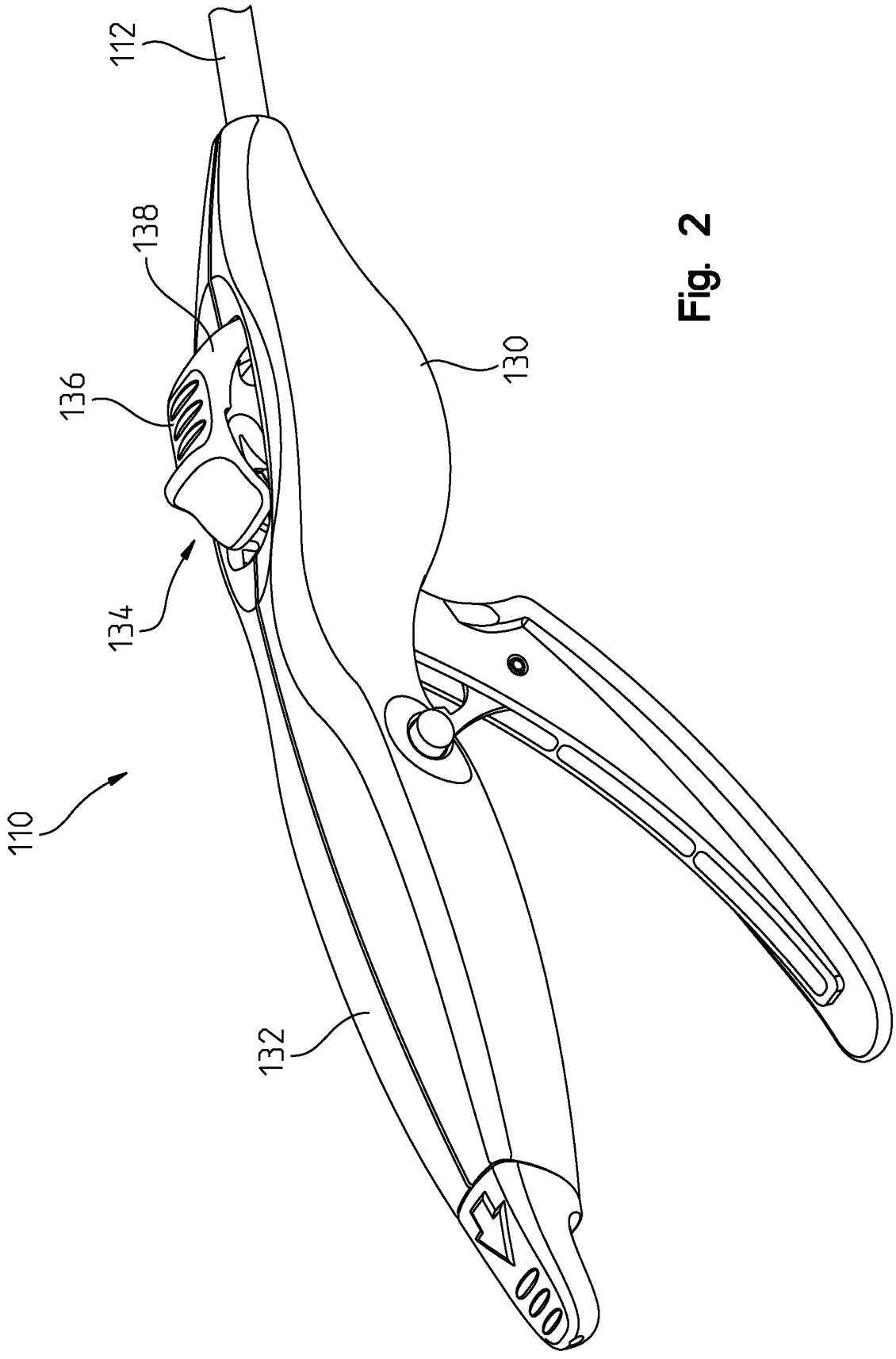


Fig. 2

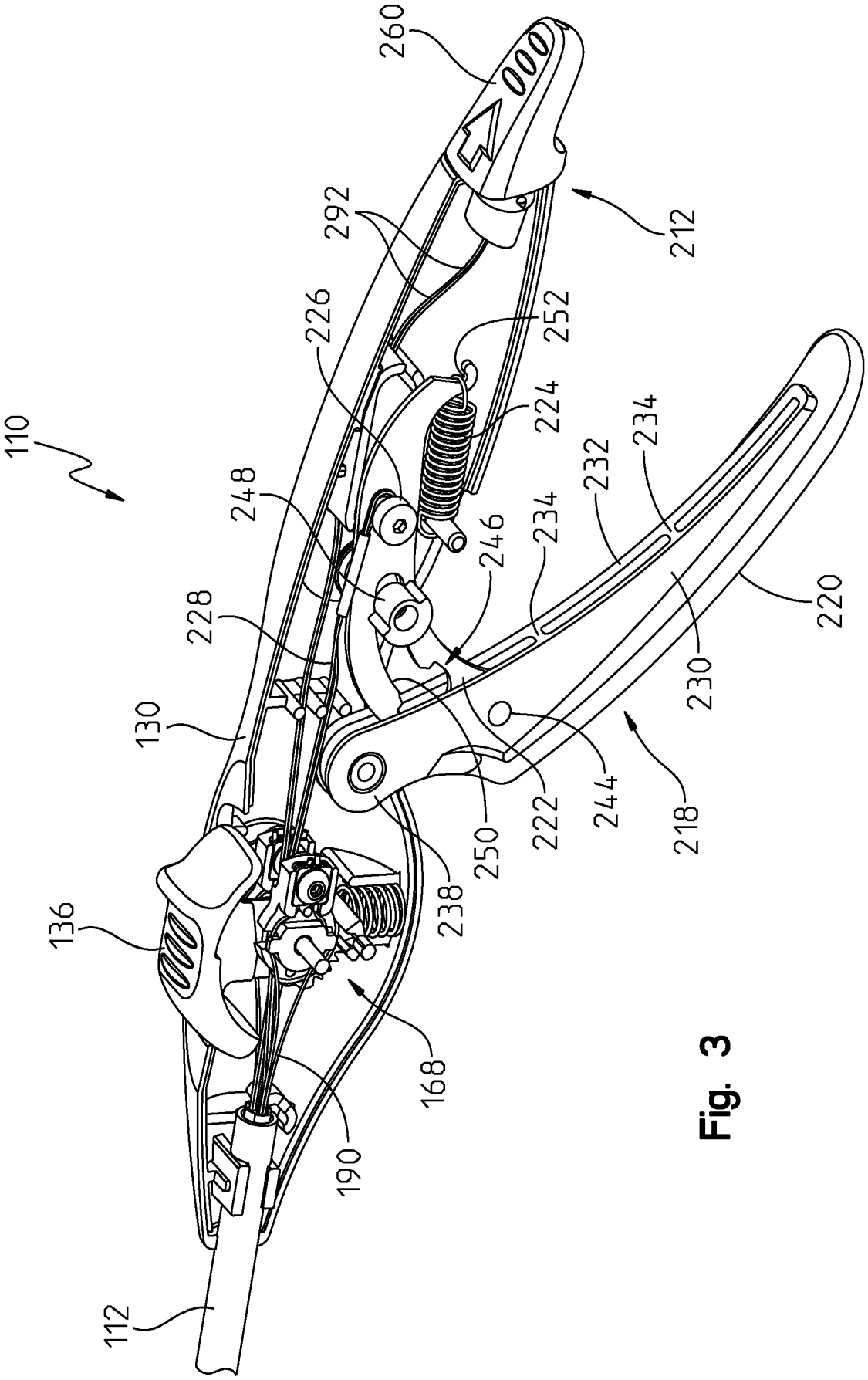

260
292
212
226
252
224
110
234
232
248
234
246
228
220
130
230
244
222
218
250
238
136
168
190
112

Fig. 3

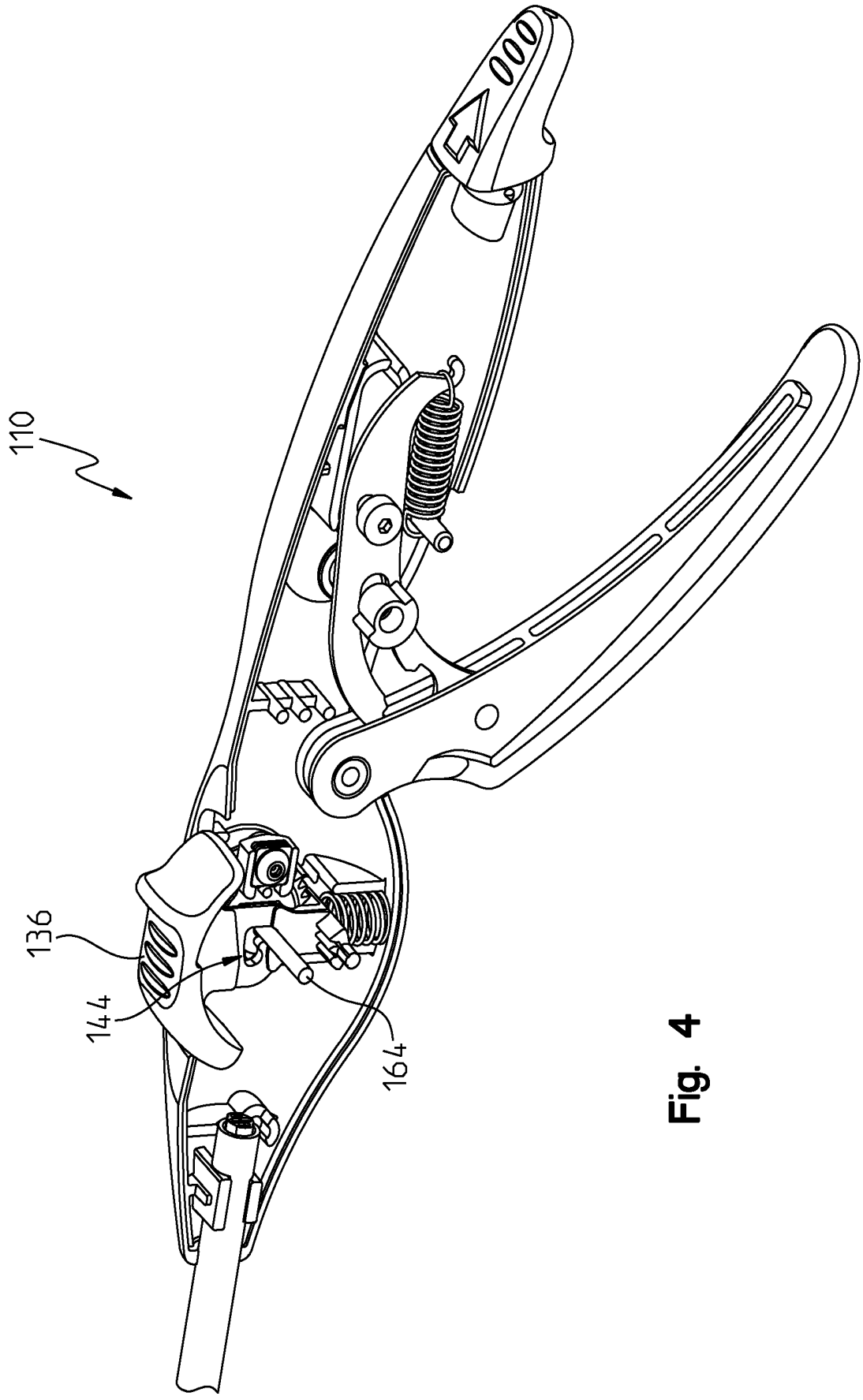


Fig. 4

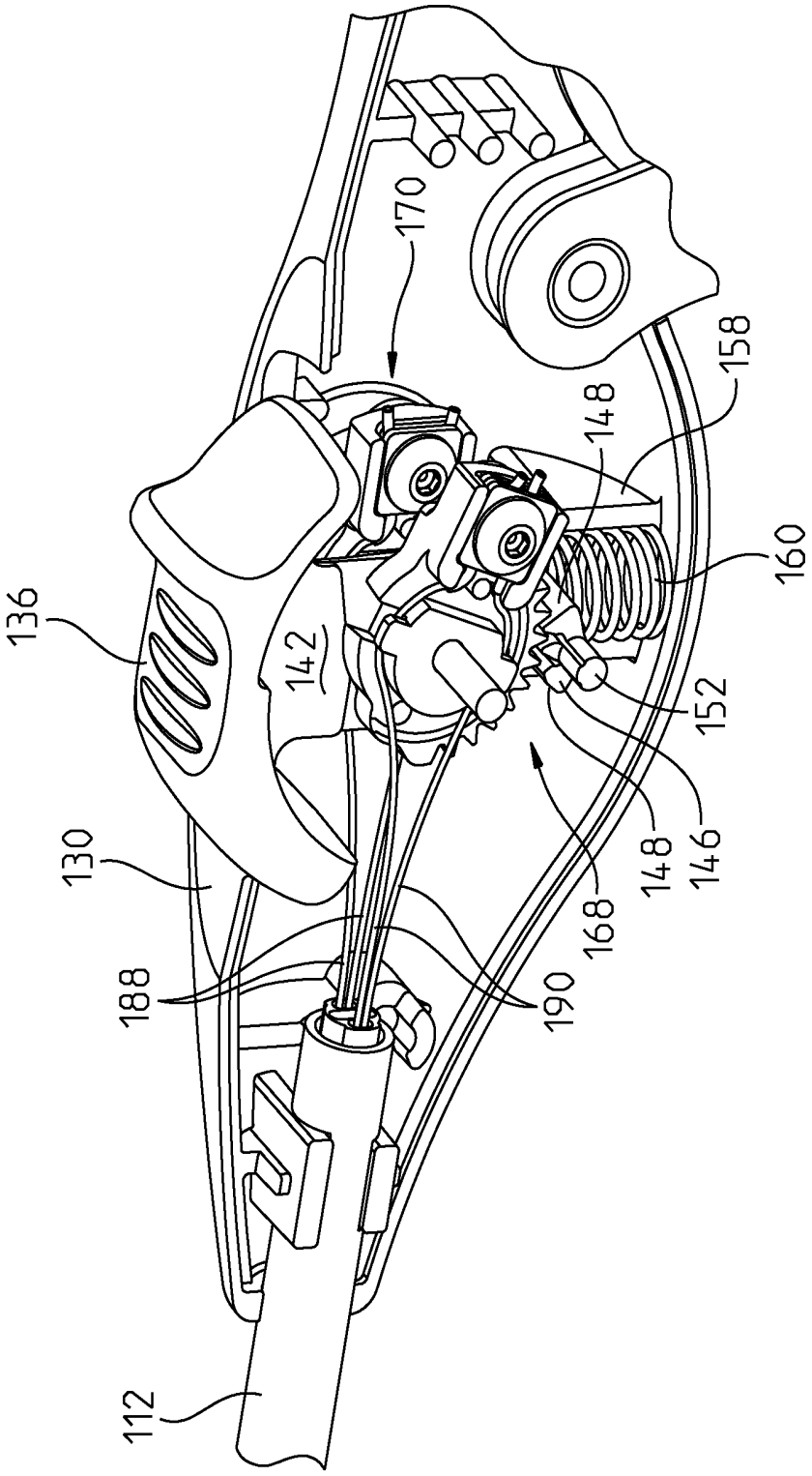


Fig. 5

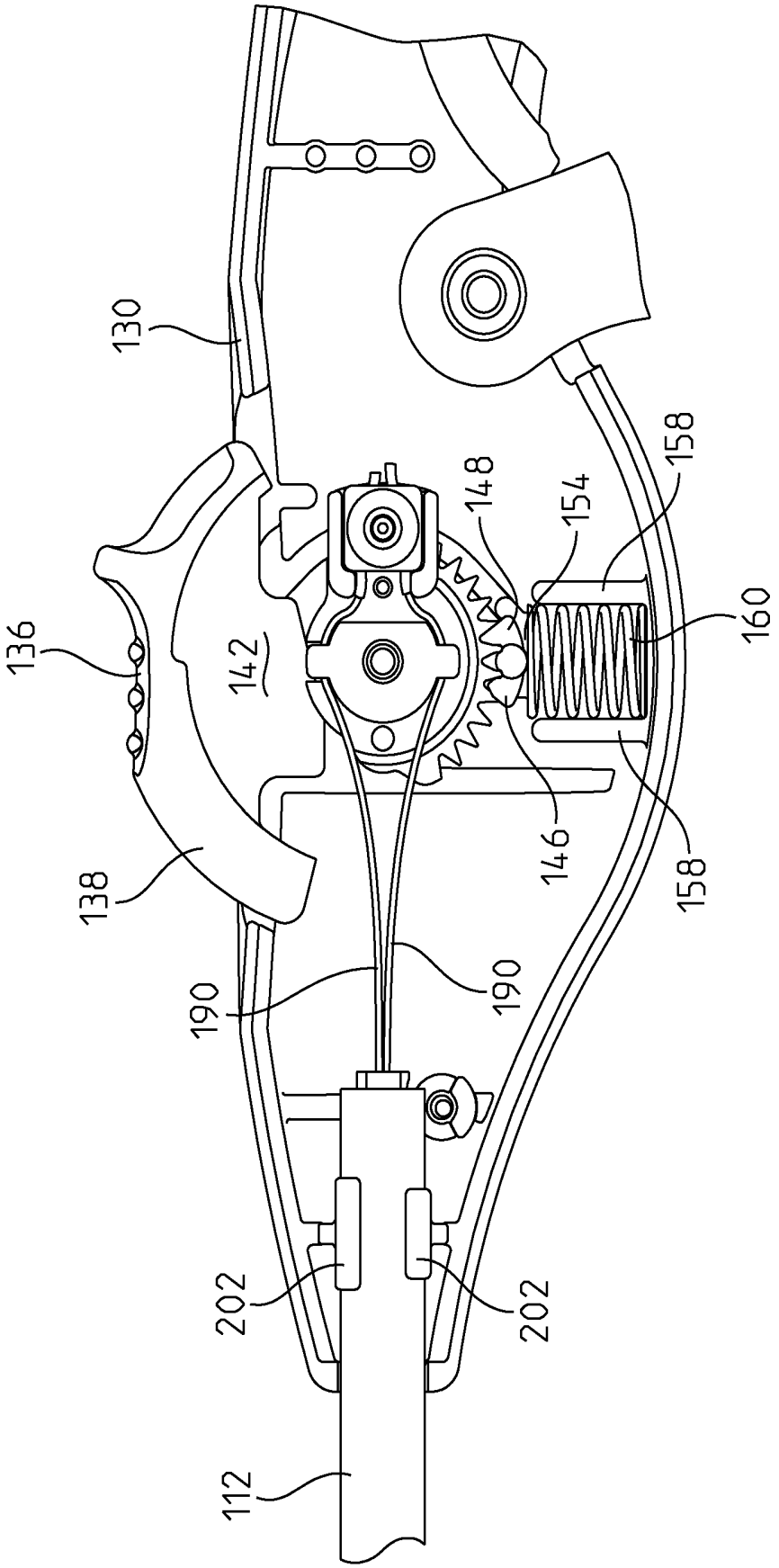


Fig. 6

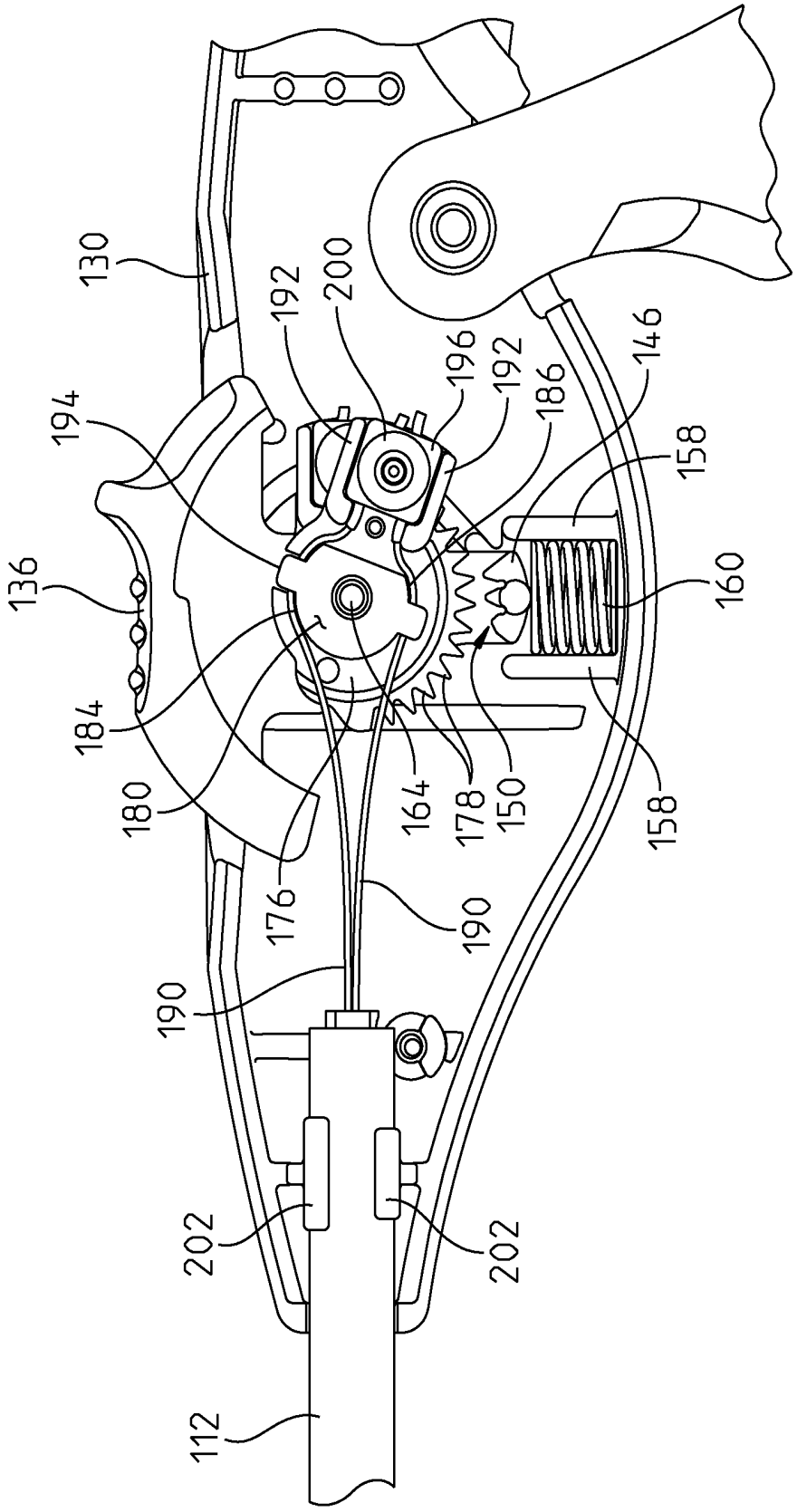

130
192
200
196
192
186
146
194
158
136
160
184
180
164
178
150
158
176
190
190
202
202
112

Fig. 7

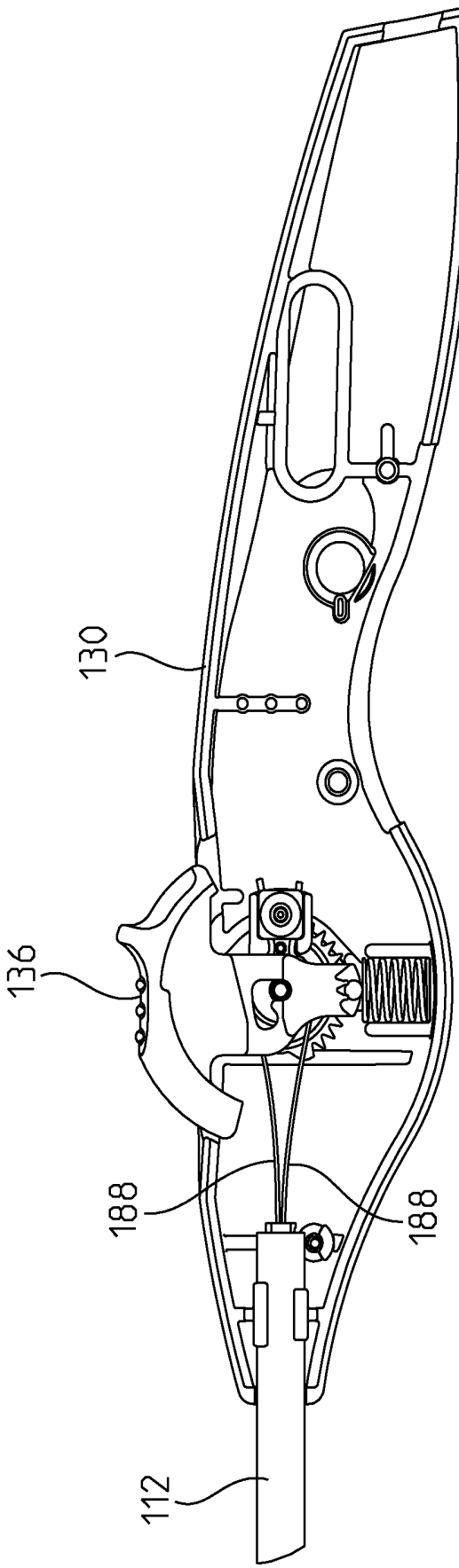


Fig. 8

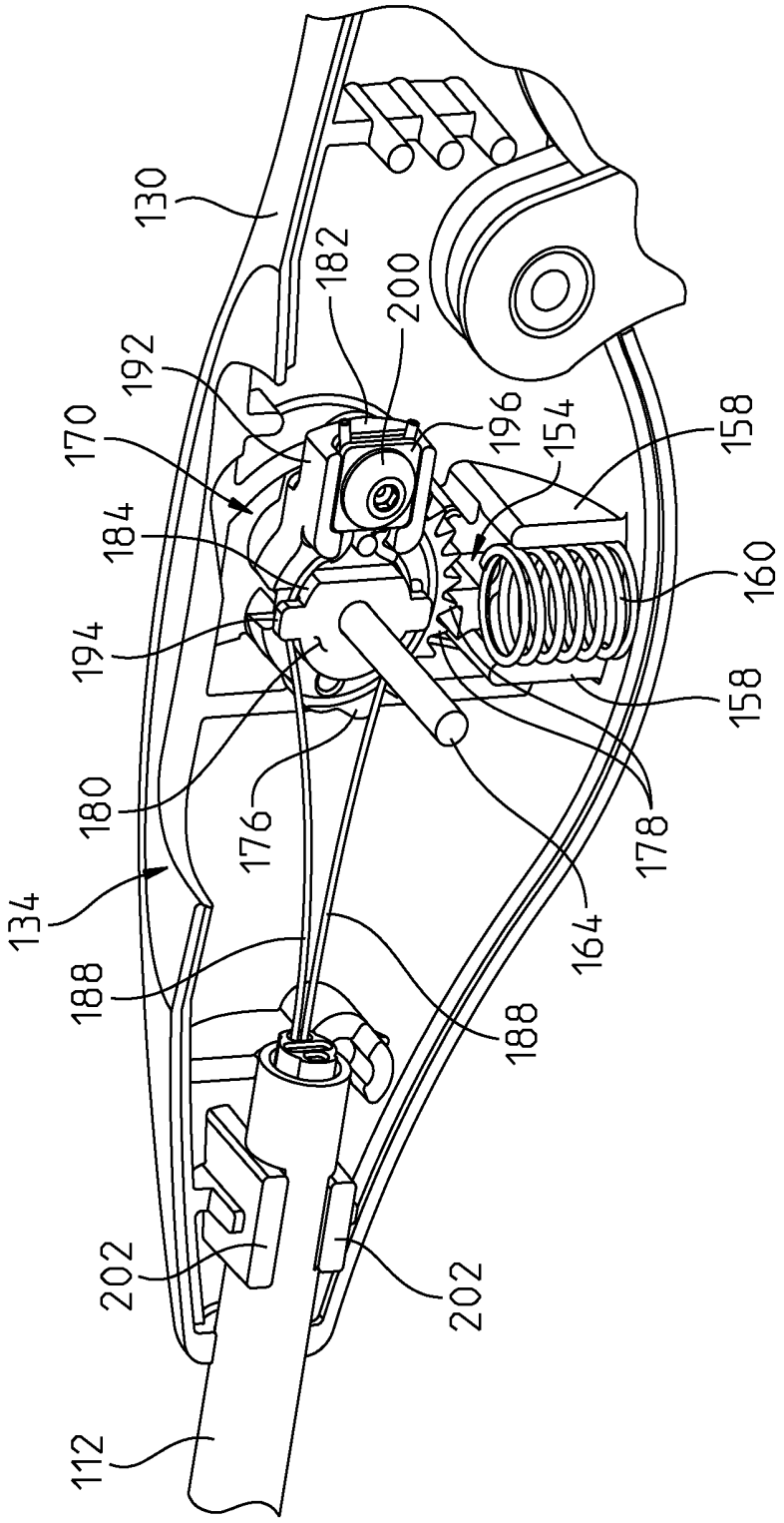

130
182
200
192
170
196
154
158
184
160
194
158
180
176
178
134
164
188
188
202
202
112

Fig. 9

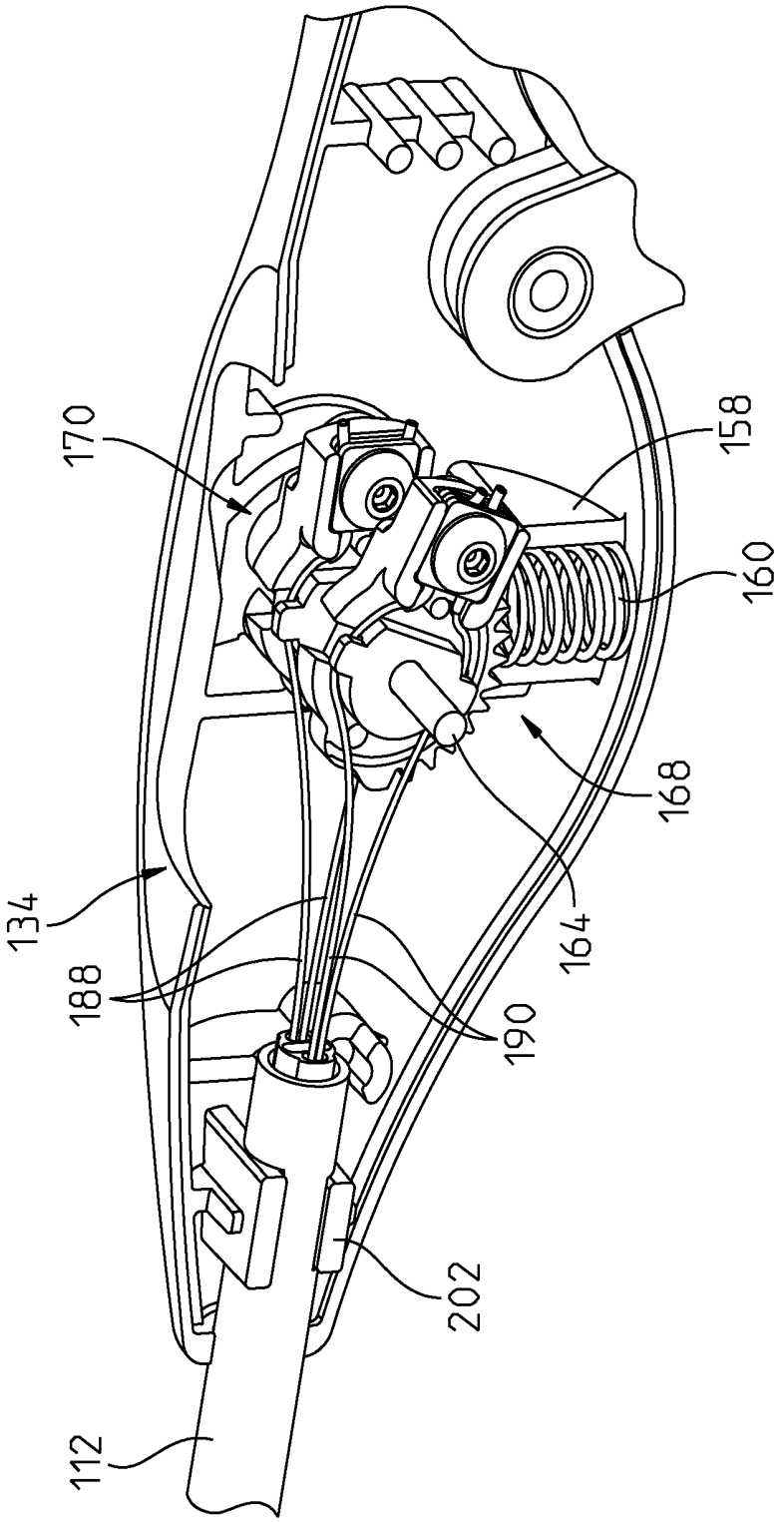
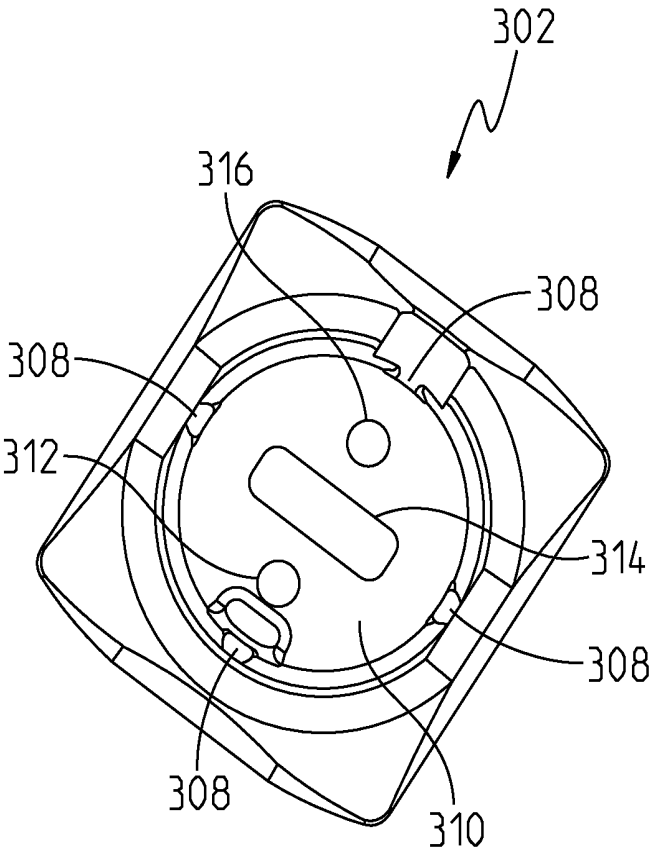


Fig. 10

Fig. 11



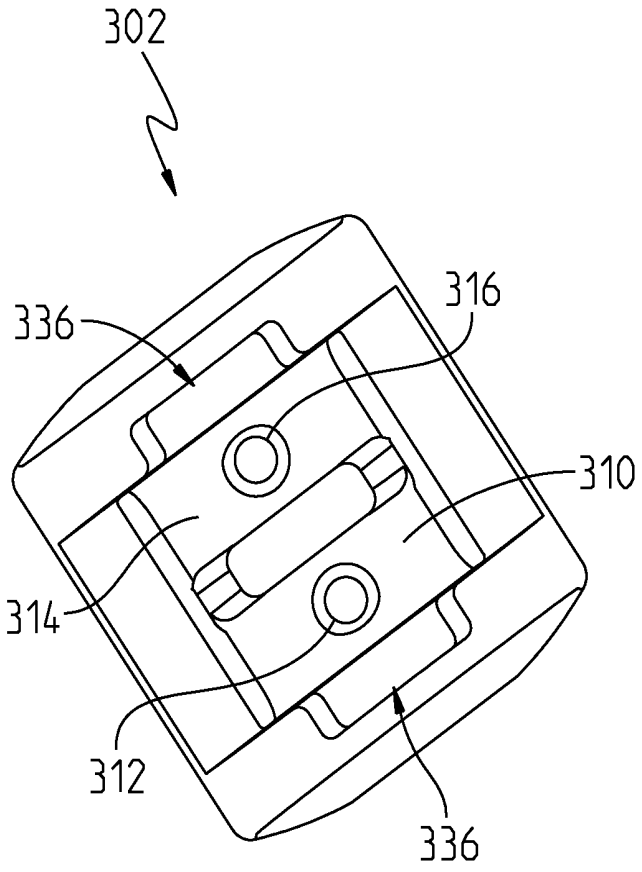


Fig. 12

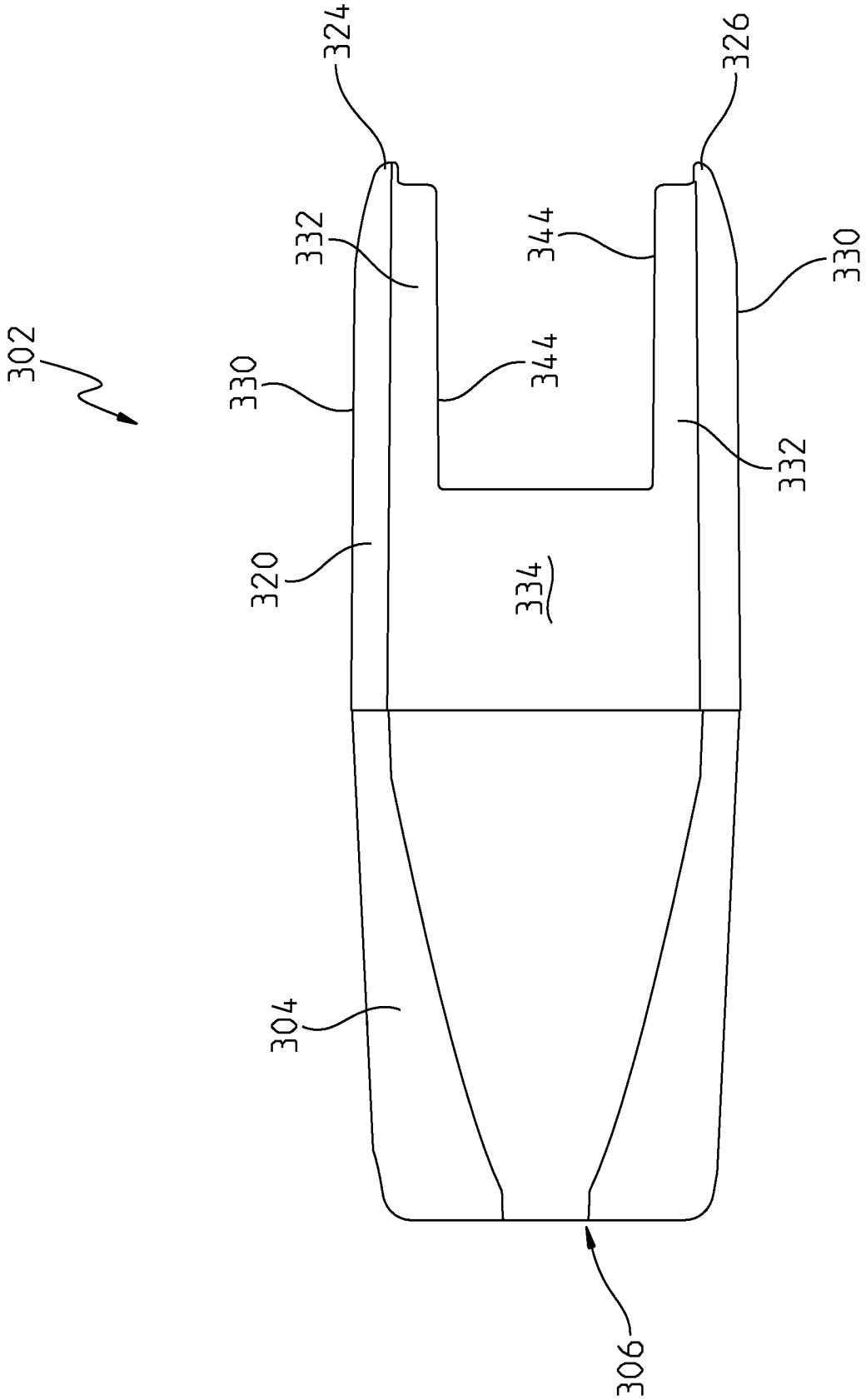


Fig. 13

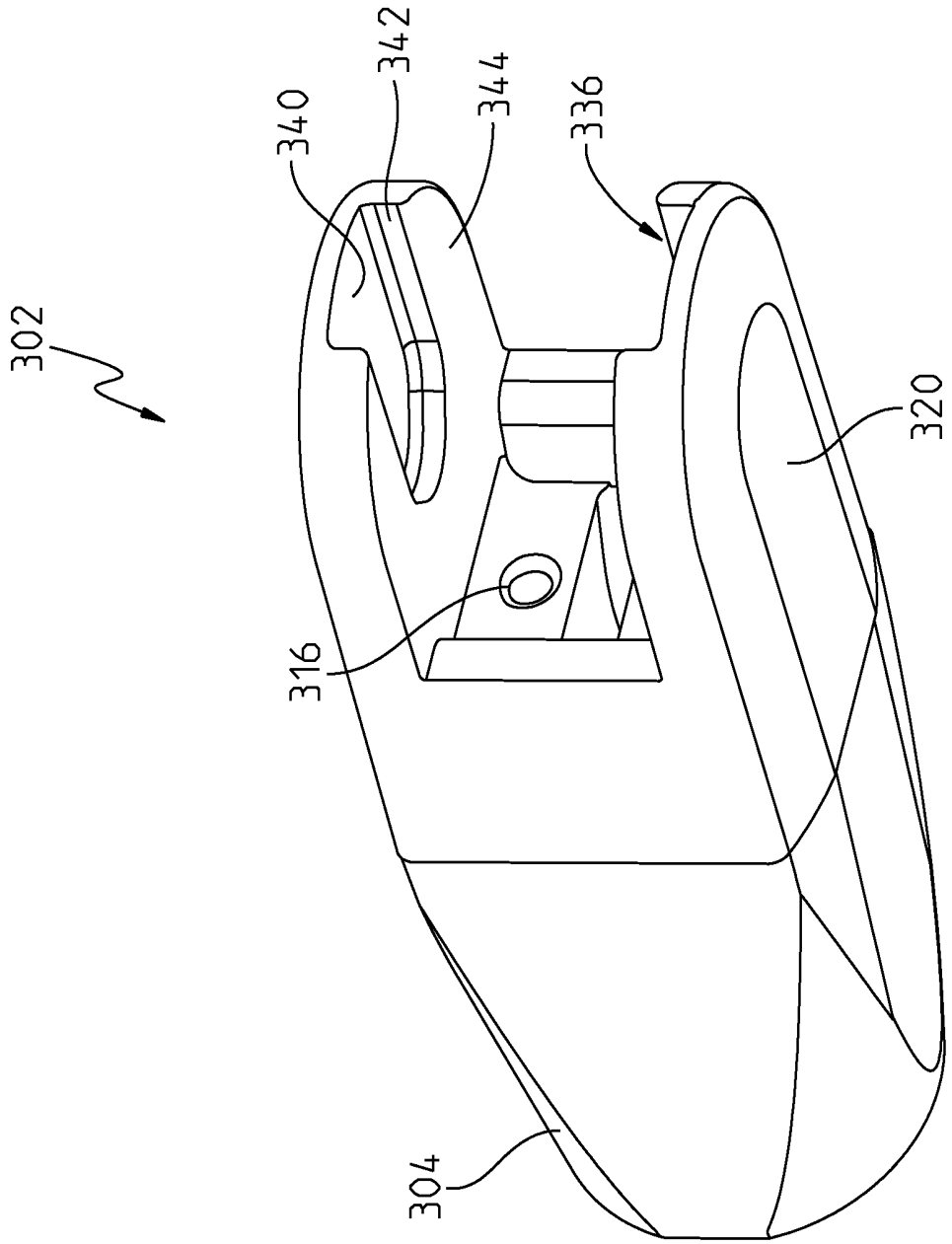


Fig. 14

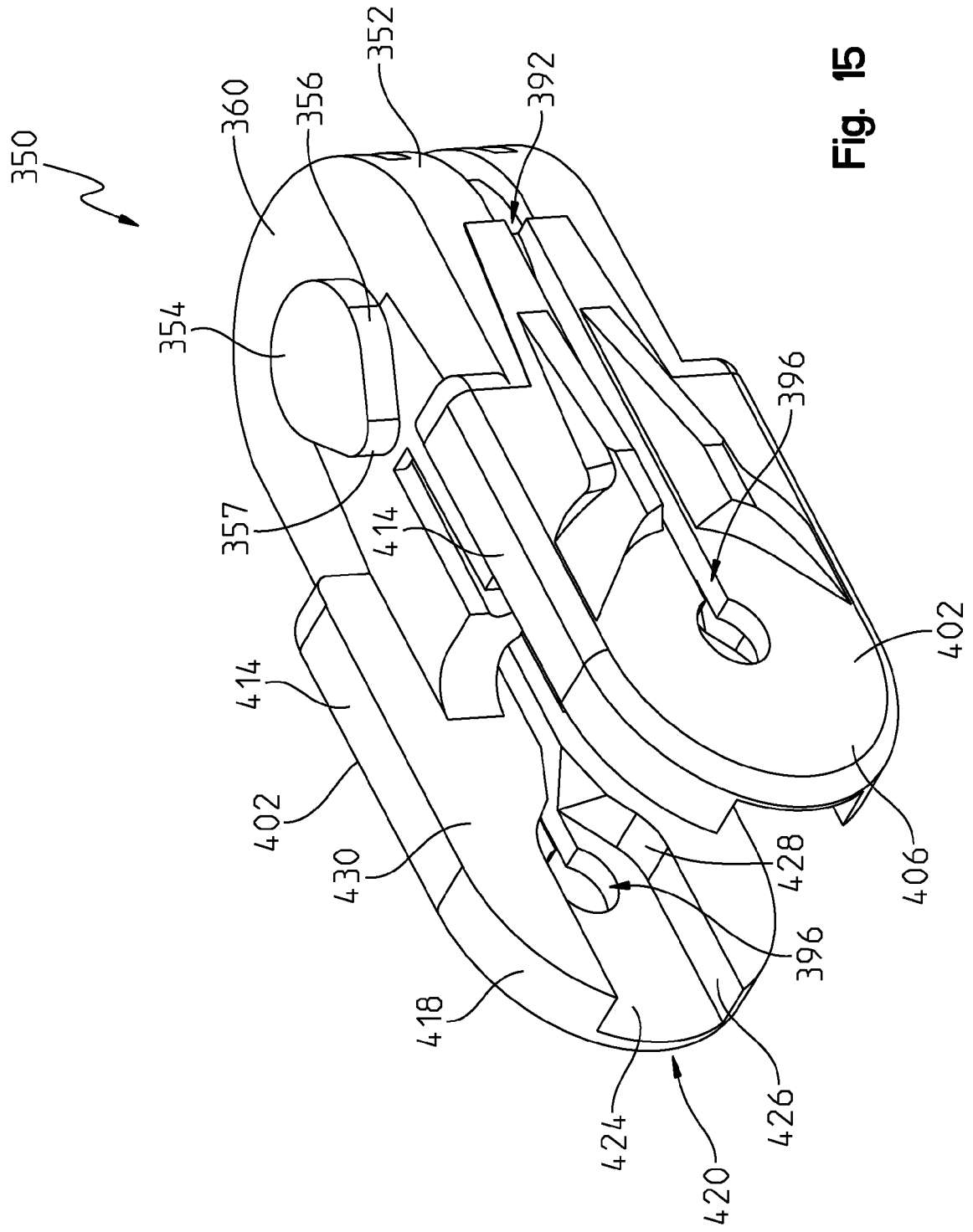

350
360
356
352
392
354
357
414
396
402
414
402
430
428
406
396
418
424
426
420

Fig. 15

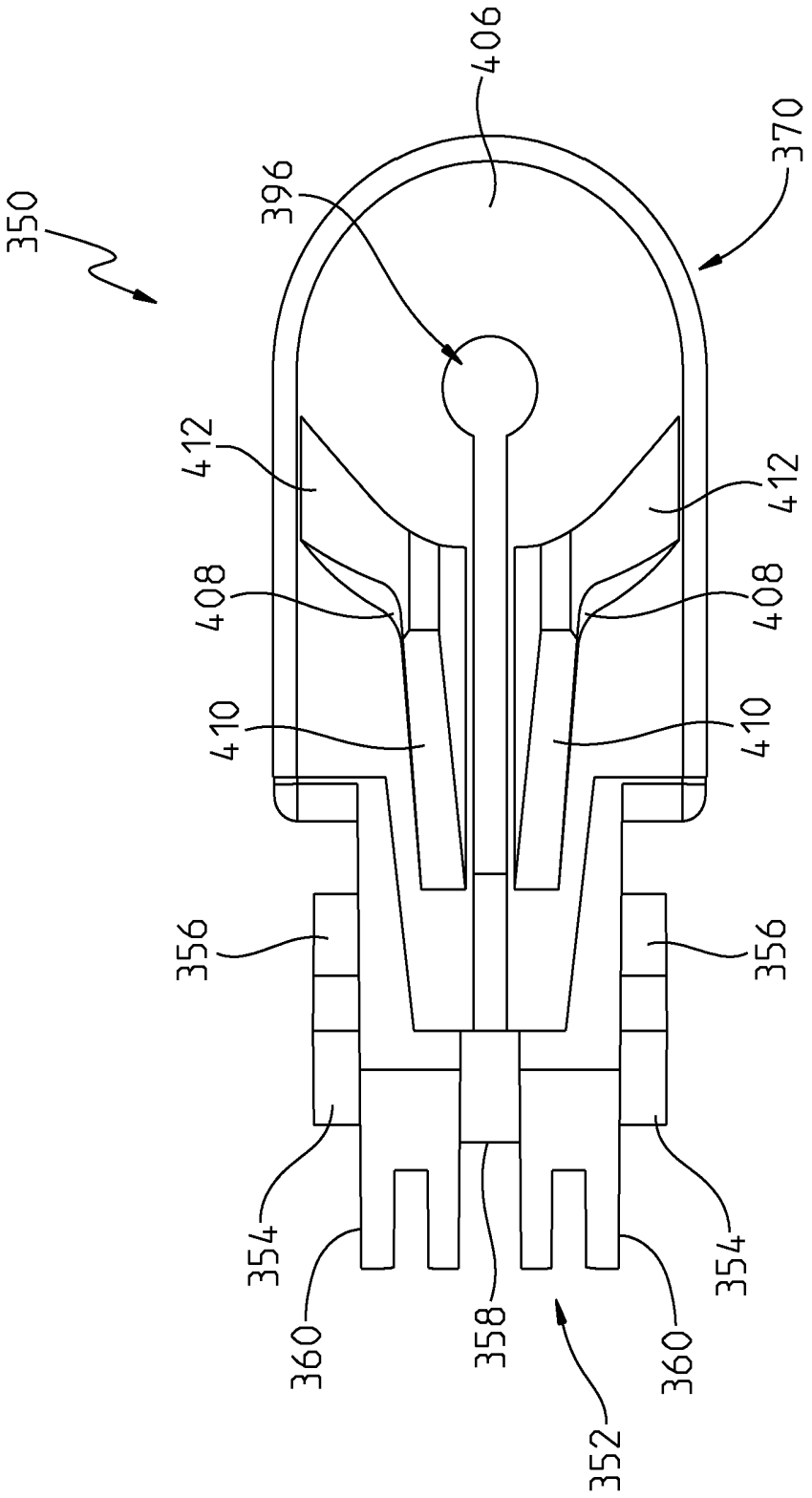

406
370
396
350
412
412
408
408
410
410
356
356
354
354
360
358
360
352

Fig. 16

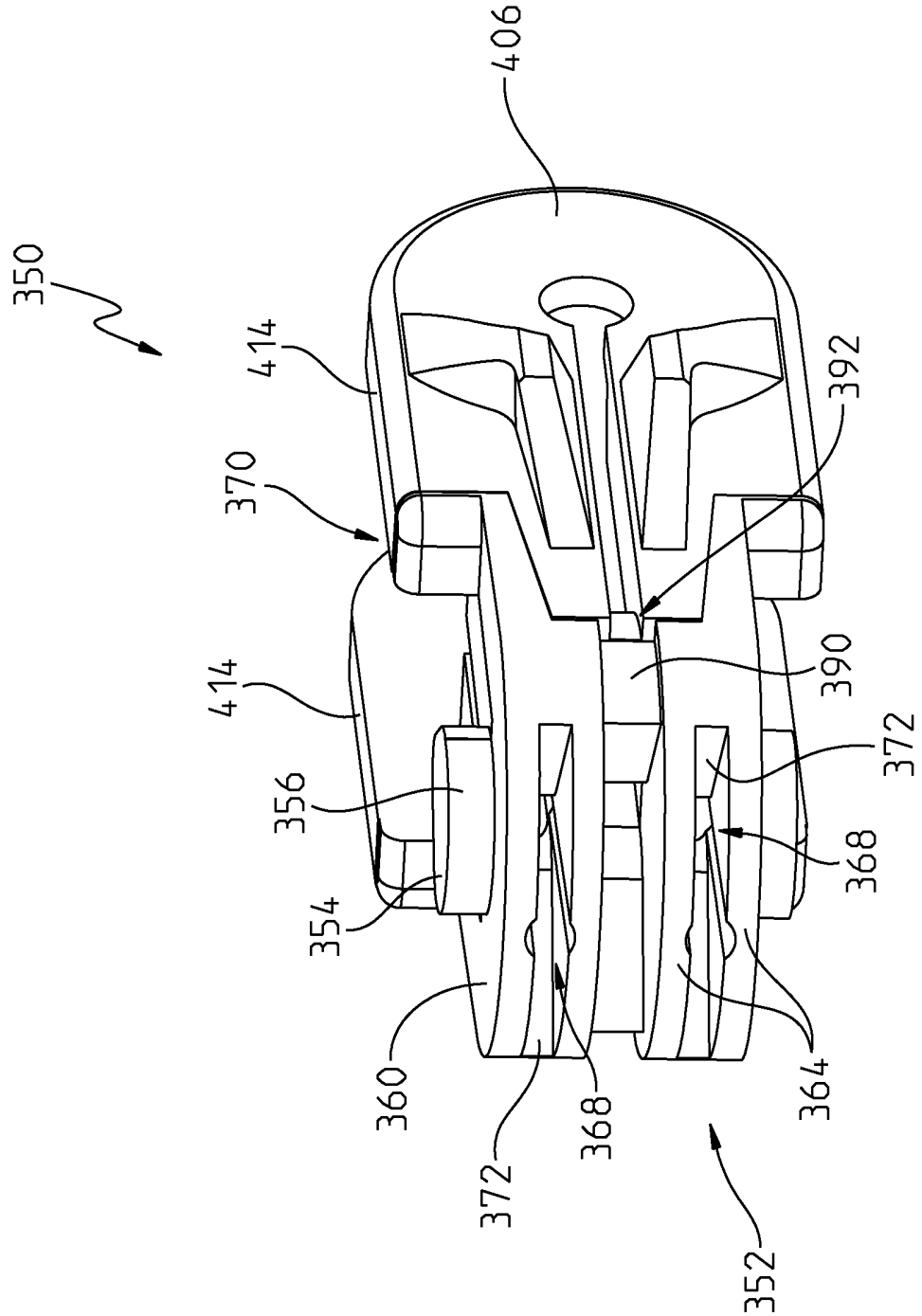


Fig. 17

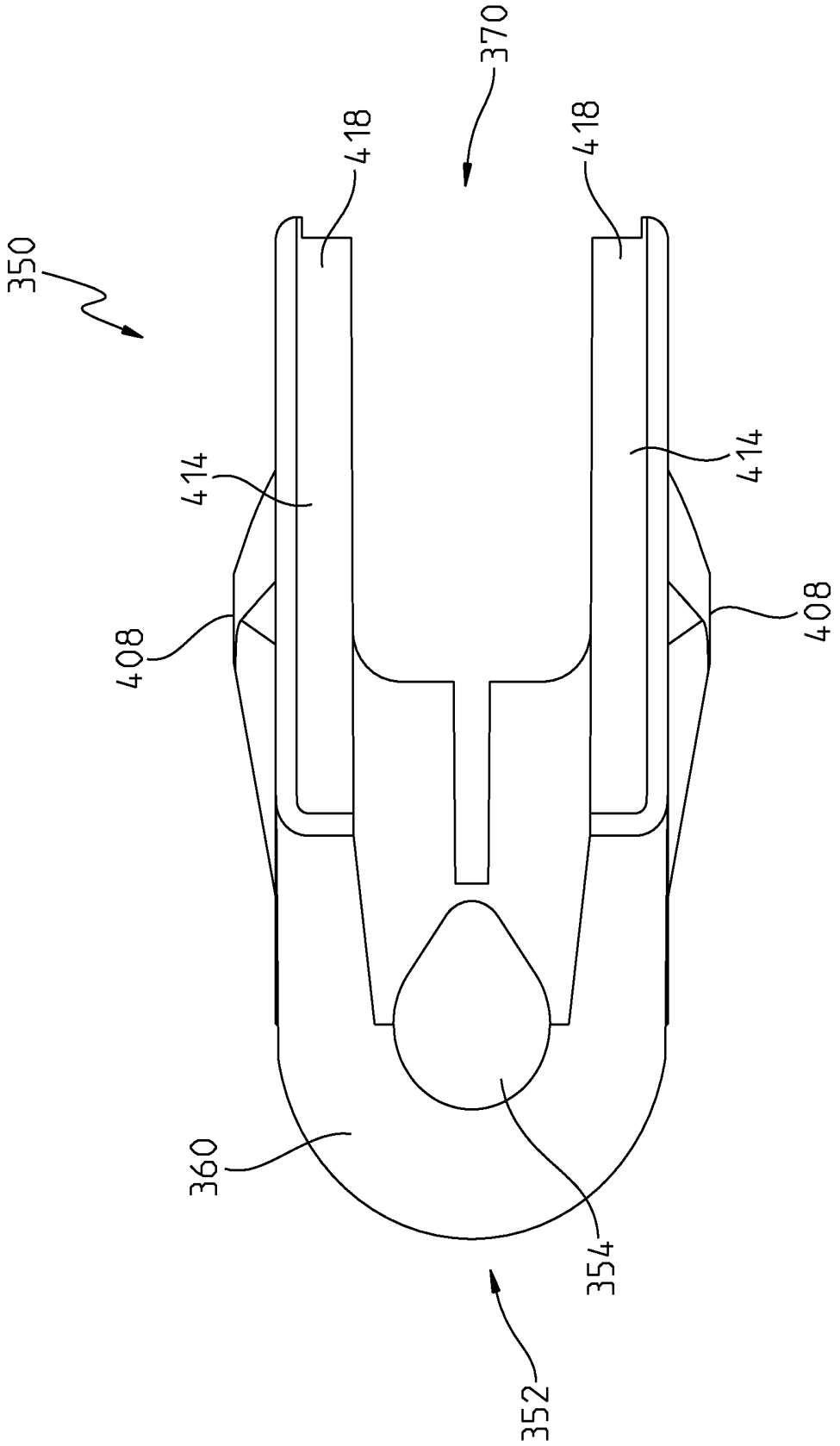
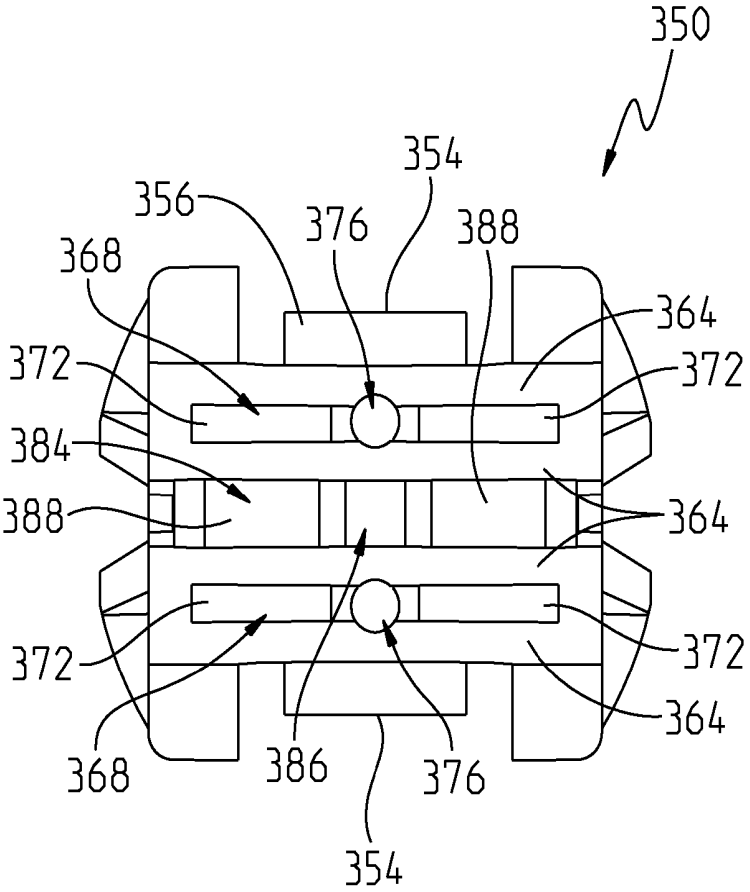


Fig. 18

Fig. 19


350
354
356
376
388
368
364
372
372
384
388
364
372
372
364
368
386
376
354

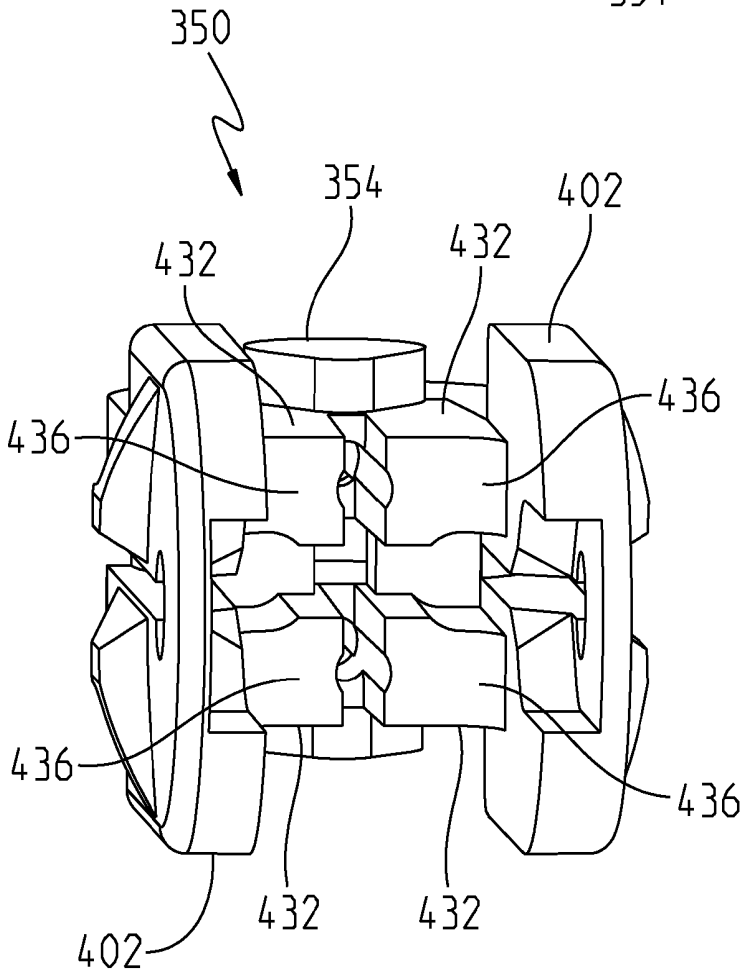

350
354
402
432
432
436
436
436
436
402
432
432

Fig. 20

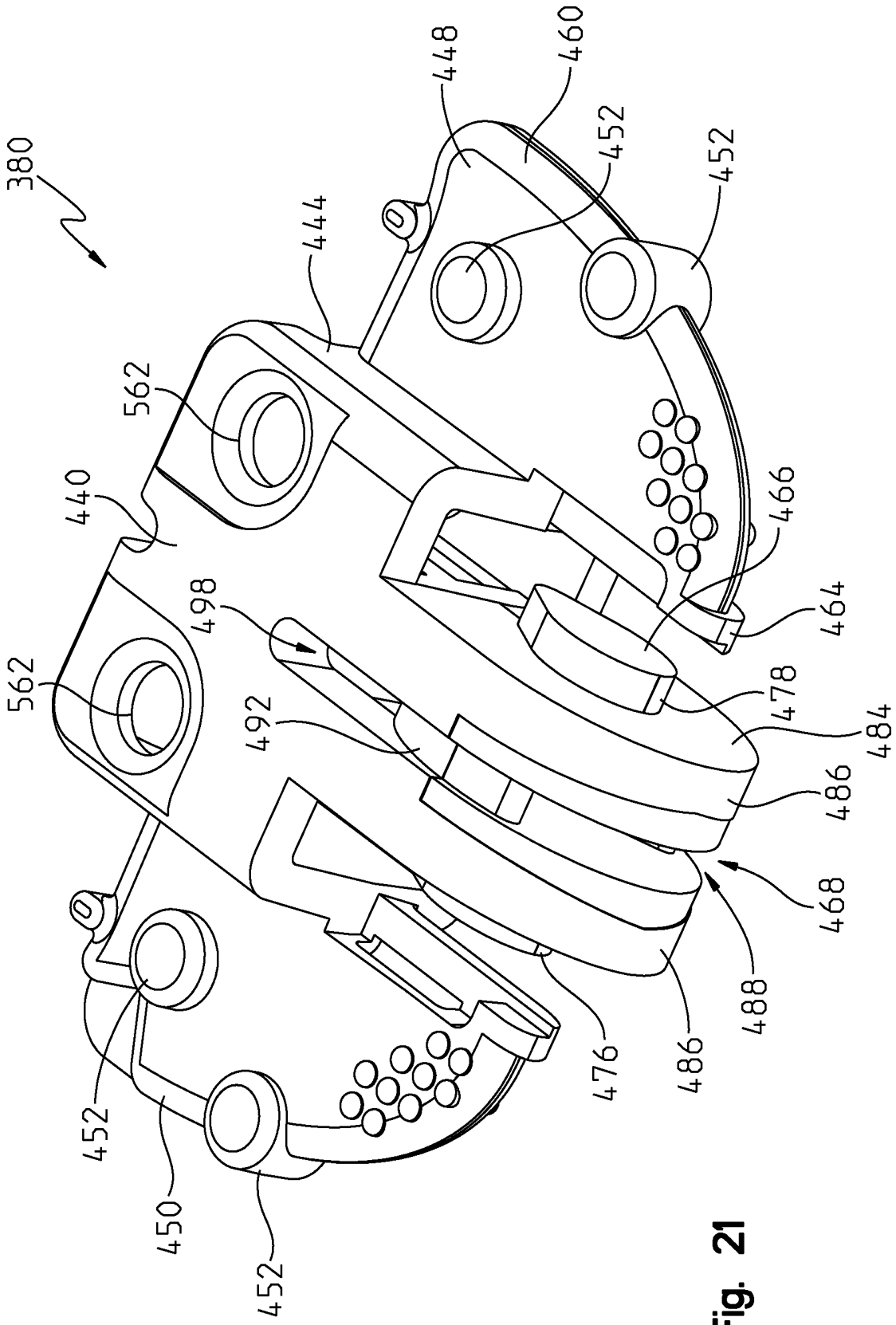

380
448
460
452
452
444
562
440
466
498
464
562
478
492
484
486
468
488
476
486
452
450
452

Fig. 21

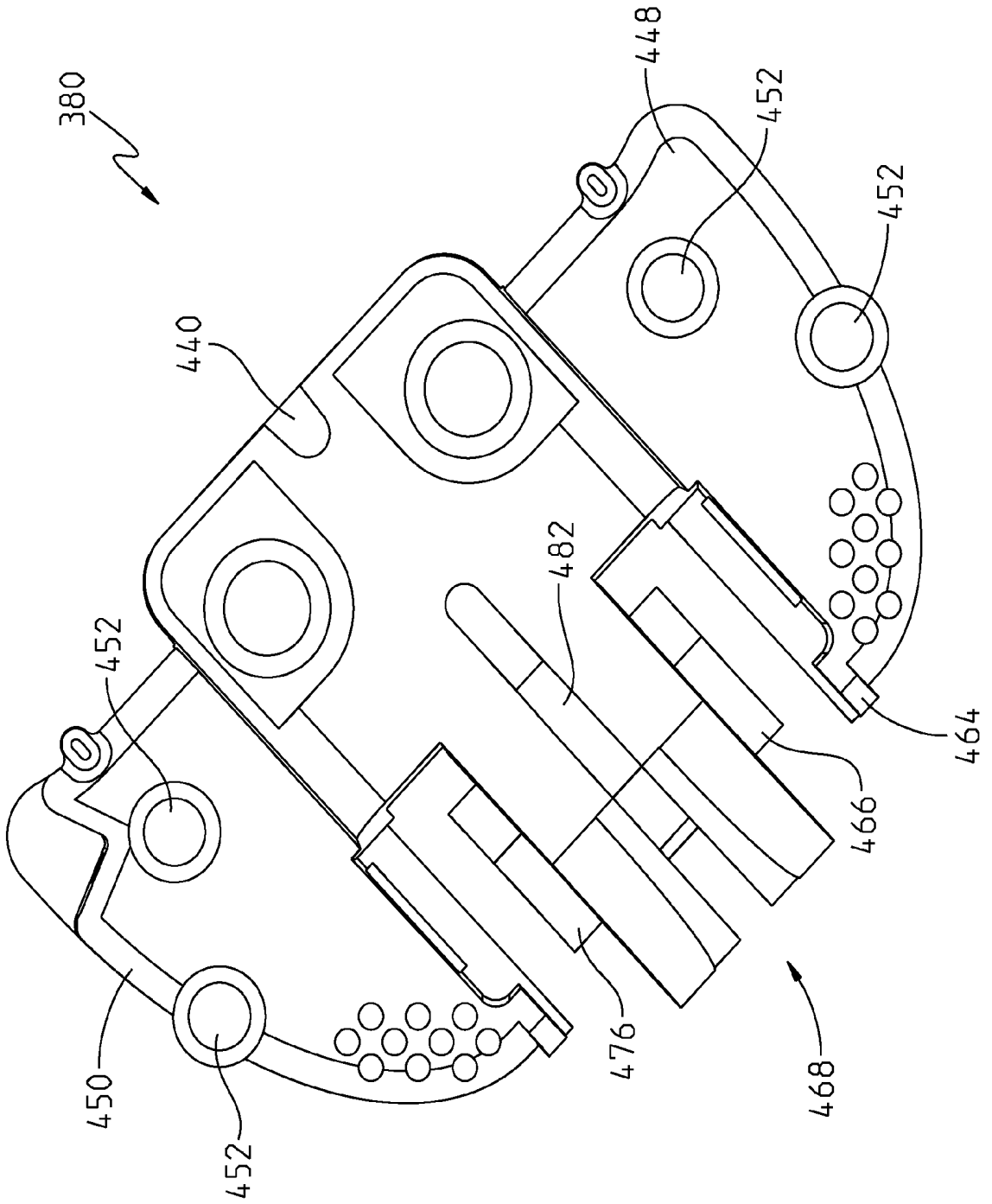


Fig. 22

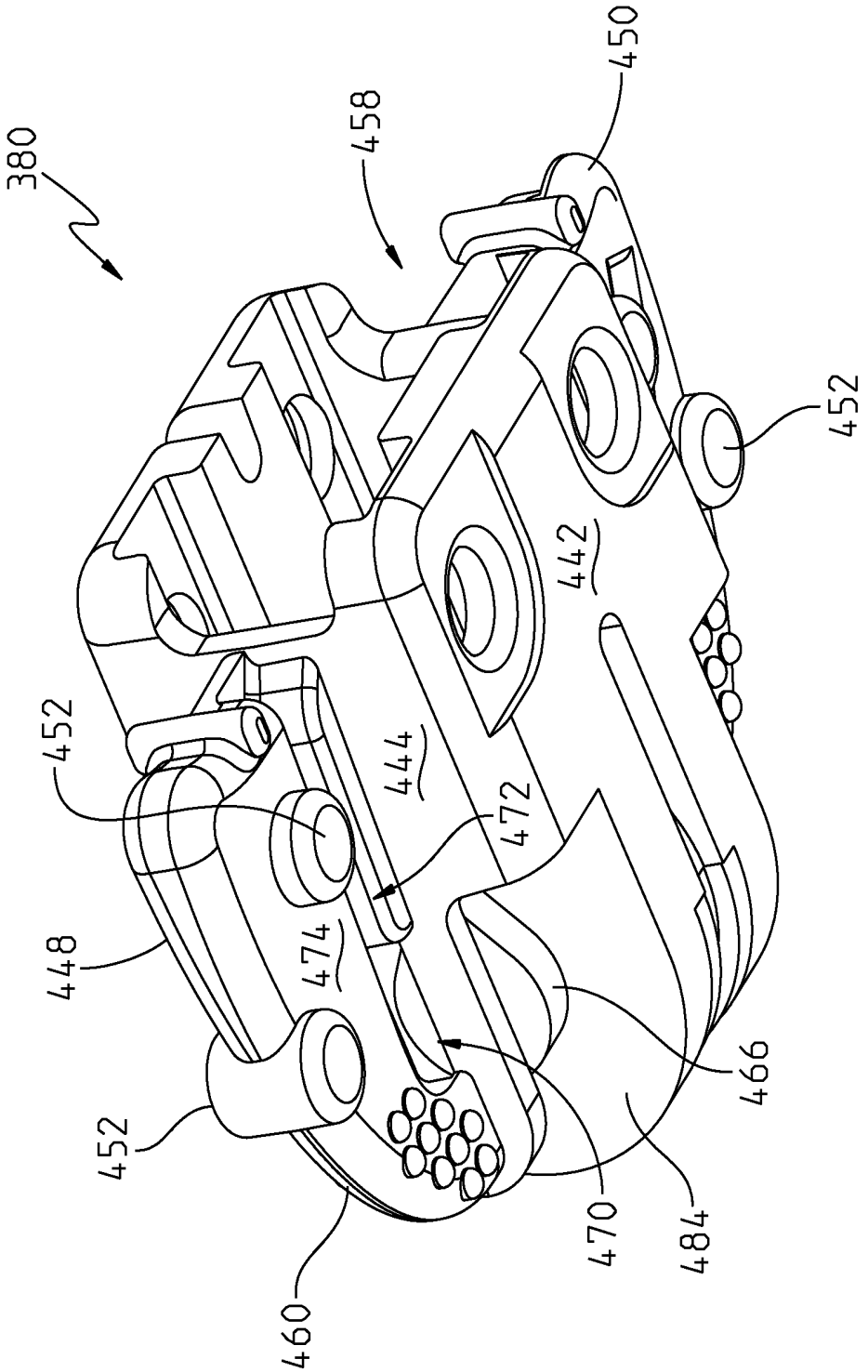


Fig. 23

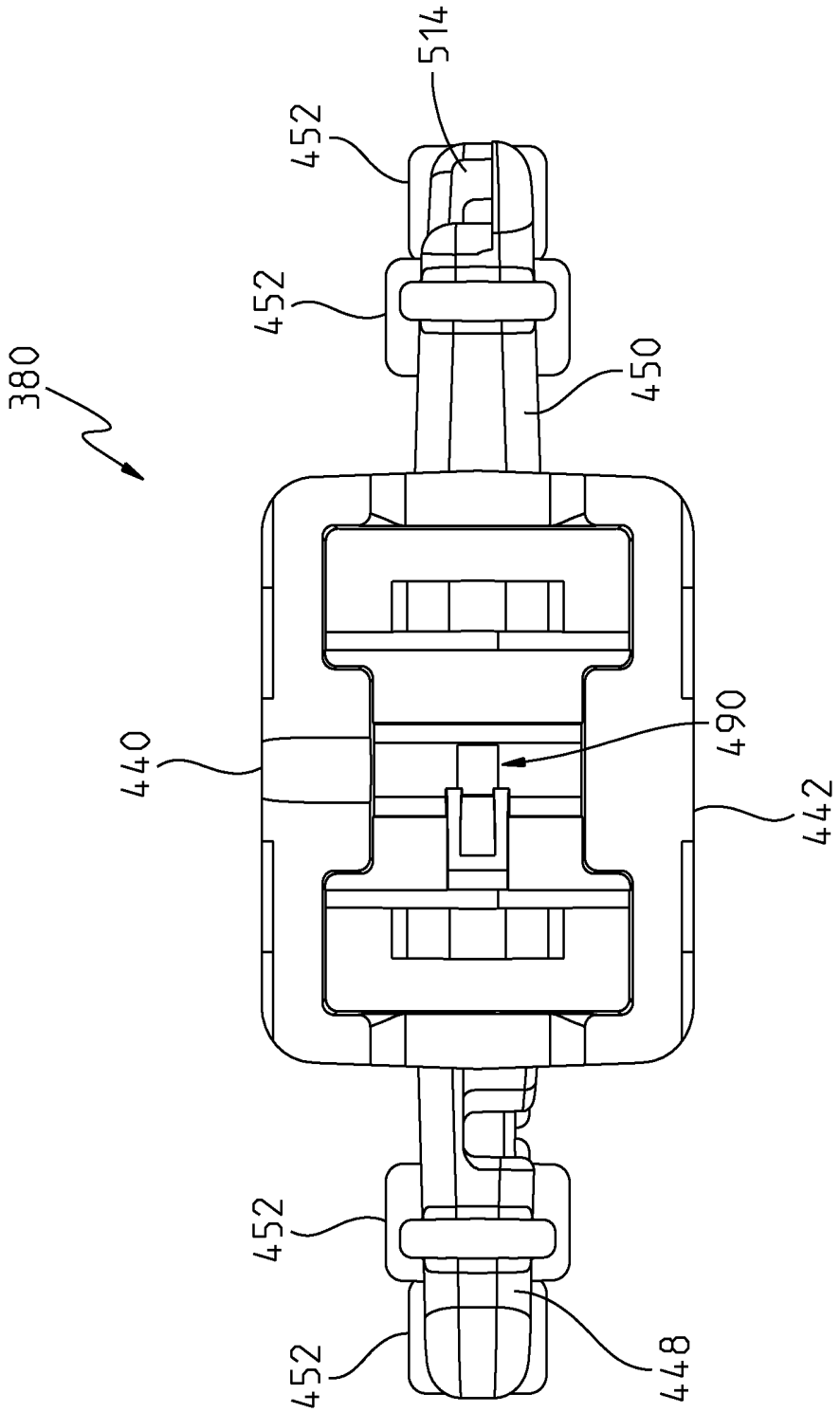


Fig. 24

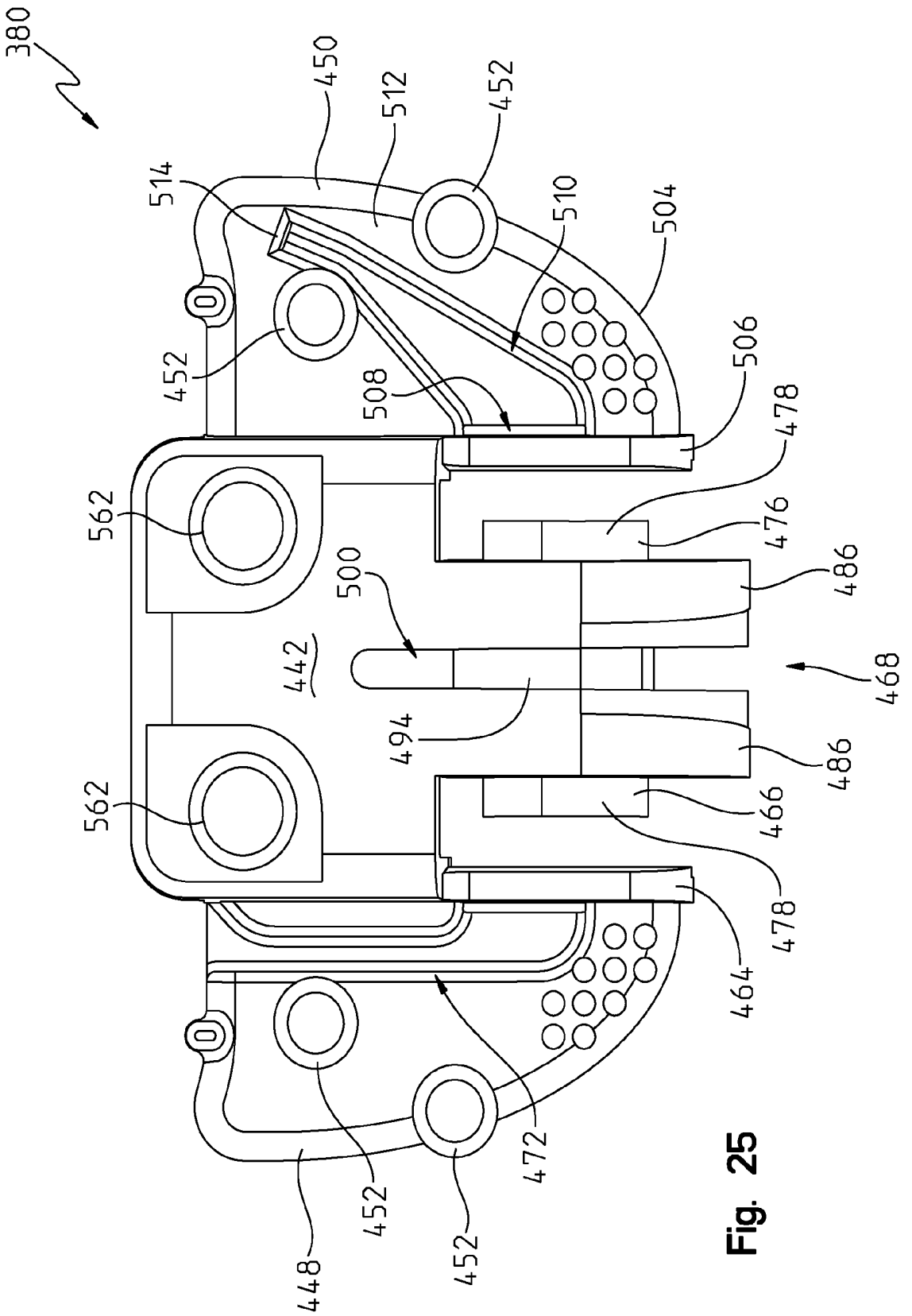

380
450
512
452
514
510
504
452
508
506
478
562
476
500
486
442
468
494
562
486
466
478
464
472
452
452
448

Fig. 25

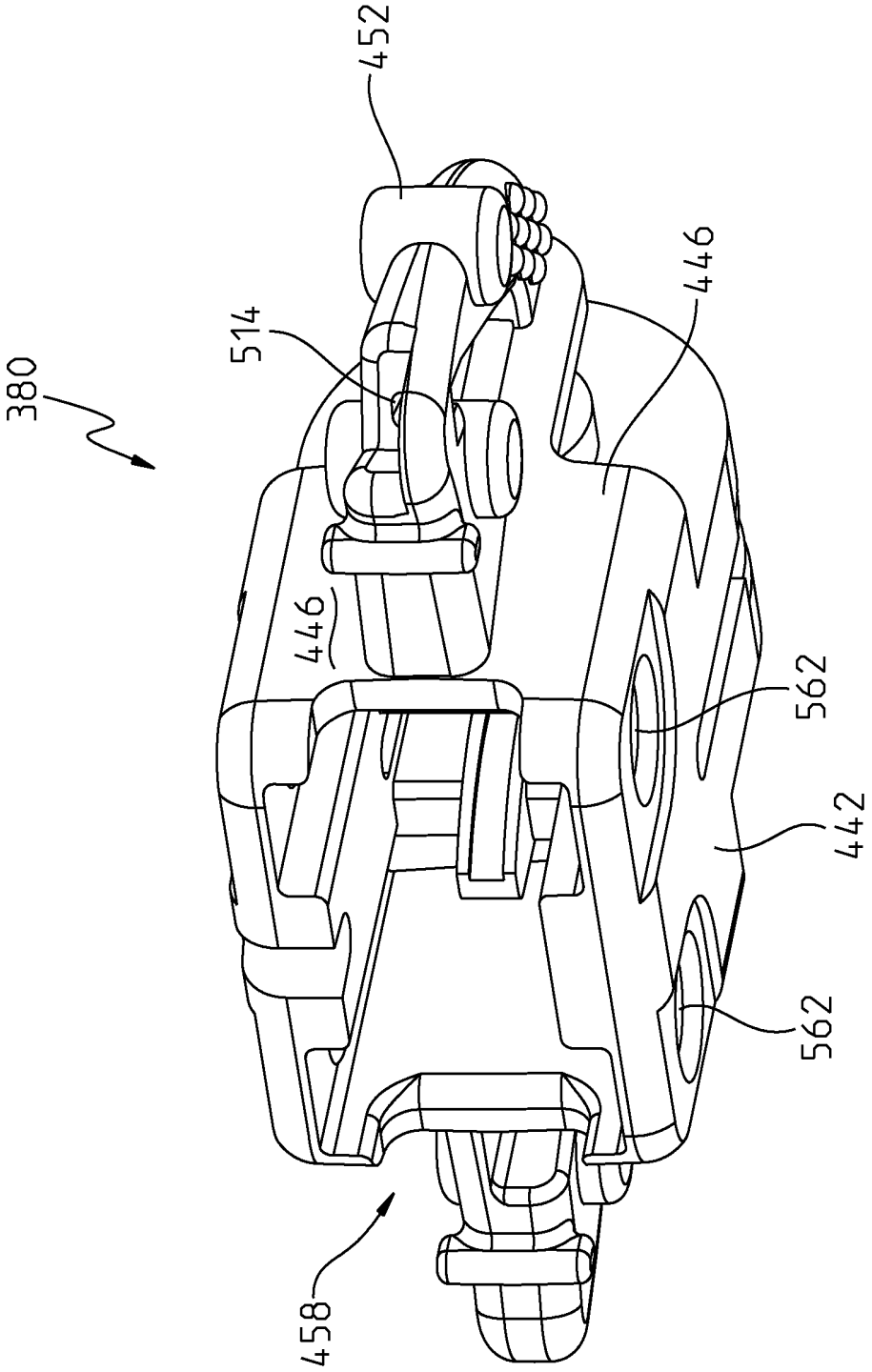


Fig. 26

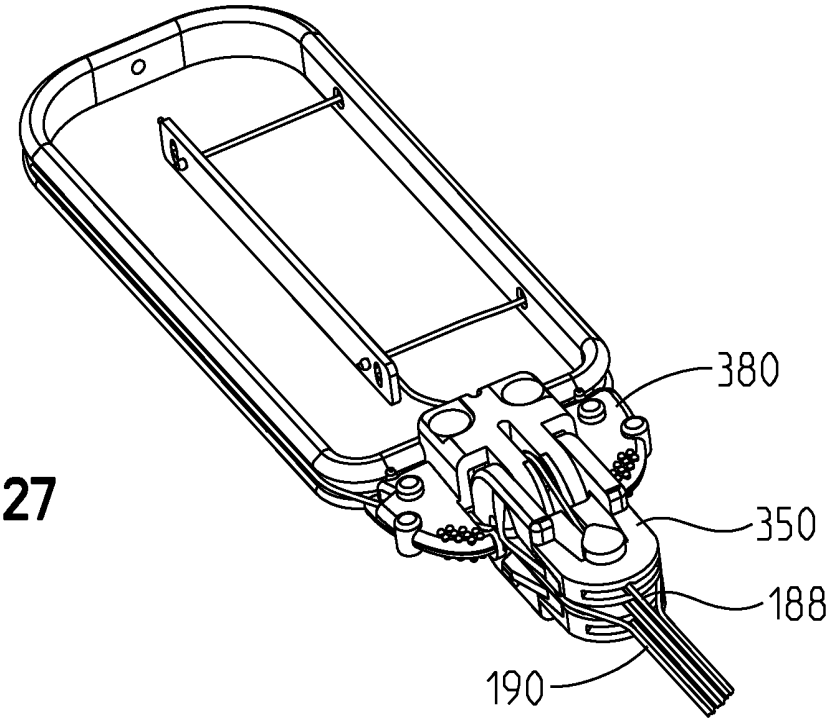


Fig. 27

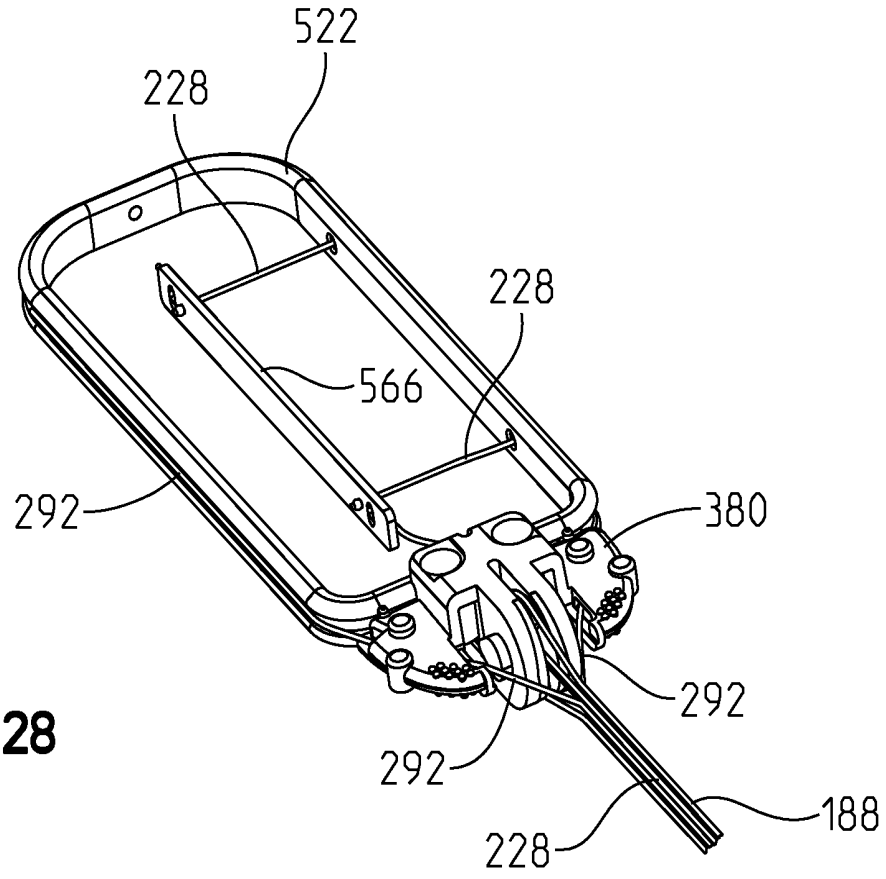


Fig. 28

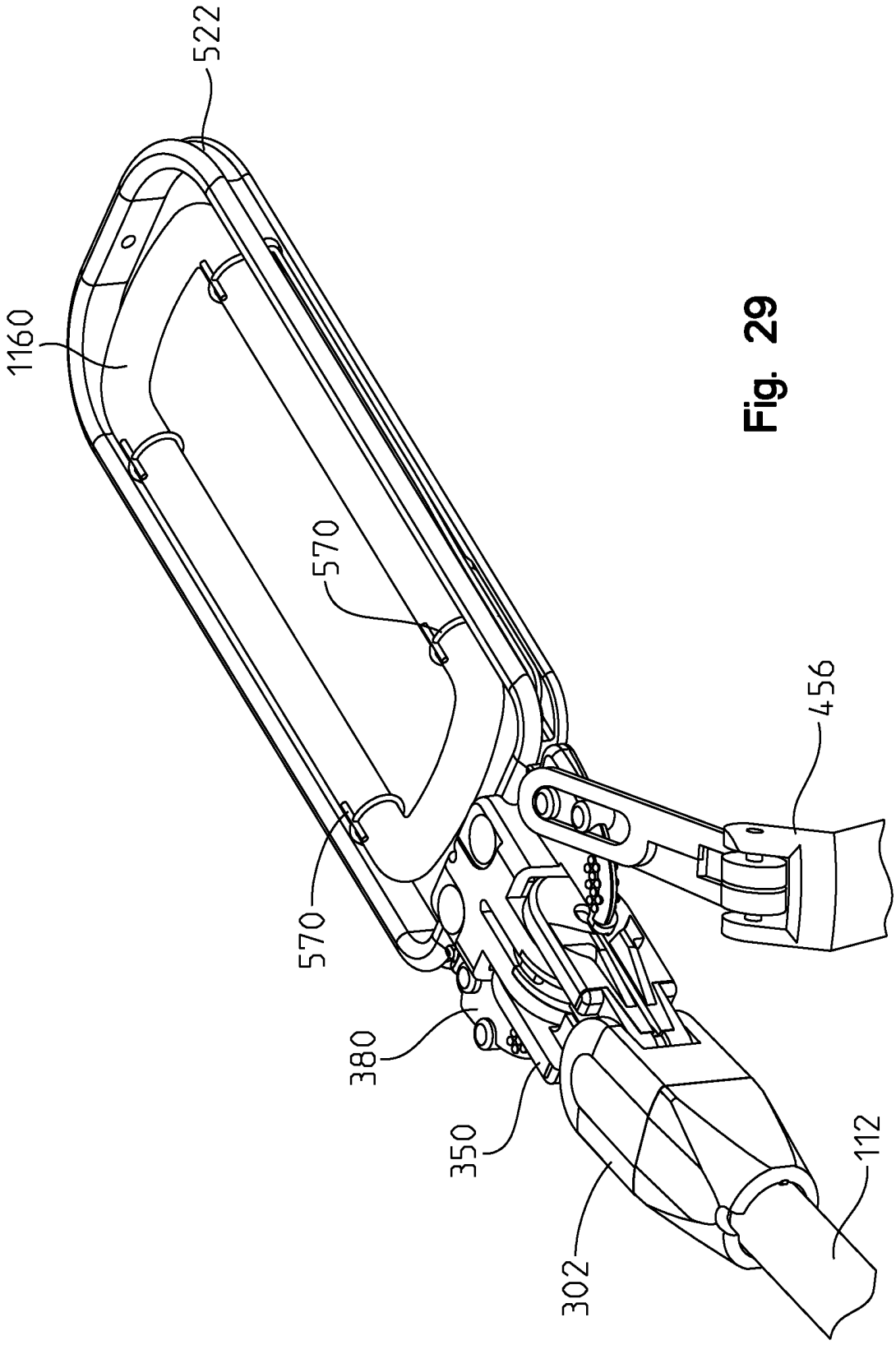


Fig. 29

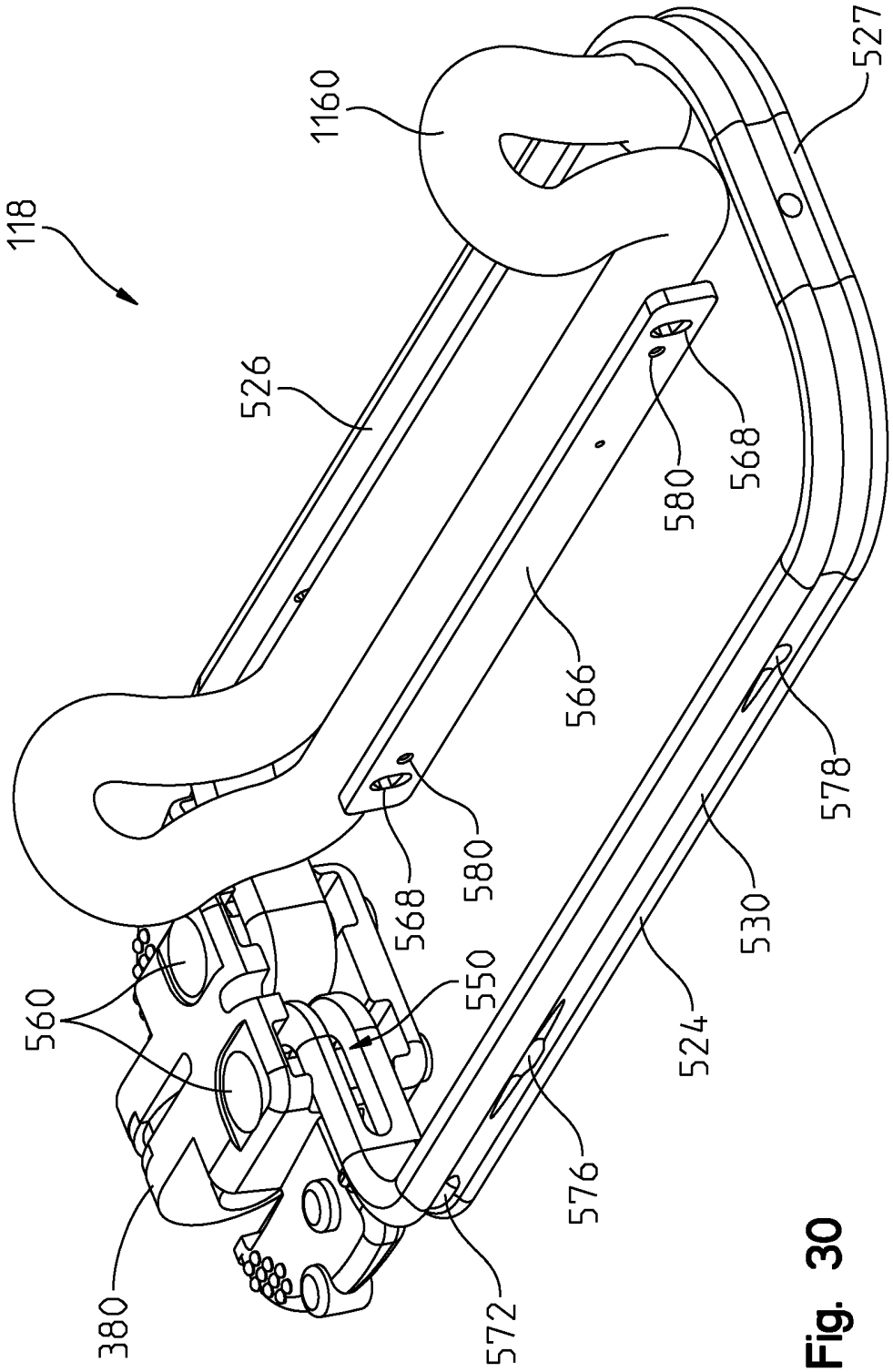

118
1160
527
526
580
568
566
578
580
568
530
550
560
524
576
572
380

Fig. 30

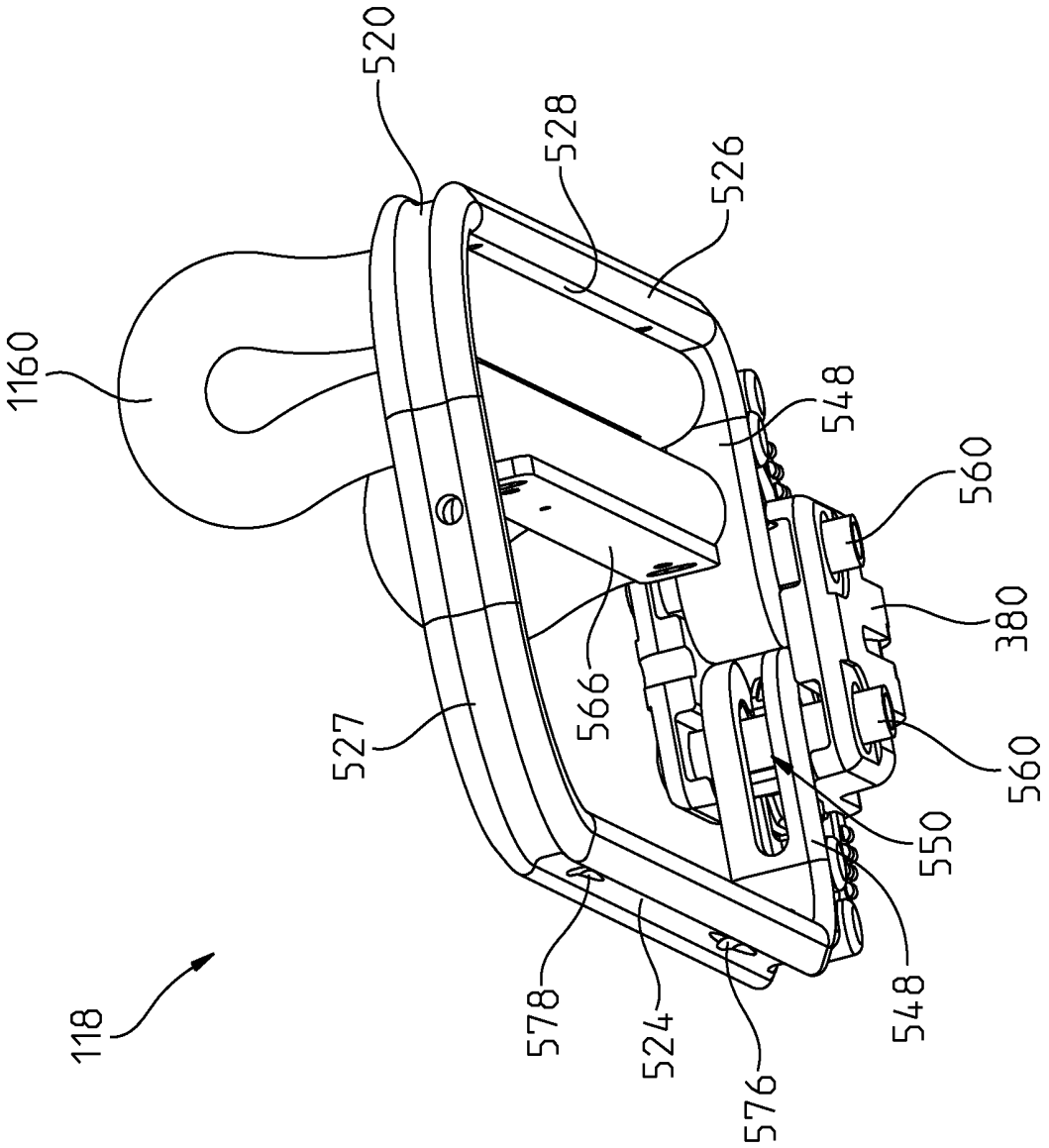


Fig. 31

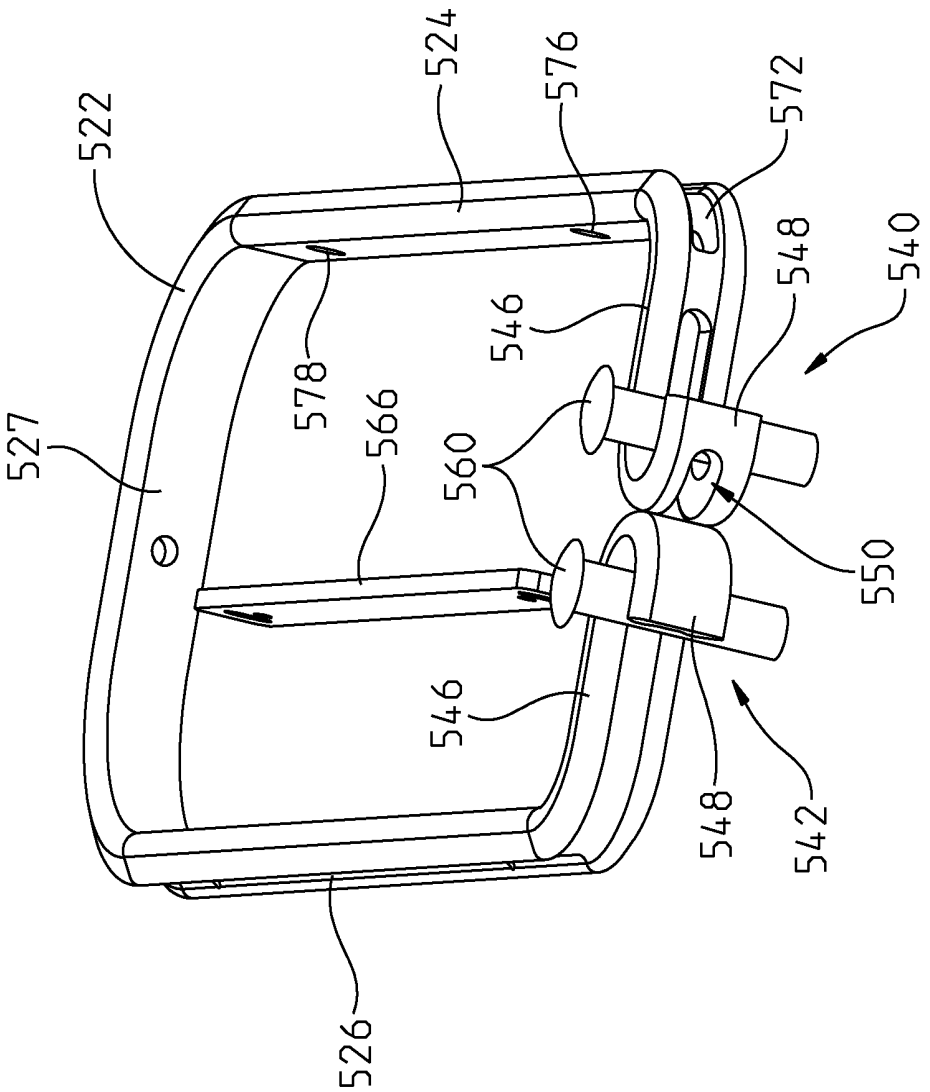


Fig. 32

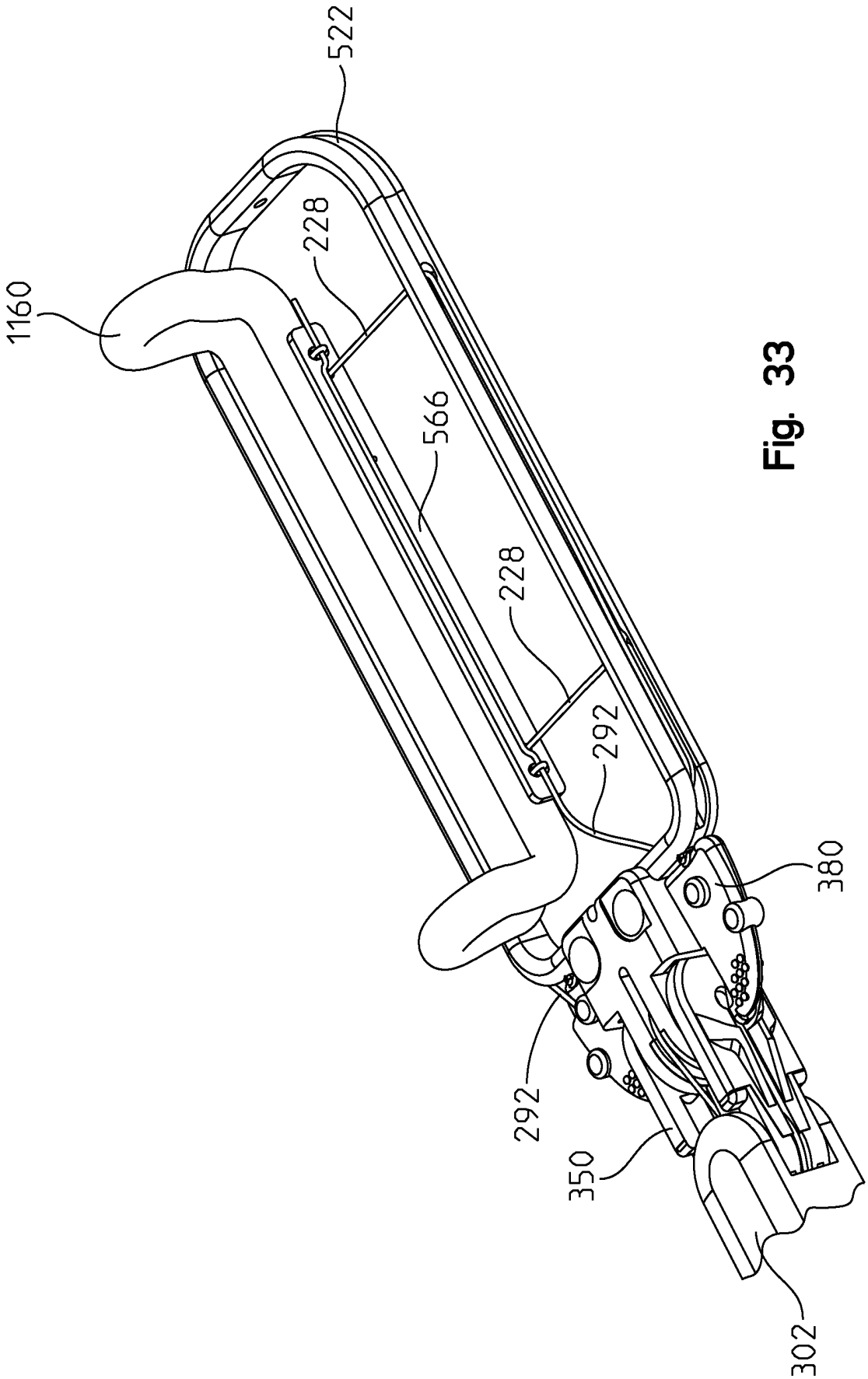


Fig. 33

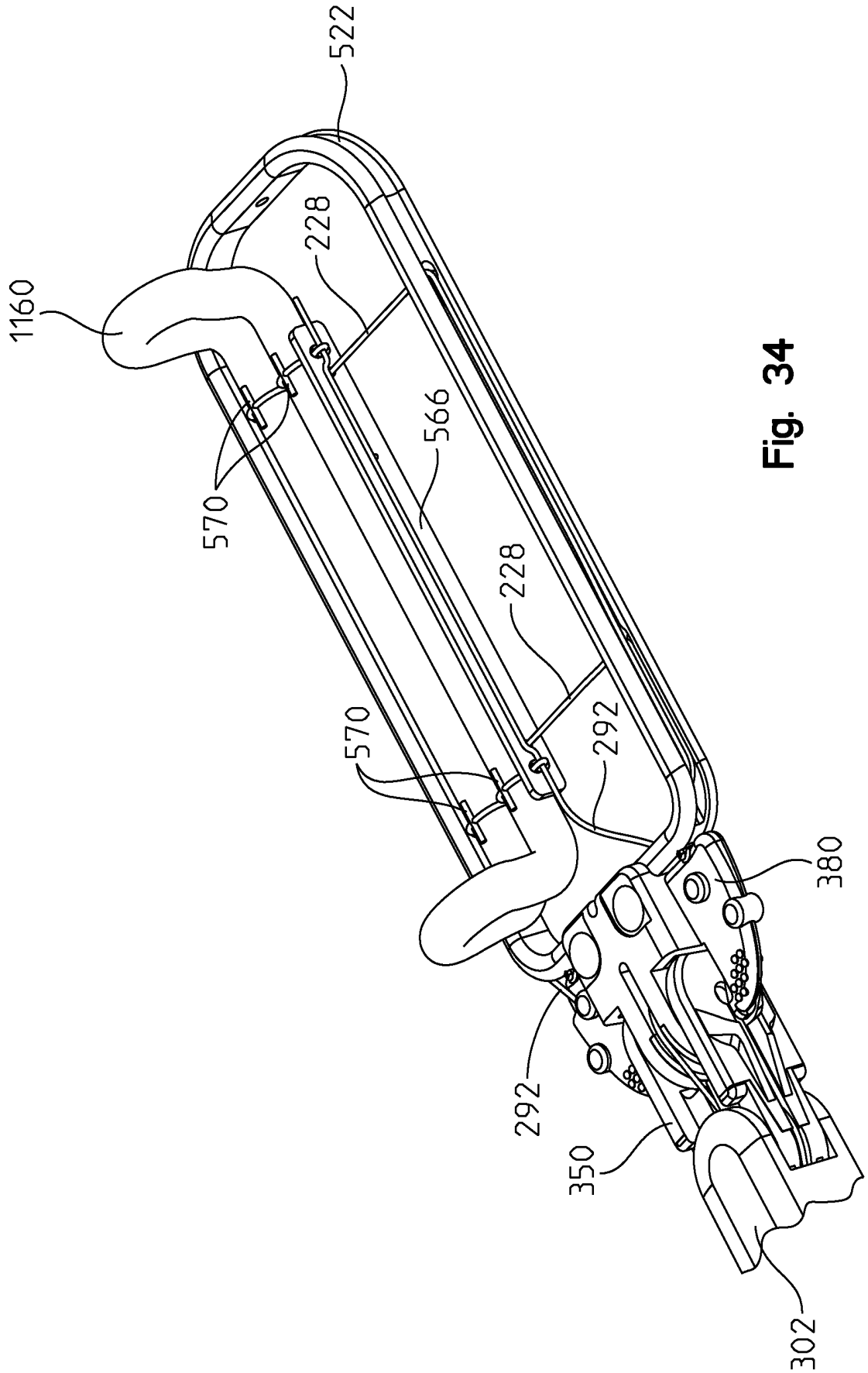


Fig. 34

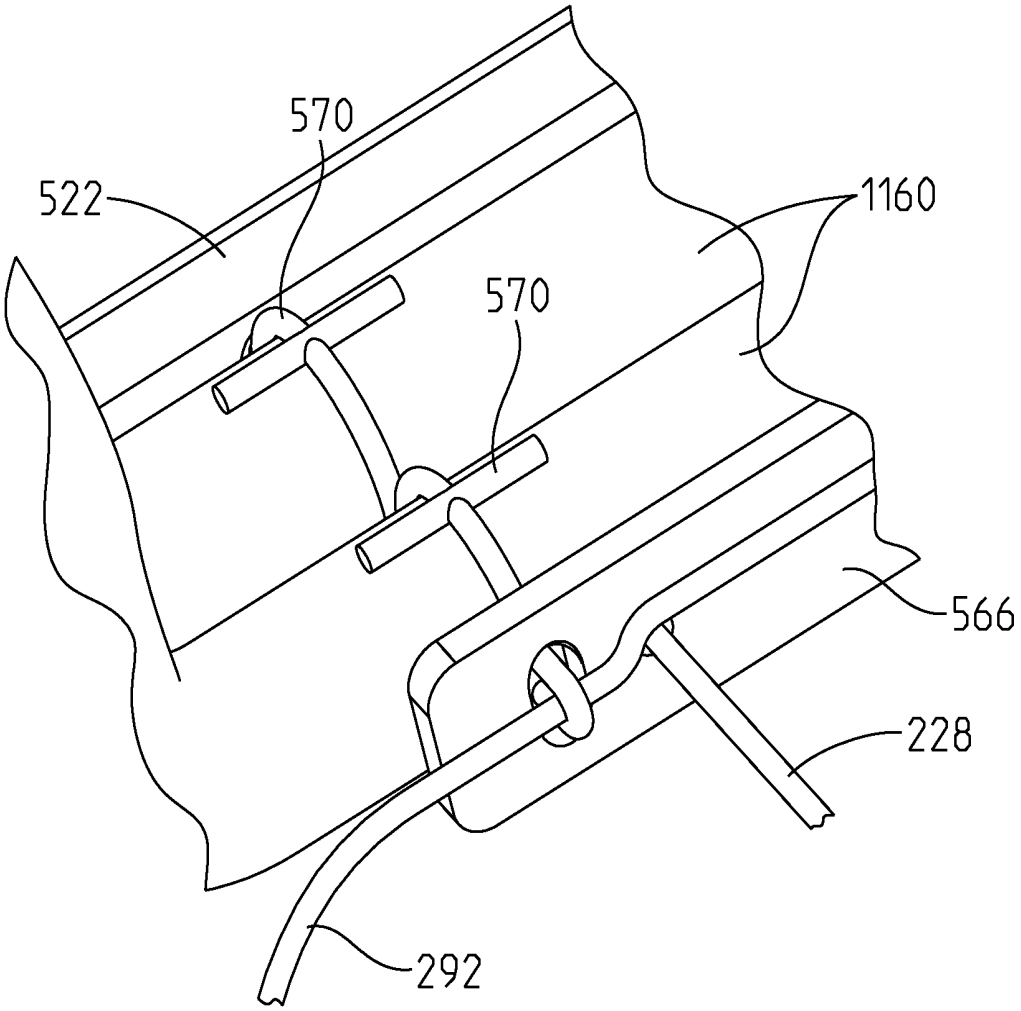


Fig. 35

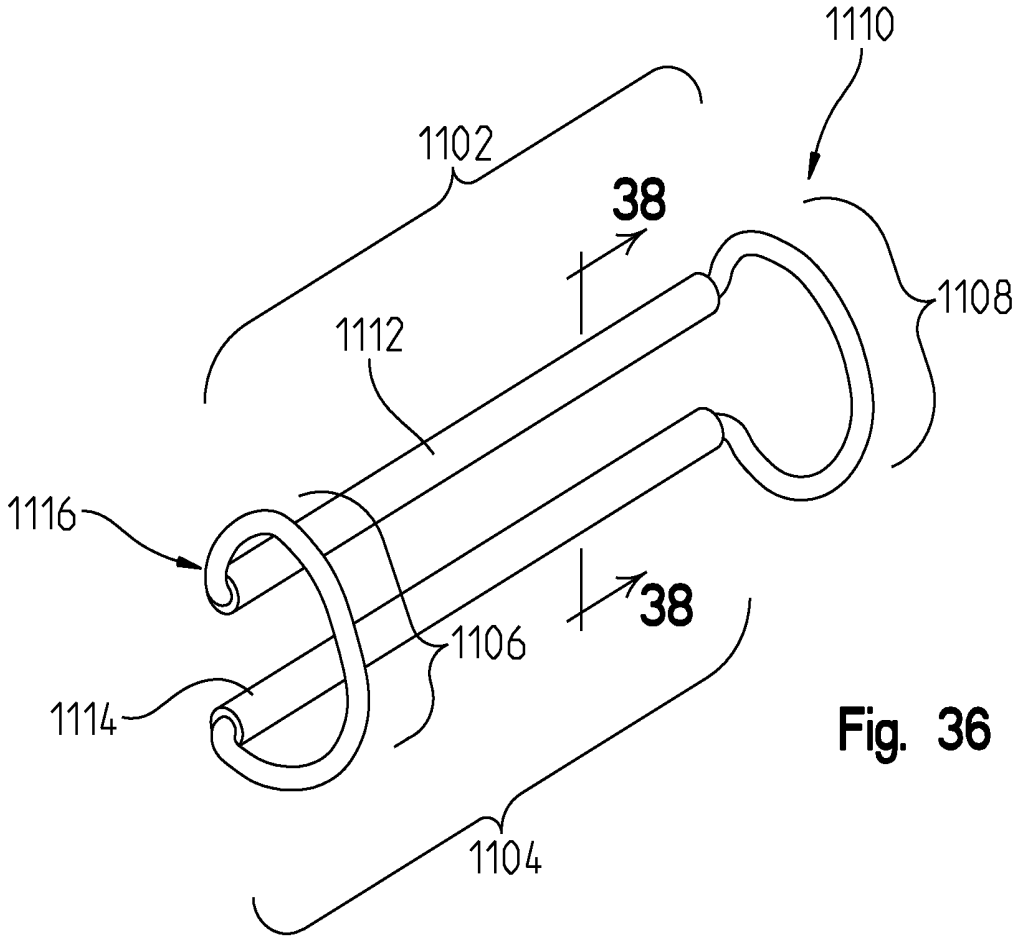

1110
1102
38
1108
1112
1116
38
1106
1114
1104

Fig. 36

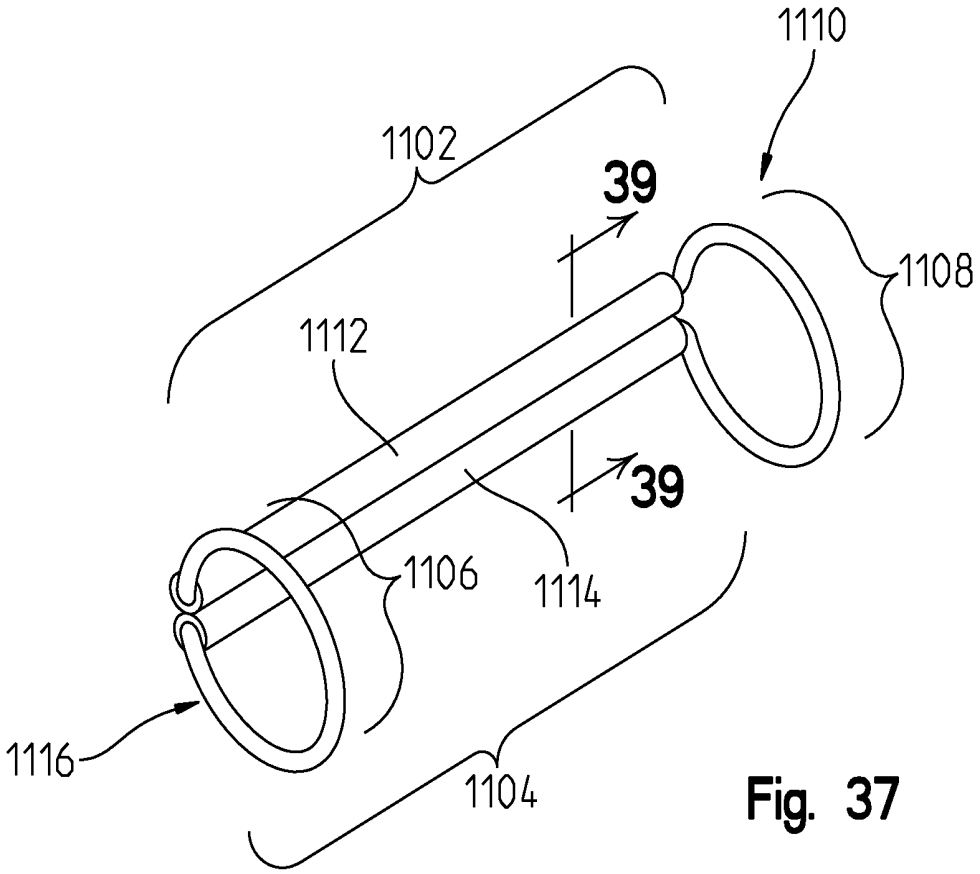

1110
1102
39
1108
1112
39
1106
1114
1116
1104

Fig. 37

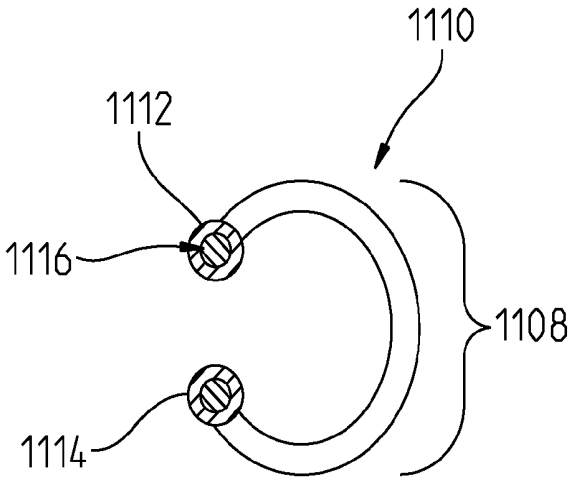


Fig. 38

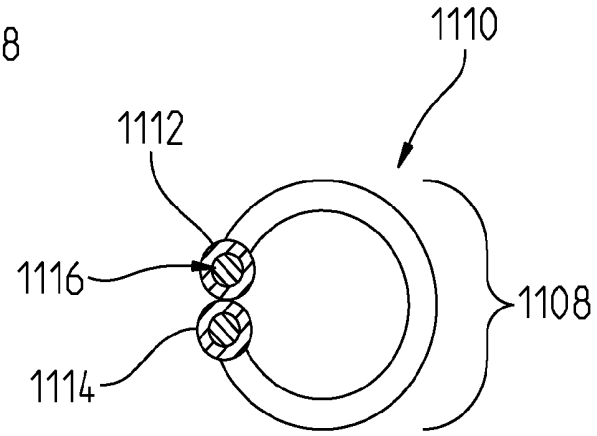


Fig. 39

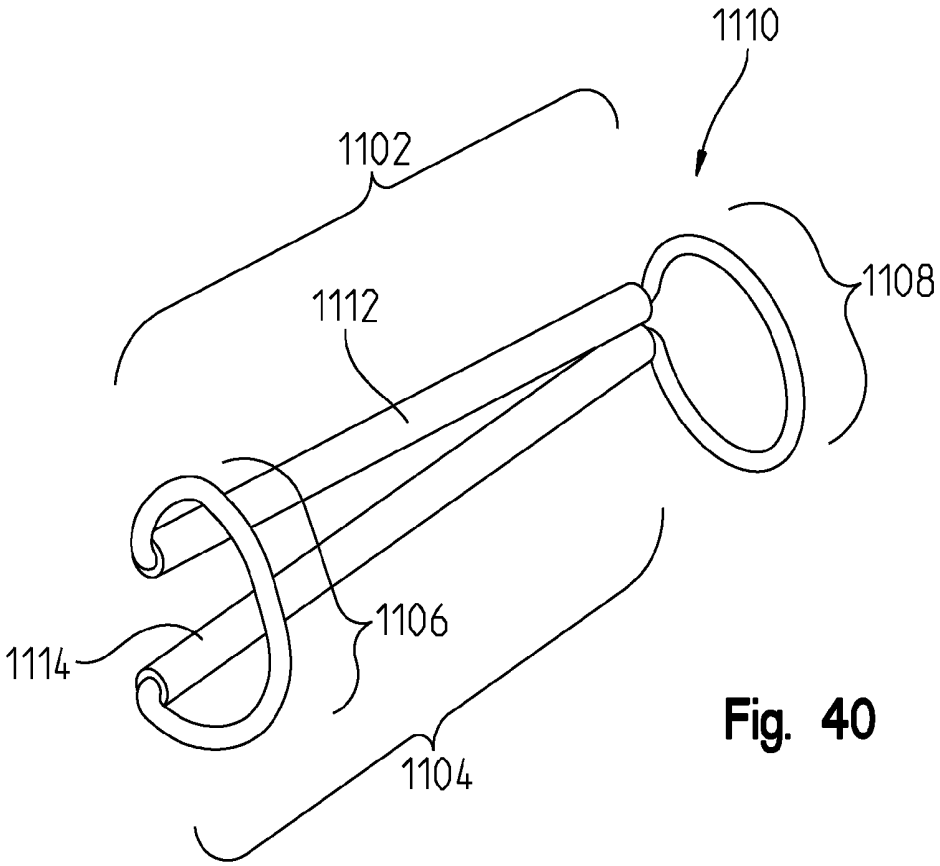


Fig. 40

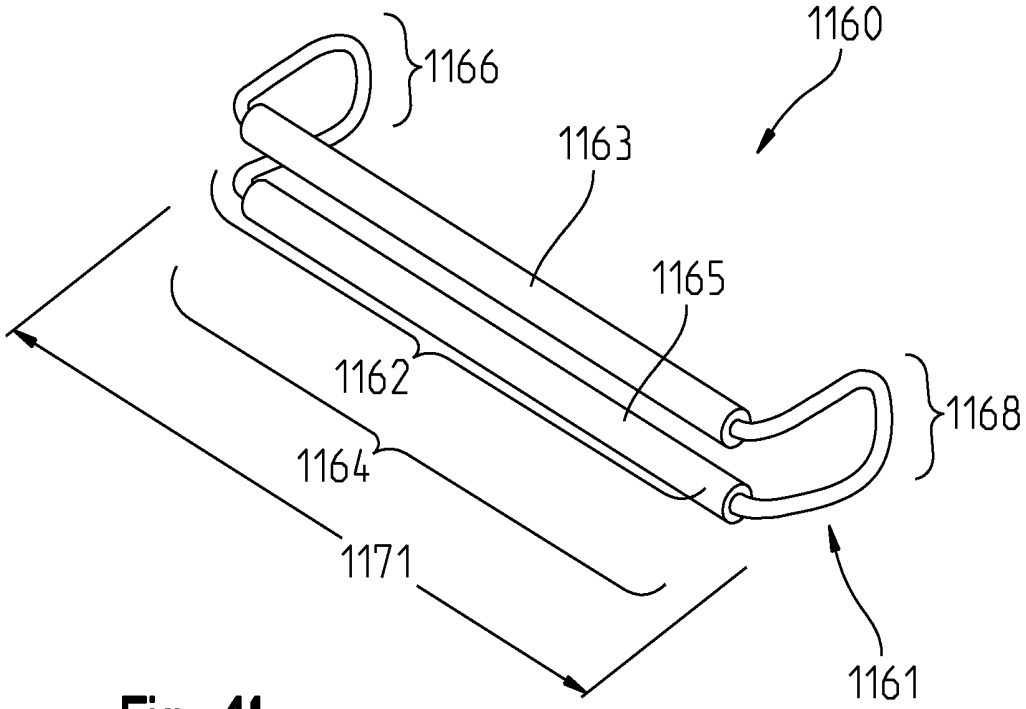

1160
1166
1163
1165
1162
1168
1164
1171
1161

Fig. 41

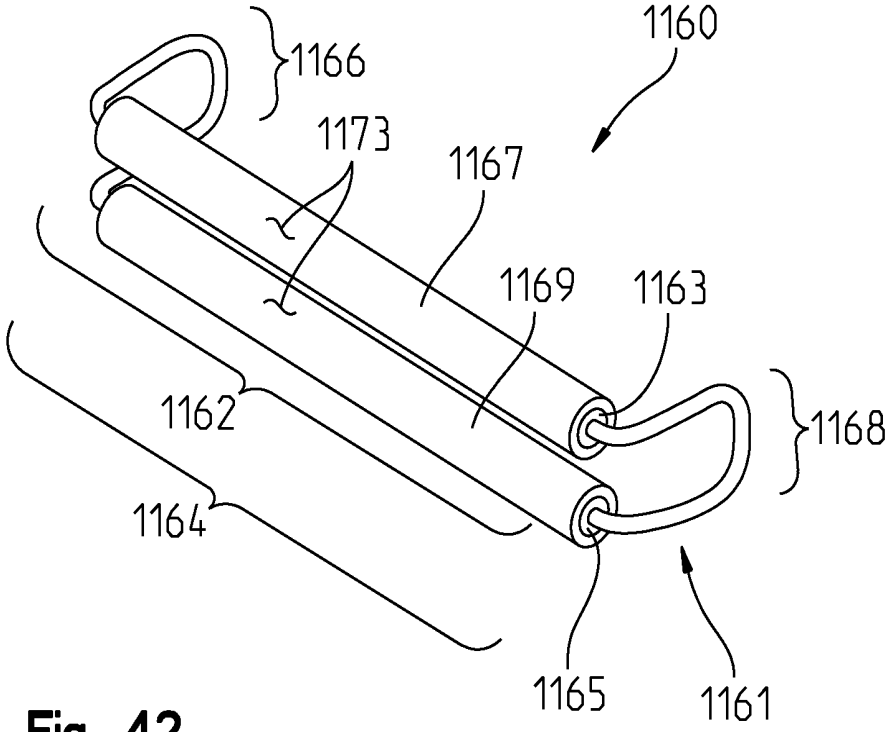

1160
1166
1173
1167
1169
1163
1162
1168
1164
1165
1161

Fig. 42

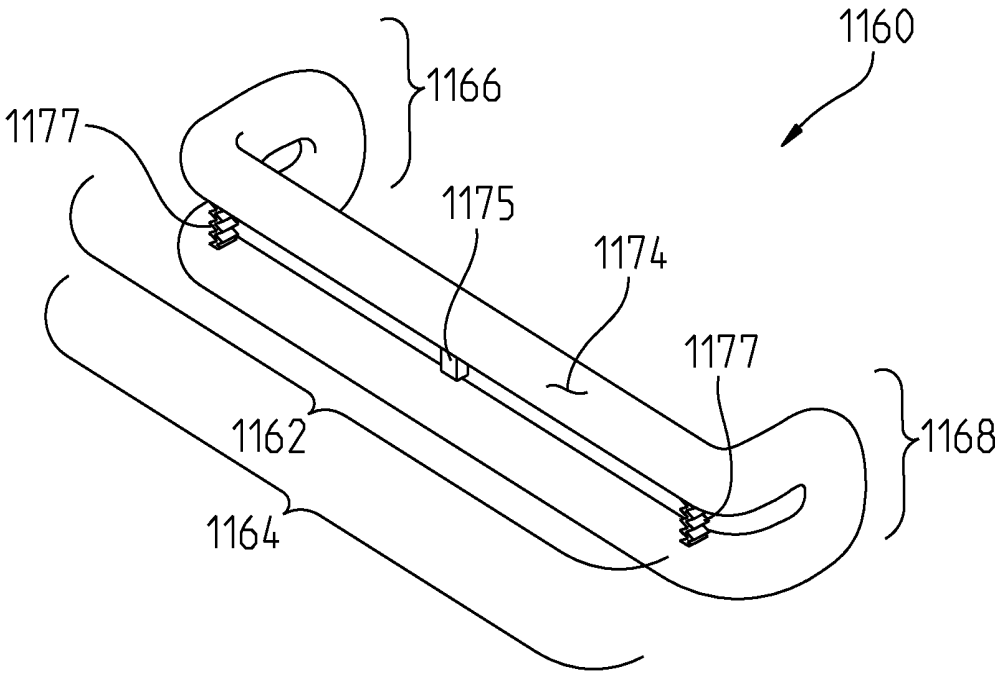


Fig. 43

CLIP DEPLOYMENT TOOL AND ASSOCIATED METHODS

FIELD OF THE INVENTION

The present disclosure relates to deployment of an occlusion clip and, more specifically, to devices and methods utilized to deploy an occlusion clip using a handheld device.

INTRODUCTION TO THE INVENTION

The exemplary embodiments disclosed herein include one or more active or passive repositioning mechanisms. As will be discussed in more detail hereafter, an active repositioning mechanism provides for infinite adjustments as the user is physically operating a control to directly manipulate the repositioning of an end effector or a device mounted to an end effector. In contrast, a passive repositioning mechanism can be thought of as acting similar to a light switch, either off or on. In this manner, the passive repositioning mechanism either allows or disallows repositioning of the end effector or a device mounted to the end effector, but is not responsible for actively manipulating the aspect ultimately repositioned. Put another way, the passive repositioning system allows for free movement of the end effector or a device mounted to the end effector within the relevant range of motion when the mechanism is in the "on" position, but locks movement when the mechanism is in the "off" position. In exemplary form, a laparoscopic device may incorporate passive repositioning mechanisms to control movements in different directions, such as pitch and yaw.

It is a first aspect of the present invention to provide a laparoscopic device comprising: (a) a housing operatively coupled to a first control and a second control; (b) an end effector operatively coupled to the first control, the end effector comprising a first component and a second component selectively repositionable with respect to one another within an X-Y plane, the end effector also including a third component selectively repositionable with respect to the second component within an Y-Z plane; (c) a laparoscopic conduit extending between the housing and the end effector; and, (d) an occlusion clip deployment device operatively coupled to the end effector and the second control.

In a more detailed embodiment of the first aspect, the handle housing is operatively coupled to a third control, the third control is operatively coupled to the occlusion clip and the occlusion clip deployment device, and the third control controls disengagement of the occlusion clip from the occlusion clip deployment device. In yet another more detailed embodiment, the first control includes a first passive constraint and a second passive constraint, the first passive constraint in an unlocked position allows free motion between the first component and the second component within the X-Y plane, the first passive constraint in a locked position retards free motion between the first component and the second component within the X-Y plane, the second passive constraint in an unlocked position allows free motion between the second component and the third component within the Y-Z plane, and the second passive constraint in a locked position retards free motion between the second component and the third component within the Y-Z plane. In a further detailed embodiment, the first passive constraint includes at least one connection wire in tension that is operatively coupled to the second component and to the housing, and the second passive constraint includes at least one connection wire in tension that is operatively coupled to the third component and to the housing. In still a further detailed embodiment, the first control includes a repositionable button selectively coupled to a first reel and a second reel, where the button is repositionable between a locked and an unlocked position, where the locked position retards rotation of the first reel and the second reel, and where the unlocked position allows rotation of the first reel and the second reel, the first reel is operatively coupled to a first connection line operatively coupled to the first component, the second reel is operatively coupled to a second connection line operatively coupled to the second component, and wherein the first reel is independently repositionable with respect to the second reel.

In yet another more detailed embodiment of the first aspect, the second control includes a lever operatively coupled and selectively repositionable with respect to the housing, the lever being operatively coupled to a first connection line operatively coupled to the occlusion clip deployment device so that movement of the lever is operative to reposition at least a portion of the occlusion clip deployment device, the lever is repositionable between a locked and an unlocked position, the unlocked position allows the lever to be repositioned, and the locked position retards the lever from being repositioned. In still another more detailed embodiment, the laparoscopic device further includes a third control operatively coupled to the housing, wherein the third control is operatively coupled to a first connection line operatively coupled to the occlusion clip deployment device so that movement of the third control is operative to reposition at least a portion first connection line with respect to the occlusion clip deployment device. In a further detailed embodiment, the third control includes a plug detachable from the housing, the plug is repositionable from an attached position coupled to the housing to a detached position decoupled from the housing, and repositioning the plug from the attached position to the detached position causes more of the first connection line to be drawn into the housing and further away from the occlusion clip deployment device. In still a further detailed embodiment, the laparoscopic device further includes an occlusion clip operatively coupled to the clip deployment device using the first connection line. In a more detailed embodiment, the end effector includes a robotic grasping feature to facilitate grasping and repositioning of the end effector by a robotic grasper.

It is a second aspect of the present invention to provide a laparoscopic device comprising: (a) a housing operatively coupled to a first control; (b) an end effector operatively coupled to the first control, the end effector comprising a clevis selectively repositionable with respect to a dual pivot joint within an X-Y plane, the dual pivot joint selectively repositionable with respect to a yoke within an Y-Z plane; (c) a laparoscopic conduit extending between the housing and the end effector.

In a more detailed embodiment of the second aspect, the first control includes a first line and a second line extending along the laparoscopic conduit concurrently coupled to the dual pivot joint, the first line impacting movement of the dual pivot joint with respect to the clevis in a first direction within the X-Y plane, the second line impacting movement of the dual pivot joint with respect to the clevis in a second direction, generally opposite the first direction, within the X-Y plane, and the first control includes a third line and a fourth line extending along the laparoscopic conduit concurrently coupled to the yoke, the third line impacting movement of the yoke with respect to the dual pivot joint in a third direction within the Y-Z plane, the fourth line impacting movement of the yoke with respect to the dual pivot joint in a fourth direction, generally opposite the third direction, within the Y-Z plane. In yet another more detailed embodiment, the first line and the second line are coupled to a first actuator mounted to

the housing, the first actuator is repositionable and operative to reposition the first line and the second line in order to create movement between the clevis and dual pivot joint, the third line and the fourth line are coupled to a second actuator mounted to the housing, the second actuator is repositionable and operative to reposition the third line and the fourth line in order to create movement between the yoke and dual pivot joint. In a further detailed embodiment, the first actuator comprises a first reel upon which at least a portion of the first line and the second line are wound, the second actuator comprises a second reel upon which at least a portion of the third line and the fourth line are wound, repositioning of the first reel is operative to distally reposition one of the first line and the second line, while repositioning of the first reel is operative to proximally reposition the other of the first line and the second line, repositioning of the second reel is operative to distally reposition one of the third line and the fourth line, while repositioning of the second reel is operative to proximally reposition the other of the third line and the fourth line.

In yet another more detailed embodiment of the second aspect, the first control includes a brake that may be selectively applied to the first actuator and the second actuator to retard movement of the dual pivot joint with respect to the clevis within the X-Y plane and movement of the yoke with respect to the dual pivot joint within the Y-Z plane. In still another more detailed embodiment, the brake comprises a spring biased button operatively coupled to a series of teeth, the first reel includes a series of teeth, the second reel includes a series of teeth, and engagement between at least one of the series of teeth operatively coupled to the spring biased button and at least one of the series of teeth of the first reel and least one of the series of teeth of the second reel is operative to retard movement of the dual pivot joint with respect to the clevis within the X-Y plane and movement of the yoke with respect to the dual pivot joint within the Y-Z plane. In a further detailed embodiment, the laparoscopic device further includes an occlusion clip deployment device operatively coupled to the end effector and to a second control, where the housing is operatively coupled to the second control, and the second control includes a clip repositioning line extending along the laparoscopic conduit, the clip repositioning line impacting movement of the occlusion clip deployment device between a first position and a second position. In still a further detailed embodiment, the second control includes a lever operatively coupled and selectively repositionable with respect to the housing, the lever being operatively coupled to the clip repositioning line so that movement of the lever is operative to reposition the occlusion clip deployment device, the lever is repositionable between a locked and an unlocked position, the unlocked position allows the lever to be repositioned, and the locked position retards the lever from being repositioned. In a more detailed embodiment, the laparoscopic device further includes a deployment control operatively coupled to the housing, the deployment control including a deployment line extending along the laparoscopic conduit and concurrently mounted to a deployment plug removably fastened to the housing. In a more detailed embodiment, the laparoscopic device further includes an occlusion clip operatively coupled to the occlusion clip deployment device using the deployment line. In another more detailed embodiment, the occlusion clip includes a first jaw opposing a second jaw, a first retainer loop at least partially circumscribes the first jaw, at least a portion of the occlusion clip deployment device, and at least a portion of the deployment line, a second retainer loop at least partially circumscribes the second jaw, at least a portion of the occlusion clip deployment device, and at least a portion of the deployment line. In yet another more detailed embodiment, the end effector includes a robotic grasping feature to facilitate grasping and repositioning of the end effector by a robotic grasper.

It is a third aspect of the present invention to provide a laparoscopic device comprising: (a) a laparoscopic handle; (b) a laparoscopic conduit operatively coupled to the laparoscopic handle; (c) a laparoscopic end effector operatively coupled to the laparoscopic conduit; (d) a passive control allowing repositioning of an end effector with respect to the laparoscopic conduit within an X-Y plane and a Y-Z plane when the passive control is disengaged and retarding repositioning of the end effector with respect to the laparoscopic conduit within the X-Y plane and the Y-Z plane when the passive control is engaged.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevated perspective view of an exemplary laparoscopic device in accordance with the instant disclosure.

FIG. **2** is an elevated perspective view of the proximal end of the exemplary laparoscopic device of FIG. **1**.

FIG. **3** is an elevated perspective view of the proximal end of the exemplary laparoscopic device of FIG. **2**, without the left side housing.

FIG. **4** is a profile view of the proximal end of the exemplary laparoscopic device of FIG. **2**, without the left side housing and without some of the internal components in order to show the axle in a distal portion of a through hole in the repositionable button.

FIG. **5** is an elevated perspective view of a distal portion of the proximal end of the exemplary laparoscopic device of FIG. **2**, without the left side housing and without the clip release wires and the draw wires, and with the pitch and yaw controls in an unlocked position.

FIG. **6** is a profile view of a distal portion of the proximal end of the exemplary laparoscopic device of FIG. **2**, without the left side housing and without the clip release wires and the draw wires, and with the pitch and yaw controls in a locked position.

FIG. **7** is a profile view of a distal portion of the proximal end of the exemplary laparoscopic device of FIG. **2**, without the left side housing and without the clip release wires and the draw wires, and with the pitch and yaw controls in the unlocked position.

FIG. **8** is a profile view of a distal portion of the proximal end of the exemplary laparoscopic device of FIG. **2**, without the left side housing, the clip release wires, the draw wires, and the yaw control.

FIG. **9** is an elevated perspective view of a distal portion of the proximal end of the exemplary laparoscopic device of FIG. **2**, without the left side housing, the clip release wires, the draw wires, and the yaw control.

FIG. **10** is an elevated perspective view of a distal portion of the proximal end of the exemplary laparoscopic device of FIG. **2**, without the left side housing, the clip release wires, the draw wires, and the control button.

FIG. **11** is an end view, from the proximal end, of an exemplary clevis of the exemplary laparoscopic device of FIG. **1**.

FIG. **12** is an end view, from the distal end, of the exemplary clevis of FIG. **11**.

FIG. **13** is a profile view of the exemplary clevis of FIG. **11**.

FIG. **14** is an elevated perspective view of the exemplary clevis of FIG. **11**.

FIG. **15** is an elevated perspective view, from a distal end, of an exemplary dual pivot joint of the exemplary laparoscopic device of FIG. **1**.

FIG. **16** is a profile view of the exemplary dual pivot joint of FIG. **15**.

FIG. **17** is an elevated perspective view, from a proximal end, of the exemplary dual pivot joint of FIG. **15**.

FIG. **18** is a top view of the exemplary dual pivot joint of FIG. **15**.

FIG. **19** is an end view, from the proximal end, of the exemplary dual pivot joint of FIG. **15**.

FIG. **20** is another elevated perspective view, from a distal end, of the exemplary dual pivot joint of FIG. **15**.

FIG. **21** is an elevated perspective view, from a proximal end, of an exemplary yoke of the exemplary laparoscopic device of FIG. **1**.

FIG. **22** is a top view of the exemplary yoke of FIG. **21**.

FIG. **23** is an underneath perspective view, from a lateral side, of the exemplary yoke of FIG. **21**.

FIG. **24** is a distal view of the exemplary yoke of FIG. **21**.

FIG. **25** is a bottom view of the exemplary yoke of FIG. **21**.

FIG. **26** is another underneath perspective view, from the opposite lateral side, of the exemplary yoke of FIG. **21**.

FIG. **27** is an elevated perspective view, from the proximal end, of the exemplary dual pivot joint and yoke mounted to a clip deployment device, where the view shows the both sets of connection wires, the draw wires, and the clip release wires.

FIG. **28** is an elevated perspective view, from the proximal end, of the exemplary yoke mounted to a clip deployment device, where the view shows one set of connection wires, the draw wires, and the clip release wires.

FIG. **29** is an elevated perspective view, from the proximal end, of the exemplary clevis, dual pivot joint, and yoke mounted to a clip deployment device and an occlusion clip, where the yoke is being grasped by a robotic grasper.

FIG. **30** is an elevated perspective view, from the distal end, of the exemplary yoke mounted to a clip deployment device, where the view is devoid of the draw wires and the clip release wires.

FIG. **31** is an underneath perspective view, from the distal end, of the exemplary yoke mounted to a clip deployment device, where the view is devoid of the draw wires and the clip release wires.

FIG. **32** is an elevated perspective view, from the proximal end, of the exemplary clip deployment device and retention dowels, where the view is devoid of the draw wires and the clip release wires.

FIG. **33** is an elevated perspective view, from the proximal end and lateral side, of the exemplary clevis, dual pivot joint, and yoke mounted to a clip deployment device and an occlusion clip, where the draw wires and the clip release wires are shown.

FIG. **34** is an elevated perspective view, from the proximal end and lateral side, of the exemplary clevis, dual pivot joint, and yoke mounted to a clip deployment device and an occlusion clip, where the draw wires, the clip release wires, and the suture loops are shown.

FIG. **35** is a magnified elevated perspective view showing the attachment between the occlusion clip and the clip deployment device, as well as the interaction of the draw wires and the clip release wires.

FIG. **36** is a perspective view of an exemplary clamp in an open position that may be used with the exemplary laparoscopic device of FIG. **1**.

FIG. **37** is a perspective view of the exemplary clamp of FIG. **36** in a closed position.

FIG. **38** is a cross-sectional view of the exemplary clamp of FIG. **36** in its open configuration, showing the wire member, rigid tubular members, and the urging members.

FIG. **39** is a cross-sectional view of the exemplary clamp of FIG. **37** in its closed configuration, showing the wire member, rigid tubular members, and the urging members.

FIG. **40** is a perspective view of the exemplary clamps of FIGS. **36-39** and showing the ability to close in a non-parallel fashion.

FIG. **41** is a perspective view of the first stage of assembly of an alternate embodiment of a clamp, showing a wire member surrounded by rigid tubular members.

FIG. **42** is a perspective view of the second stage of assembly of the clamp of FIG. **41**, in which platens have been added over the rigid tubular members.

FIG. **43** is a perspective view of the claim of FIGS. **41** and **42**, once an outer fabric covering has been disposed over the entire surface of the clamp.

DETAILED DESCRIPTION

The exemplary embodiments of the present disclosure are described and illustrated below to encompass surgical equipment and, more specifically, to surgical equipment that may be used in minimally invasive procedures. The disclosure also relates to surgical equipment to facilitate the positioning and deployment of an atrial appendage occlusion device. In addition, the disclosure relates to surgical equipment that is adapted to accommodate or work in tandem with flexible endoscopes. Of course, it will be apparent to those of ordinary skill in the art that the embodiments discussed below are exemplary in nature and may be reconfigured without departing from the scope and spirit of the present disclosure. However, for clarity and precision, the exemplary embodiments as discussed below may include optional steps, methods, and features that one of ordinary skill should recognize as not being a requisite to fall within the scope of the present disclosure.

Referring to FIG. **1**, an exemplary clip deployment apparatus **100** comprises a controller **110** mounted to a proximal portion of a rigid or semi-rigid conduit **112** that is relatively linear. The controller **110** includes various controls in order to manipulate a repositionable mechanism operatively coupled to an end effector **118**, where the repositionable mechanism is mounted to a distal portion of the conduit **112**. In this exemplary embodiment, the repositionable mechanism is coupled to an end effector comprising a clip deployment device **118**. But as will be discussed in more detail hereafter, the end effector **118** may comprise any number of devices such as, without limitation, forceps, ablation rails, jaws, linear cutters, ablation pens, ablation clamps, illuminated dissectors, and non-illuminated dissectors.

The exemplary repositionable mechanism incorporates a dual passive mechanism. The first passive mechanism is operative to control the pitch (i.e., up and down) of the end effector **118**, while the second passive mechanism is operative to control the yaw (i.e., side to side) of the end effector.

Referencing FIGS. **1-10**, the controller **110** is coupled to the conduit **112** in order to manipulate a repositionable mechanism operatively coupled to the end effector **118**. The controller **110** comprises a right side housing **130** and a left side housing **132** that cooperatively define an internal cavity and corresponding openings to accommodate throughput of certain controls. A first of these openings is a dorsal opening **134** that accommodates throughput of a repositionable button **136**. As will be discussed in more detail hereafter, the repositionable button **136** may be manipulated vertically to lock and unlock the repositionable mechanisms, as well as forward-to-rearward to lock and unlock the position of the but-

ton itself, in order to provide for or constrain lateral and vertical adjustability of the end effector **118**.

The repositionable button **136** comprises a proximal-to-distal arcuate top **138** that includes bumps and a proximal ridge to accommodate the thumb of a user being positioned on top of the button. The medial-to-lateral width of the arcuate top **138** is generally constant and overlaps a vertical, planar appendage **142** that extends from the underside of the arcuate top. This vertical appendage **142** has a relatively constant and minimal medial-to-lateral dimension, but includes a proximal-to-lateral dimension that tapers from a maximum where the appendage extends from the arcuate top, to a minimum where the appendage ends. Extending through this vertical appendage **142** is a U-shaped through hole **144** that is partially occupied by an axle **164**. This U-shaped through hole **144** allows the button **136** to be vertically repositioned with respect to the axle **164** so that active pressure is required to maintain a depressed button position when the axle is in a distal portion of the through hole. Instead of having to maintain pressure upon the button **136** to sustain it in a depressed position, the user may choose to rotate the button with respect to the axle **164** in order to seat the axle in a proximal portion of the through hole **144**, thus effectively locking the button in the depressed position. In order to unlock the button **136**, a user simply rotates or pushes the button proximally to cause the axle **164** into the distal portion of the through hole **144**.

At the end of the appendage **142**, a pair of tooth receivers **146** extend outward in the medial and lateral directions from opposing sides of the appendage. The tooth receivers **146** each include a series of longitudinal pyramidal shapes **148** that are in parallel and radially arranged in order to define a series of corresponding longitudinal pyramidal cavities **150**. At the medial end of the medial tooth receiver **146** and at the lateral end of the lateral tooth receiver **146** is a cylindrical projection **152** that is received within corresponding vertical, oblong grooves **154** on the interior of the housings **130**, **132**. These grooves **154** inhibit significant medial-to-lateral and proximal-to-distal travel of the tooth receivers **146** as the tooth receivers are vertically repositioned. In other words, as the button **136** is depressed vertically, the toothed receivers **146** are vertically repositioned in a corresponding vertical manner. In this way, the movement of the toothed receivers **146** is directly attributable to the movement of the button **136** as the toothed receivers are indirectly mounted to the button via the appendage **142**.

The button **136** is biased vertically to its highest vertical position shown in FIG. **6**. To achieve this bias, the housings **130**, **132** include parallel walls **158** that cooperate to form medial-to-lateral trench within which at least one spring **160** is seated. The spring **160** is rated at a sufficient spring force to overcome the weight of the button **136**, appendage **142**, tooth receivers **146**, and cylindrical projections **152** to force the button to its highest vertical position. But the spring force is not so great that it requires too great a force from a user's thumb to depress the button **136** and overcome the bias of the spring **160**.

An axle **164** extends in the medial-to-lateral direction within the interior cavity cooperatively defined by the housings **130**, **132**. This axle **164** is cylindrical in shape and includes a constant longitudinal diameter, thereby giving the axle a circular circumference. In exemplary form, the medial and lateral ends of the axle **164** are received within corresponding cylindrical cavities (not shown) on the interior of the housings. The depth of these cavities is not so great as to cover the majority of the axle **164**. The exposed cylindrical portion of the axle **164** is operative to receive a pair of toothed assemblies **168**, **170** that are interposed by the appendage **142**, which itself includes a vertical, oblong orifice (not shown) to accommodate throughput of the axle and vertical travel of the appendage with respect to the axle, which has a fixed orientation. In exemplary form, the toothed assemblies **168**, **170** include a through cylindrical orifice **172** allowing the assemblies to rotate on the outside of the axle.

Each of the toothed assemblies **168**, **170** are identical to each other. Accordingly, a redundant description of the second toothed assembly has been omitted in furtherance of brevity. The toothed assemblies **168**, **170** include a wheel **176** having circumferentially distributed teeth **178** that are sized to engage a respective tooth receivers **146** and be received within the longitudinal pyramidal cavities **150** when the tooth receivers in a raised vertical position (see FIG. **6**). In exemplary form, the spring rate of the spring **160** is chosen to allow the tooth receivers **146** to be depressed by forces applied to the toothed assemblies **168**, **170** above a predetermined threshold. For example, a high load applied to the end effector in any one direction may result in repositioning of one or both of the toothed assemblies **168**, **170**, thereby causing a wheel **176** and its teeth **178** to rotate and correspondingly depress against the corresponding tooth receiver **146**, which depresses against the spring **160** to compress the spring, thus allowing one or both wheels to rotate to avoid breaking any of the components.

The wheel **176** has a generally uniform width but for a pair of outgrowths **180**, **182**. The first outgrowth **180** is generally centered radially with respect to the wheel and partially defines the through orifice **172** that receives the axle **164**. This first outgrowth **180** is semicircular in shape extends medially from the wheel **176** and includes a corresponding top and bottom arcuate surfaces **184**, **186** that are radially inset with respect to the wheel. These arcuate surfaces **184**, **186** act as camming surfaces for respective connection wires **188**, **190** that extend from the second outgrowth **182**. The first outgrowth **180** also includes a pair of vertical flanges **194** that extend from the arcuate surfaces **184**, **186** and cooperate with the circumferential ends of the wheels in order to provide medial and lateral guides for the connection wires **188**, **190** so that the connection wires stay therebetween. The second outgrowth **182** is proximally oriented with respect to the first outgrowth **180** and includes a rectangular profile with a pair of L-shaped walls **192** and floor **196** cooperating to define an internal cavity. An opening (not shown) extends through the floor and into the cavity. This opening receives a fastener (such as a screw) **200** around which the connection wires **188**, **190** are wound and secured in place. The fastener **200** is also recessed within the cavity so that the L-shaped walls **192** extend laterally beyond the end of the fastener. Accordingly, the connection wires **188**, **190** extending from the fastener are threaded through a gap between the L-shaped walls **192**, with one of the wires being threaded over the top arcuate surface **184**, while the second wire is threaded under the bottom arcuate surface **186**. Thereafter, the wires **188**, **190** extend distally and taper to extend through a respective eyelet opening at the proximal end of the conduit **112**.

Each of the toothed assemblies **168**, **170** is independently rotatably repositionable with respect to one another. The first toothed assembly **168** is operative provide part of a passive repositionable mechanism in order to control the pitch (i.e., up and down) of the end effector **118**, while the second toothed assembly **170** is operative to provide part of a passive repositionable mechanism in order to control the yaw (i.e., side to side) of the end effector. In exemplary form, when the button **136** is not depressed, the spring **160** is operative to bias the toothed receivers **146** into engagement with the teeth **178** of the toothed assemblies **168**, **170**, thereby inhibiting rota-

tion of the toothed assemblies around the axle **164**. When the tooth assemblies **168**, **170** are locked in position (see FIG. **6**) the end effector **118** cannot be repositioned in the vertical direction (i.e., affecting pitch) or in the medial-to-lateral direction (i.e., affecting yaw). Thus, when the tooth assemblies **168**, **170** are locked in position (see FIG. **6**), so too is the end effector **118** locked in position.

In order to change the vertical or medial-to-lateral position of the end effector **118**, a user would depress the button **136**. By depressing the button **136**, the toothed receivers **146** are operative to further compress the spring **160** and disengage the toothed assemblies **168**, **170**. More specifically, the longitudinal pyramidal shapes **148** and corresponding longitudinal pyramidal cavities **150** no longer engage the teeth **178** of the toothed assemblies **168**, **170**, thereby allowing rotation of the toothed assemblies around the axle **164**. By allowing free rotation of the toothed assemblies **168**, **170** around the axle **164**, the connection wires **188**, **190** linking the end effector **118** and the toothed assemblies may be repositioned, which allows the end effector to be freely repositionable in the vertical direction (i.e., affecting pitch) and in the medial-to-lateral direction (i.e., affecting yaw). After the respective vertical and medial-to-lateral position of the end effector **118** has been reached, the user would discontinue depressing the button **136** to lock in the relative vertical and medial-to-lateral positions. In order to lock in the positions, the spring **160** forces the toothed receivers **146** upward and into engagement with the toothed assemblies **168**, **170**. Because the toothed assemblies **168**, **170** include teeth **178** that engage the longitudinal pyramidal shapes **148** of the toothed receivers **146**, the spring **160** will direct the toothed receivers upward and cause the toothed assemblies to possibly rotate slightly about the axle **164** so that the teeth are fully received within the longitudinal pyramidal cavities **150**. If the position of the end effector **118** is such that the teeth **178** are aligned with the longitudinal pyramidal cavities **150**, then the vertical and medial-to-lateral positions will be precisely maintained because of the tension on the connection wires **188**, **190**. But if the position of the end effector **118** is such that the teeth **178** are slightly misaligned with the longitudinal pyramidal cavities **150**, then the vertical and medial-to-lateral positions will be changed as the toothed assemblies **168**, **170** rotate slightly about the axle **164** so that the teeth are fully received within the longitudinal pyramidal cavities **150**. After the teeth **178** are aligned and received within the longitudinal pyramidal cavities **150**, the vertical and medial-to-lateral positions will be precisely maintained because of the tension on the connection wires **188**, **190**.

In order to maintain the orientation of the semi-rigid conduit (which carries the connection wires **188**, **190**) with respect to the housings **130**, **132**, a distal portion of the right side housing **130** includes a pair of detents **202** that engage the conduit **112**. These detents **202** inhibit longitudinal movement of the conduit **112** with respect to the controller **110**. Both detents **202** extend in parallel to one another and extend from an interior circumferential surface of the right side housing **130**.

The right and left side housings **130**, **132** cooperate to delineate a handle mechanism port **210** and a proximal port **212** open to the interiors of the respective housings. The handle mechanism port **210** accommodates throughput of a portion of a handle mechanism **218** that comprises a repositionable lever **220**, a drive plate **222**, a return spring **224**, and a wire retainer **226**. As will be discussed in more detail hereafter, the wire retainer **226** is concurrently coupled to draw wires **228** and the drive plate **222** so that movement of the lever **220** is operative to open and close an occlusion clip **1160** (compare FIGS. **29** and **34**), such as during an atrial appendage occlusion clip deployment surgical procedure. A more detailed explanation of the respective components of the handle mechanism **218** follows.

The repositionable lever **220** includes an arcuate, ventral gripping surface that may include a series of convex bumps longitudinally spaced apart to facilitate gripping by a user. Opposite the ventral gripping surface is a corresponding interior surface from which a pair of spaced apart, parallel vertical walls **230**, **232** extend. The vertical walls **230**, **232** are also connected to one another via a plurality of cross walls **234**. The vertical walls **230**, **232** each include a distal upstanding loop **238** that provides a through opening in the medial-to-lateral direction to receive a axle **240** extending from the right side housing **130** around which the lever **220** rotates. Extending distally from the loop **238**, the walls **230**, **232** include a circular opening extending in the medial-to-lateral direction that receives a pin **244** in order to repositionably mount the drive plate **222** to the lever **220**.

The exemplary drive plate **222** comprises an arcuate, flat plate sized to fit between the walls **230**, **232** of the lever **220**. A distal end of the plate **222** includes an opening to receive the pin **244**. Extending proximally from the opening is an elongated, arcuate opening **246** adapted to receive a dowel **248** extending from the interior of the right side housing **130**. In this manner, the dowel **248** is repositioned with respect to the opening **246** as the lever **220** repositions the drive plate **222**. In exemplary form, the opening is partially defined by a lip **250** that acts to retain the dowel **248** in a static position after the lever **220** is fully closed. At the same time, the proximal end of the drive plate **222** includes an orifice **252** that receives a portion of the spring **224** in order to bias the lever **220** to the open position shown in FIG. **3**. The opposing end of the spring **224** is mounted to a dowel **254** that extends from the interior of the right side housing **220**.

The controller **110** also includes a removable stem **260** that is seated within the proximal port **212** of the housings **130**, **132**. The removable stem **260** is coupled to one or more clip release wires **292** (in this case, two clip release wires) that act to disconnect an occlusion clip from the clip deployment device **118**. In this manner, the stem **260** may be removed from the proximal end of the controller **110**, thereby drawing the release wire(s) proximally and disconnecting the occlusion clip from the clip deployment device **118**. In this exemplary embodiment, the stem **260** is secured within the proximal port **212** via a friction fit that may be overcome by the user applying pressure to the stem to move it proximally with respect to the controller **110**. But it is also within the scope of the disclosure to use detents or other affirmative release mechanisms to release the stem **260** from the controller **110**.

The controller **110** is mounted to a rigid or semi-rigid conduit **112** that is relatively linear and has a relatively constant circular cross section. In this exemplary embodiment, the conduit **112** is fabricated from stainless steel and includes a proximal circular opening and a distal circular opening. The proximal circular opening provides access between the interior of the conduit **112** and the interior of the controller **110**. More specifically, the hollow interior of the conduit **112** accommodates throughput of the connection wires **188**, **190** and the clip release wires **292**. The conduit **112** includes a proximal section having a pair of rectangular, arcuate cut-outs providing respective recesses for the detents **202** of the right side housing **130** to occupy and mount the conduit **112** to the housings **130**, **132**.

In addition, the conduit **112** may be relatively linear but include two additional orifices that accommodate a separate conduit (not shown) adapted to provide a separate avenue for

an exploratory tool. Exemplary exploratory tools for use with the instant semi-rigid conduit include, without limitation, forceps, ablation rails, jaws, linear cutters, ablation pens, ablation clamps, illuminated dissectors, and non-illuminated dissectors. The exemplary exploratory tool may be used in combination with the end effector, which is manipulated by the repositionable mechanism.

Referring to FIGS. **11-14**, a distal portion of the exemplary repositionable mechanism comprises a clevis **302** having a partially enclosed proximal section **304** that delineates a cavity **306** receives a distal section of the conduit **112** to mount the clevis to the conduit. On the interior of the cavity **306** are four equidistantly, radially spaced apart ribs **308** that extend longitudinally and in parallel to one another. The ribs **308** operate to decrease the diameter of the cavity **306** so that the ribs contact the exterior, circumferential surface of the conduit **112** to mount the conduit to the clevis **302** via a friction fit. Each of the ribs **308** terminates distally at a wall **310** extending normal to the longitudinal direction of the ribs. The wall **310** includes a series of orifices **312**, **314**, **316** that accommodate throughput of the connection wires **188**, **190** and the clip release wires **292**. In exemplary form, the first orifice **312** accommodates throughput of the first connection wire **188**, while the second orifice **314** accommodates throughput of the clip release wires **292**, while the third orifice **316** accommodates throughput of the second connection wire **190**. The wall **310** also bridges the proximal section **304** and a distal section **320** of the clevis **302**.

Te distal section **320** of the clevis **302** includes a pair of distal projections **324**, **326** extending away from the wall **310** to create a ceiling and floor. The projections **324**, **326** are oriented to provide a gap therebetween extending in proximal-to-distal direction and in a medial-to-lateral direction. Each projection **324**, **326** includes a mildly convex outer surface **330** that is jointed by a peripheral surface **332** that is rounded to at the distal tip. The peripheral surfaces **332** are jointed by respective exterior side surfaces **334**. Each projection **324**, **326** includes a depression **336** that originates at the distal tip of the clevis **302** and extends proximally. The bounds of the depression **336** are delineated by a planar bottom surface **340**, a horseshoe (i.e., semicircular) peripheral surface **342**, and a planar base surface **344**. The arcuate contour of the peripheral surface **342** is operative to allow a dual pivot joint to **350** to pivot in a single plane with respect to the clevis **302**.

Referring to FIGS. **15-20**, the dual pivot joint **350** comprises a proximal section **352** having a pair of plateaus **354** that extend in opposite directions from one another. Each plateau **354** includes a teardrop shaped circumferential surface **356** with the rounded portion of the surface adapted to have an arcuate curvature that approximates the arcuate curvature of the peripheral surface **342** of the clevis **302**. The plateaus **354** are interposed by a platform **358** having opposed, generally planar parallel surfaces **360**. Accordingly, the dual pivot joint **350** may pivot with respect to the clevis **302** by the plateaus **354** pivoting or rotating with respect to the peripheral surface **342**, while the planar surfaces **360** contact the planar base surfaces **344** of the clevis to limit significant vertical play between the clevis and dual pivot joint. The pointed aspect of each circumferential surface **356** cooperates with the straight walls of the peripheral surface **342** of the clevis **302** to provide stops that limit the pivotal motion of the dual pivot joint **350** with respect to the clevis **302** to no more than fifty-five degrees from center (total range of motion of approximately 110 degrees). As will be understood by those skilled in the art, the range of travel may be increased by increasing the angle of the pointed aspect of the circumferential surfaces. Conversely, the range of travel may be decreased by decreasing the angle of the pointed aspect of the circumferential surfaces.

A proximal aspect of the platform **358** is rounded and includes two pair of arcuate walls **364** that are spaced apart from one another to create a gap **368** that tapers distally to create a cylindrical through hole **376** extending into the interior of a distal aspect **370** of the dual pivot joint. The tapered feature of each gap **368** is partially defined by a pair of angled faces **372** that operate to allow the connection wires **188** to be fed in between the walls **364**, through the cylindrical hole **376** and into the interior of the distal aspect, where the wires are ultimately connected to a yoke **380**. The tapered nature of each gap **368** ensures that the connection wires **188** do not become bound up by pivoting action of the dual pivot joint **350** with respect to the clevis **302**. But for the tapered nature of the gap **368**, pivoting action beyond center of the dual pivot joint **350** with respect to the clevis **302** would cause the path of the connection wires **188** to be lengthened, thereby resulting in pivoting of the yoke **380** with respect to the dual pivot joint.

Interposing the two pair of arcuate walls **364** and respective gaps **368** is a centered gap **384** that also tapers distally to create a through hole **386** having a rectangular, rounded cross-section that extends into the interior of the distal aspect **370** of the dual pivot joint. The tapered feature of this centered gap **384** is partially defined by a pair of angled faces **388** that operate to allow the draw wire **228** and clip release wires **292** to be fed in between the walls **364**, through the hole **386**, and into the interior of the distal aspect, where the wires are ultimately fed through a clip deployment frame **520**. The tapered nature of this gap **384** ensures that the draw wire **228** and clip release wires **292** do not become bound up by pivoting action of the dual pivot joint **350** with respect to the clevis **302**. But for the tapered nature of the gap **384**, pivoting action beyond center of the dual pivot joint **350** with respect to the clevis **302** would cause the path of the draw wire **228** and clip release wires **292** to be lengthened, thereby potentially resulting in premature release of the clip **1160** and opening of the clip.

Adjoining the angled faces **388** is an arcuate wall **390** that curves around a lateral edge of the proximal section **352** and extends into the interior of the distal section **370**. The arcuate wall **390** is inset within the proximal section **352** to create a lateral trench **392** on the right and left sides. Each lateral trench **392** ends distally proximate a lateral, longitudinal opening **396** extending through right and left side paddles **402**. This pair of lateral trenches **390** respectively receives one of the connection wires **190** so that the ends of each connection wire extend into the interior of the distal section **370**. Each end of the connection wire **190** is enlarged to prohibit the end from passing through the longitudinal opening **396**. In other words, the longitudinal opening **396** is sized to allow throughput of the connection wire **190** along the longitudinal length of the connection wire, but is sized to prohibit throughput of the enlarged end of the connection wire. In this manner, tension can be applied the connection wires **190** in order to cause the dual pivot joint **350** to pivot with respect to the clevis **302**. By applying tension to the right side connection wire **190**, the dual pivot joint pivots to the right side. Conversely, by applying tension to the left side connection wire **190**, the dual pivot joint pivots to the left side.

The right side paddle **402** is a mirror image of the left side paddle. Accordingly, for purposes of explanation, only a single paddle will be described. Each paddle **402** includes a lateral exterior surface **406** that is substantially planar but for a pair of projections **408** that are spaced apart from one

another by the longitudinal opening **396** extending therebetween. Each projection **408** includes a linear aspect **410** that extends in parallel with the longitudinal opening **396** and a curved aspect **412**. As will be discussed in more detail hereafter, the curved aspect **412** has a curvature that mirrors the arcuate motion of the yoke **380**. The paddle **402** includes a vertical height extending above and below the proximal section **352**. The top and bottom surfaces **414** of the paddle **402** are generally planar and are bridged by a curved circumferential surface **418**. The lateral or widthwise dimension of the paddle **402** is substantially uniform, from proximal to distal, but for an interior depression **420** that is open on the distal end of the paddle and extends proximally to intersect the longitudinal opening **396**. The depression **420** is partially defined by a planar wall **424** that is perpendicular to a second planar wall **426** with an arcuate transition therebetween. At the same time, a third wall **428** is also perpendicular to the planar wall **424** and includes an arcuate profile that corresponds to the arcuate profile of a plateau of the yoke **380**. An interior planar wall **430** of each paddle **402** intersects a pair of rectangular projections **432**. Each rectangular projection **432** includes a distal wall **436** that is arcuate from right to left. The arcuate curvature of the distal wall generally tracks the arcuate profile of a portion of the yoke **380**.

Referring to FIGS. **21-26**, the yoke **380** comprises a hollow box having a roof **440**, a floor, **442**, a right side wall **444**, and a left side wall **446**. The front of the box is open and reveals the interior cavity. Extending laterally outward from the right and left side walls **444**, **446** are respective right and left wings **448**, **450**.

Each wing **448**, **450** includes a pair of circumferential projections **452** that extend vertically therethrough to protrude above and below the wing. In this exemplary embodiment, the projections are sized and spaced apart to facilitate grasping of the yoke **380** by a robotic grasper **456** (see FIG. **29**). A distal portion of the each wing **448**, **450** is generally flush with walls defining a distal recess **458** within the respective right and right and left side walls **444**, **446**. As will be discussed in more detail hereafter, the distal recess is sized to accommodate partial insertion of the clip deployment frame **520**.

The right wing **448** is laterally widest at its distal end and tapers in a widthwise dimension, bounded by an arcuate peripheral surface **460**. The proximal portion of the right wing **448** extends proximally beyond the hollow box and includes a planar guide **464** that is parallel to a right side plateau **466** extending from a proximal section **468** of the yoke **380**. A hole **470** extends through the planar guide **464** and extends into communication with an underneath trench **472** formed into the bottom surface **474** of the right wing. This underneath trench **472** terminates distally at the distal end of the right wing **448**. In particular, one of the clip deployment wires **292** is fed past the proximal section **468**, through the hole **470**, and along this underneath trench **472** to exit and extend distally from the trench.

The proximal section **468** includes right and left side plateaus **466**, **476** that extend in opposite directions from one another. Each plateau **466**, **476** includes a teardrop shaped circumferential surface **478** with the rounded portion of the surface adapted to have an arcuate curvature that approximates the arcuate curvature of the third wall **428** of the dual pivot joint **350**. The plateaus **466**, **476** are interposed by a platform. **482** having opposed, generally planar parallel surfaces **484**. Accordingly, the yoke **380** may pivot with respect to the dual pivot joint **350** by the plateaus **466**, **476** pivoting or rotating with respect to the third wall **428**. The pointed aspect of each circumferential surface **478** cooperates with the straight walls of the second planar wall **426** of the dual pivot joint **350** to provide stops that limit the pivotal motion of the dual pivot joint with respect to the yoke to no more than fifty-five degrees from center (total range of motion of approximately 110 degrees). As will be understood by those skilled in the art, the range of travel may be increased by increasing the angle of the pointed aspect of the circumferential surfaces. Conversely, the range of travel may be decreased by decreasing the angle of the pointed aspect of the circumferential surfaces.

A proximal aspect of the platform **482** is rounded and includes two pair of arcuate, solid walls **486** that are spaced apart from one another to create a gap **488** that tapers distally to create a through hole **490** extending into the interior of the hollow box. The tapered feature of this gap **488** is partially defined by a pair of angled faces that operate to allow the draw wires **228** to be fed in between the walls **486**, through the hole **490** and fed through the clip deployment frame **520**, where the wires are ultimately connected to an occlusion clip **1160** (see FIG. **30**). The tapered nature of this gap **488** ensures that the draw wires **228** do not become bound up by pivoting action of the yoke **380** with respect to the dual pivot joint **350**. But for the tapered nature of the gap **488**, pivoting action beyond center of the yoke **380** with respect to the dual pivot joint **350** would cause the path of the draw wires **228** to be lengthened, thereby resulting in potentially premature opening of the occlusion clip **1160**.

Interposing the solid walls **486** and inset therein are top and bottom arcuate walls **492**, **494**. The arcuate nature of these walls **492**, **494**, teamed with being inset in between the solid walls **486** creates a groove that feeds respective top and bottom holes **498**, **500** that are open to the interior of the hollow box. In exemplary form, each connection wire **188** is received within the respective grooves so that the distal ends of the connection wires extend into the interior of the hollow box. Each end of the connection wires **188** is enlarged to prohibit the end from passing through the top and bottom holes **498**, **500**. In other words, the holes **498**, **500** are sized to allow throughput of the connection wires **188**, but are sized to prohibit throughput of the enlarged end of the connection wires. In this manner, tension can be applied the connection wires **188** in order to cause the yoke **380** to pivot with respect to the dual pivot joint **350**. By applying tension to the top side connection wire **188**, the yoke pivots upward with respect to the dual pivot joint **350**. Conversely, by applying tension to the bottom connection wire **188**, the yoke pivots downward with respect to the dual pivot joint **350**.

Adjacent the platform **482**, on the left side, is the left wing **450**. The left wing **450** is laterally widest at its distal end and tapers in a widthwise dimension, bounded by an arcuate peripheral surface **504**. The proximal portion of the left wing **450** extends proximally beyond the hollow box and includes a planar guide **506** that is parallel to the left side plateau **476**. A hole **508** extends through the planar guide **506** and extends into communication with an underneath trench **510** formed into the bottom surface **512** of the left wing. This underneath trench **510** terminates prior to reaching the distal end of the left wing **450**. In particular, the trench **510** terminates and feeds into a distal tunnel **514** that extends through a distal portion of the left wing **450**. In this exemplary embodiment, a second of the clip deployment wires **292** is fed past the proximal section **468**, through the hole **508**, along this underneath trench **510**, through the tunnel **514** and exits distally from the tunnel.

Referring to FIGS. **27-35**, the clip deployment device **118** is partially received within the interior of the hollow box. In exemplary form, the clip deployment device **118** includes a

rectangular frame **520** having parallel longitudinal sides **524**, **526** that are connected to one another via a distal cross-member **527** with rounded corners therebetween. In this exemplary embodiment, each parallel side **524**, **526** includes a substantially planar interior wall **528** and a concave exterior wall **530**, opposite the interior wall. The concave nature of the exterior wall **530** creates a longitudinal channel, with one exterior channel receiving a first of the clip deployment wires **292**. In addition, the parallel sides **524**, **526** may include one or more through orifices extending through the interior and exterior walls **528**, **530**.

The proximal end of the rectangular frame **522** includes a pair of rounded corners that extend from the parallel sides **524**, **526**. Each rounded corner on the proximal end forms part of an S-shaped retainer **540**, **542** that is partially received within the hollow box interior of the yoke **380**. More specifically, both S-shaped retainers **540**, **542** comprise a first rounded corner that transitions into a straight segment **546**, which transitions into a semicircular segment **548**. The S-shaped retainers **540**, **542** are mirror images of one another, except that the one retainer **540** includes an orifice **550** that extends through the interior and exterior surfaces and along the majority of the straight and semicircular segments **546**, **548**.

In order to secure the clip deployment device **118** to the yoke **380**, two dowels **560** are inserted through corresponding holes **562** in the top and bottom surfaces **440**, **442** of the yoke. The holes **562** are sized to retain the dowels **560** in position. But before the dowels **560** are inserted into the holes **562**, the S-shaped retainers **540**, **542** are inserted into the interior of the yoke **380**. In exemplary form, the vertical dimension of the S-shaped retainers **540**, **542** is such that the retainers are wedged in between the top and bottom walls **440**, **442** of the yoke **380**. Moreover, the collective lengthwise dimension of the S-shaped retainers **540**, **542** is such that the retainers are wedged in between the right and left side walls **444**, **446**. In this manner, even absent the dowels **560**, there is not significant play between the clip deployment device **118** to the yoke **380** in the vertical and lateral directions. In order to reduce play in the proximal-to-distal direction, the dowels **560** are inserted through the holes **562** after the semicircular segment **548** of each S-shaped retainers **540**, **542** is positioned to partially outline an imaginary cylinder extending through the holes. This locks the S-shaped retainers **540**, **542** in position with respect to the yoke **380**, thereby mounting the clip deployment device **118** to the yoke.

The orifice **550** of the one retainer **540** provides an egress hole through which a second of the clip deployment wires **292** passes through. The second of the clip deployment wires **292** extends into the interior of the rectangular frame **522** and passes longitudinally along the exterior of an elongated deployment plate **566**. The deployment plate **566** includes a pair of orifices **568** near the proximal and distal ends of the plate. As will be discussed in more detail hereafter, the orifices **568** receive suture loops **570** that are captured by the clip deployment wire **292** passing therethrough.

The orifice **550** also provides an egress hole through which the draw wires **228** pass through. The draw wires **228** are initially routed into the interior of the rectangular frame **522** to pass through an orifice **572** in one of the proximal rounded corners. Both wires **228** extend along the longitudinal channel of one of the parallel sides **524** created by the concave exterior wall **530**. One of the wires passes through a first proximal orifice **576** in the first parallel side **524**, while the second wire continues to extend along the longitudinal channel until reaching a second distal orifice **578**. Both wires **228** then extend into the interior of the rectangular frame **522** and pass perpendicularly through a second set of orifices **580** of the elongated deployment plate **566**. This second set of orifices **580** are inset with respect to the pair of orifices **568** near the proximal and distal ends of the plate. The wires are joined and create a closed loop coupled to the deployment plate **566**.

Referring to FIGS. **36-38** show one embodiment of a left atrial appendage occlusion clamp **1110** in an open position with spaced apart rigid clamping portions **1102**, **1104** and resilient or elastic urging members **1106**, **1108** at opposite ends of each clamping portion **1102**, **1104**. Clamping portions **1102**, **1104** may be tubular, and both clamping portions **1102**, **1104** may be at least substantially parallel to each other when arrest, i.e., when they are not being used to clamp tissue. Clamping portions **1102**, **1104** may also be of substantially equal length or of different length, and each may be of larger outer diameter than the wire that may be used to form each of the urging members **1106**, **1108**. In this regard, the wire forming urging members **1106**, **1108** can extend through the hollow interiors of the clamping portions **1102**, **1104**. In this illustrative example, the urging members **1106**, **1108** are each shaped as a loop. The planes defined by the looped configuration of each of the urging members **1106**, **1108** may be substantially parallel to each other and, in turn, substantially perpendicular to each of the clamping portions **1102**, **1104**. Of course, other angular orientations are possible as well.

FIGS. **37-39** show the same clamp **1110** of FIGS. **36-38** with the clamping portions **1102**, **1104** in their normally biased together positions. Contact between the clamping portions **1102**, **1104** may occur initially along their entire parallel lengths as shown. Of course, when clamping portions **1102**, **1104** are covered in fabric or other material as later described, contact may occur between the fabric or other material instead. In FIGS. **36-39**, only the structure and relative positions of the rigid members **1102**, **1104** and urging members **1106**, **1108** are shown. The final assembly is depicted in FIGS. **40-42** which, although describing a slightly different embodiment, show the general steps in the construction of each embodiment. The clamping portions **1102**, **1104** may be made from rigid tubes **1112**, **1114** of a rigid metal such as titanium disposed over a wire member **1116**. In this embodiment, titanium is used for its compatibility with MRI imaging, its biocompatibility and its galvanic compatibility with the wire member **1116** when the wire member **1116** is formed from superelastic materials such as a nickel titanium alloy. This embodiment and the other embodiments disclosed herein may use a superelastic material such as a nickel titanium alloy to form the urging members **1106**, **1108**. Superelastic properties will allow the material to be greatly extended to open the clamping portions **1106**, **1108** of the clamp **1110** without permanently deforming the material. These superelastic materials can also be compatible with MRI imaging and easily tolerated as an implant material in the body. The rigid tubular members **1112**, **1114** of this embodiment are mechanically fastened to the underlying wire member **1116** preferably by mechanically swaging the titanium tubes **1112**, **1114** to the wire members **1116**. Although a single, continuous wire member is shown directed through both clamping portions **1102**, **1104** and urging members **1106**, **1108**, the clamp **1110** of this embodiment may also be made with two or more wires, or with any other suitable components.

As shown in FIG. **40**, in addition to being able to close on tissue or anatomical structure in a parallel fashion, the clamp **1110** can also apply force to the anatomical structure in a nonparallel clamping fashion. This allows the clamp **1110** to accommodate non-uniform tissue thickness over the length of the clamping portions **1102**, **1104**. In addition, with separate

urging members **1106**, **1108** at opposite ends of the clamping portions **1102**, **1104** the nonparallel clamping can originate from either side of the clamp **1110**. The non-parallel clamping feature of this embodiment allows the clamp **1110** to accommodate a wide range of hollow anatomical structures with varying wall thicknesses throughout its length and breadth. For example, some anatomical structures such as atrial appendages of the heart have internal structures called trabeculae, which are non-uniform and very often cause variable thicknesses across one or more of their dimensions. Nonuniform clamping, therefore, can be advantageous in this application for this reason or for other reasons.

FIG. **41** shows an alternate embodiment of a clamp **1160** including two urging members **1166**, **1168** shaped to resemble a letter "U" instead of the more circular loop configuration of the embodiment of FIGS. **36-39**. As is the case with the first clamp **1110**, the U-shaped urging members **1166**, **1168** of clamp **1160** may also lie in planes generally parallel to each other and perpendicular to the axes of the clamping portions **1162**, **1164**. A potential use of the embodiment of FIG. **41** may lie in the lesser force exerted by U-shape urging members **1166**, **1168** on the clamping portions **1162**, **1164** with respect to the force exerted by the loop-shape urging members **1106**, **1108** of clamp **1110** in FIGS. **36-39**, making it more suitable for clamping of anatomical structures not requiring a relatively high clamping force. The U-shape configuration of the urging members **1166**, **1168** generally requires less space in the direction perpendicular to the axes of the clamping portions **1162**, **1164**. FIG. **41** shows a first stage of assembly of the clamp **1160**, where the rigid tubular members **1163**, **1165** are joined with the superelastic wire member **1161**. In this embodiment, mechanical swaging is used to join the tubular members **1163**, **1165** to the wire **1161**. However, adhesives or laser welding or other methods of attachment could be easily used instead. Similarly, it will be appreciated that rigid tubular members **1163**, **1165** may not necessarily need to be bonded to wire member **1161** at all. One may rely, for example, on designing the rigid tubular members **1163**, **1165** so that their inside diameters simply closely fit over the wire **1161**. In addition, the rigid tubular members **1163**, **1165** could take on many different cross sectional shapes. Cross-sectional shapes such as ovals, triangles or rectangles with rounded edges could be preferable and may eliminate the addition of the load spreading platens **1167**, **1169** shown in FIG. **42**, as these alternate shapes may provide a larger area of contact against the anatomical structure to be engaged by the clamp **1150**. Since different anatomical structures greatly vary from subject to subject, it is advantageous to have a manufacturing method in which the length **1171** of the clamp **1160** can be easily varied. By cutting rigid members **1163**, **1165** to various different lengths, different size assemblies can be configured.

FIG. **42** shows the next step in the assembly of the clamp. Load spreading platens **1167**, **1169** made of plastic or other biocompatible material such as urethane, may be slipped over the titanium or other suitable material tubing that forms rigid tubular members **1163**, **1165**, to provide a resilient surface **1173** to spread the load out onto a larger surface area, thereby preventing point source loading of the tissue which might otherwise result in cutting of the tissue before it has had a chance to become internally fused. The platens **1167**, **1169** can be assembled and applied over the rigid tubular members **1163**, **1165** prior to the swaging step or platens **1167**, **1169** can alternatively be manufactured in such a way so as to have a longitudinal split which allows the material to be opened and forced onto the rigid tubular members **1163**, **1165**.

FIG. **43** shows the clamp **1160** after a fabric cover material **1174** made of material such as polyester has been sewn around the clamping portions **1162**, **1164** and urging members **1166**, **1168**. It will be appreciated that this material or any other similar materials may be used as a full or partial covering in any of the disclosed embodiments. Such a material is preferably suitable to engage the tissue of the anatomical structure being clamped as well as that of surrounding areas. Preferably, the material **1174** is circular warp knit fabric tube, with a diameter of approximately 4 to 5 mm and made from a combination of 4/100, 2/100 and 1/100 textured polyester. The material **1174** may also be heat-treated to cause a velour effect. The fabric or other material **1174** is furthermore sewn or otherwise applied over the urging members **1166**, **1168**. In addition, fabric pieces **1177** may be attached at opposite respective ends of clamping portions **1162**, **1164** to prevent any part of the engaged anatomical structure from escaping the annular occlusion area between the clamping portions **1162**, **1164**. In other words, fabric pieces **1177** act as tissue blocking members or dams at opposite ends of the clamp. This or another tissue blocking feature may also be implemented into any other embodiment. This is desirable as it minimizes the probability of unintentionally leaving any part of the engaged anatomical structure unclamped. The material **1177**, like material **1174**, can also promote tissue in-growth.

Following from the above description and invention summaries, it should be apparent to those of ordinary skill in the art that, while the methods and apparatuses herein described constitute exemplary embodiments of the present invention, it is to be understood that the inventions contained herein are not limited to the above precise embodiment and that changes may be made without departing from the scope of the invention as defined by the following proposed points of novelty. Likewise, it is to be understood that it is not necessary to meet any or all of the identified advantages or objects of the invention disclosed herein in order to fall within the scope of the invention, since inherent and/or unforeseen advantages of the present invention may exist even though they may not have been explicitly discussed herein.

What is claimed is:

1. A surgical device comprising:

a housing operatively coupled to a first control and a second control;

an end effector operatively coupled to the first control, the end effector comprising a first component and a second component selectively repositionable with respect to one another within an X-Y plane, the end effector also including a third component selectively repositionable with respect to the second component within an Y-Z plane;

an occlusion clip deployment device operatively coupled to the end effector and the second control;

a third control operatively coupled to the housing, wherein the third control is operatively coupled to a first connection line operatively coupled to the occlusion clip deployment device so that movement of the third control is operative to reposition at least a portion of the first connection line with respect to the occlusion clip deployment device; and

a conduit extending between the housing and the end effector;

wherein:

the first control includes a first passive constraint and a second passive constraint;

the first passive constraint in an unlocked position allows free motion between the first component and the second component within the X-Y plane;

the first passive constraint in a locked position retards free motion between the first component and the second component within the X-Y plane;

the second passive constraint in an unlocked position allows free motion between the second component and the third component within the Y-Z plane; and,

the second passive constraint in a locked position retards free motion between the second component and the third component within the Y-Z plane;

the third control includes a plug detachable from the housing;

the plug is repositionable from an attached position coupled to the housing to a detached position decoupled from the housing; and,

repositioning the plug from the attached position to the detached position causes more of the first connection line to be drawn into the housing and further away from the occlusion clip deployment device.

2. The surgical device of claim **1**, further comprising an occlusion clip operatively coupled to the clip deployment device using the first connection line.

3. The surgical device of claim **1**, wherein the end effector includes a robotic grasping feature to facilitate grasping and repositioning of the end effector by a robotic grasper.

4. The surgical device of claim **1**, wherein:

the first passive constraint includes at least one connection wire in tension that is operatively coupled to the second component and to the housing; and,

the second passive constraint includes at least one connection wire in tension that is operatively coupled to the third component and to the housing.

5. The surgical device of claim **1**, wherein:

the first passive constraint includes a repositionable button selectively coupled to a first reel, where the button is repositionable between a locked and an unlocked position, where the locked position retards rotation of the first reel, and where the unlocked position allows rotation of the first reel;

the first reel is operatively coupled to a first connection line operatively coupled to the first component;

the second passive constraint includes the repositionable button selectively coupled to a second reel, where the locked position retards rotation of the second reel, and where the unlocked position allows rotation of the second reel;

the second reel is operatively coupled to a second connection line operatively coupled to the second component; and,

the first reel is independently repositionable with respect to the second reel.

6. The surgical device of claim **1**, wherein:

the second control includes a lever operatively coupled and selectively repositionable with respect to the housing, the lever being operatively coupled to a first connection line operatively coupled to the occlusion clip deployment device so that movement of the lever is operative to reposition at least a portion of the occlusion clip deployment device;

the lever is repositionable between a locked and an unlocked position;

the unlocked position allows the lever to be repositioned; and,

the locked position retards the lever from being repositioned.

7. A surgical device comprising:

a housing operatively coupled to a first control;

an end effector operatively coupled to the first control, the end effector comprising a clevis selectively repositionable with respect to a dual pivot joint within an X-Y plane, the dual pivot joint selectively repositionable with respect to a yoke within an Y-Z plane;

a surgical conduit extending between the housing and the end effector; and,

a deployment control operatively coupled to the housing, the deployment control including a deployment line extending along the conduit and concurrently mounted to a deployment plug removably fastened to the housing;

wherein:

the first control includes a first line and a second line extending along the conduit concurrently coupled to the dual pivot joint, the first line impacting movement of the dual pivot joint with respect to the clevis in a first direction within the X-Y plane, the second line impacting movement of the dual pivot joint with respect to the clevis in a second direction, generally opposite the first direction, within the X-Y plane; and,

the first control includes a third line and a fourth line extending along the conduit concurrently coupled to the yoke, the third line impacting movement of the yoke with respect to the dual pivot joint in a third direction within the Y-Z plane, the fourth line impacting movement of the yoke with respect to the dual pivot joint in a fourth direction, generally opposite the third direction, within the Y-Z plane.

8. The surgical device of claim **7**, further comprising an occlusion clip operatively coupled to the occlusion clip deployment device using the deployment line.

9. The surgical device of claim **8**, wherein:

the occlusion clip includes a first jaw opposing a second jaw;

a first retainer loop at least partially circumscribes the first jaw, at least a portion of the occlusion clip deployment device, and at least a portion of the deployment line;

a second retainer loop at least partially circumscribes the second jaw, at least a portion of the occlusion clip deployment device, and at least a portion of the deployment line.

10. The surgical device of claim **7**, wherein the end effector includes a robotic grasping feature to facilitate grasping and repositioning of the end effector by a robotic grasper.

11. The surgical device of claim **7**, wherein:

the first line and the second line are coupled to a first actuator mounted to the housing;

the first actuator is repositionable and operative to reposition the first line and the second line in order to create movement between the clevis and dual pivot joint;

the third line and the fourth line are coupled to a second actuator mounted to the housing;

the second actuator is repositionable and operative to reposition the third line and the fourth line in order to create movement between the yoke and dual pivot joint.

12. The surgical device of claim **11**, wherein:

the first actuator comprises a first reel upon which at least a portion of the first line and the second line are wound;

the second actuator comprises a second reel upon which at least a portion of the third line and the fourth line are wound;

repositioning of the first reel is operative to distally reposition one of the first line and the second line, while repositioning of the first reel is operative to proximally reposition the other of the first line and the second line;

repositioning of the second reel is operative to distally reposition one of the third line and the fourth line, while repositioning of the second reel is operative to proximally reposition the other of the third line and the fourth line.

13. The surgical device of claim **12**, wherein the first control includes a brake that may be selectively applied to the first actuator and the second actuator to retard movement of the dual pivot joint with respect to the clevis within the X-Y plane and movement of the yoke with respect to the dual pivot joint within the Y-Z plane.

14. The surgical device of claim **13**, wherein:

the brake comprises a spring biased button operatively coupled to a series of teeth;

the first reel includes a series of teeth;

the second reel includes a series of teeth; and

engagement between at least one of the series of teeth operatively coupled to the spring biased button and at least one of the series of teeth of the first reel and least one of the series of teeth of the second reel is operative to retard movement of the dual pivot joint with respect to the clevis within the X-Y plane and movement of the yoke with respect to the dual pivot joint within the Y-Z plane.

15. The surgical device of claim **7**, further comprising an occlusion clip deployment device operatively coupled to the end effector and to a second control, wherein:

the housing is operatively coupled to the second control; and,

the second control includes a clip repositioning line extending along the conduit, the clip repositioning line impacting movement of the occlusion clip deployment device between a first position and a second position.

16. The surgical device of claim **15**, wherein:

the second control includes a lever operatively coupled and selectively repositionable with respect to the housing, the lever being operatively coupled to the clip repositioning line so that movement of the lever is operative to reposition the occlusion clip deployment device;

the lever is repositionable between a locked and an unlocked position;

the unlocked position allows the lever to be repositioned; and,

the locked position retards the lever from being repositioned.

17. A surgical device comprising:

a housing operatively coupled to a first control;

an end effector operatively coupled to the first control, the end effector comprising a clevis selectively repositionable with respect to a dual pivot joint within an X-Y plane, the dual pivot joint selectively repositionable with respect to a yoke within an Y-Z plane;

a surgical conduit extending between the housing and the end effector;

an occlusion clip deployment device operatively coupled to the end effector and configured to deploy an occlusion clip comprising opposing parallel beams biased toward one another;

a deployment control operatively coupled to the housing, the deployment control including a deployment line extending along the conduit and concurrently mounted to a deployment plug removably fastened to the housing; and,

an occlusion clip operatively coupled to the occlusion clip deployment device using the deployment line, wherein:

the occlusion clip includes a first jaw opposing a second jaw;

a first retainer loop at least partially circumscribes the first jaw, at least a portion of the occlusion clip deployment device, and at least a portion of the deployment line;

a second retainer loop at least partially circumscribes the second jaw, at least a portion of the occlusion clip deployment device, and at least a portion of the deployment line.

18. The surgical device of claim **17**, wherein the end effector includes a robotic grasping feature to facilitate grasping and repositioning of the end effector by a robotic grasper.

* * * * *

专利名称(译)	剪辑部署工具和相关方法		
公开(公告)号	US9282973	公开(公告)日	2016-03-15
申请号	US13/355169	申请日	2012-01-20
[标]申请(专利权)人(译)	HUGHETT SR詹姆斯·戴维· MARTIN KEITH EDWARD MILLER KENNETH LANCE DOLGIN MICHAEL		
申请(专利权)人(译)	HUGHETT，SR.，JAMES DAVID MARTIN，KEITH EDWARD MILLER，KENNETH LANCE DOLGIN，MICHAEL		
当前申请(专利权)人(译)	ATRICURE INC.		
[标]发明人	HUGHETT SR JAMES DAVID MARTIN KEITH EDWARD MILLER KENNETH LANCE DOLGIN MICHAEL		
发明人	HUGHETT, SR., JAMES DAVID MARTIN, KEITH EDWARD MILLER, KENNETH LANCE DOLGIN, MICHAEL		
IPC分类号	A61B17/128 A61B17/122 A61B17/29 A61B17/00		
CPC分类号	A61B17/1285 A61B17/1227 A61B2017/00867 A61B2017/2946 A61B2017/00584		
其他公开文献	US20130190777A1		
外部链接	Espacenet USPTO		

摘要(译)

一种腹腔镜装置，包括：（a）可操作地连接到第一控制器和第二控制器的壳体;（b）可操作地连接到第一控制器的末端执行器，末端执行器包括可在XY平面内相对于彼此选择性地重新定位的第一部件和第二部件，该末端执行器还包括相对于第一部件可选择地重新定位的第三部件。YZ平面内的第二个分量;（c）在外壳和末端执行器之间延伸的腹腔镜导管;（d）可操作地连接到末端执行器和第二控制器的闭塞夹子展开装置。