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(12) **United States Patent**
Shadduck

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(54) **MEDICAL INSTRUMENT AND METHOD OF USE**

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A61B 18/18 (2006.01)

(52) **U.S. Cl.** **606/41**; 606/46; 607/105; 607/107

(58) **Field of Classification Search** 606/27, 606/28, 38–41, 45–50; 607/96, 104–107
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

408,899	A	8/1889	Bioch et al.
697,181	A	4/1902	Smith
1,719,750	A	9/1927	Bridge et al.
3,818,913	A	6/1974	Wallach
3,880,168	A	4/1975	Berman
3,930,505	A	1/1976	Wallach
4,024,866	A	5/1977	Wallach
4,083,077	A	4/1978	Knight et al.
4,672,962	A	6/1987	Hershenson
4,682,596	A	7/1987	Bales et al.
4,748,979	A	6/1988	Hershenson
4,773,410	A	9/1988	Blackmer et al.

(Continued)

FOREIGN PATENT DOCUMENTS

WO	WO 00/11927	3/2000

(Continued)

OTHER PUBLICATIONS

Moulding et al., "Preliminary studies for achieving transcervical oviduct occlusion by hot water or low-pressure steam," *Advancesin Planned Parenthood*, vol. 12, No. 2; pp. 79-85, 1977.

U.S. Appl. No. 09/181,906, filed Oct. 28, 1998, in the name of Shadduck, Non-Final Rejection mailed Mar. 15, 2000.

U.S. Appl. No. 09/181,906, filed Oct. 28, 1998, in the name of Shadduck, Notice of Allowance mailed Sep. 26, 2000.

U.S. Appl. No. 09/281,493, filed Mar. 30, 1999 in the name of Shadduck, entitled "Ionothermal system and technique for dermal treatments".

U.S. Appl. No. 09/557,931, filed Apr. 22, 2000 in the name of Shadduck, entitled "Ionothermal delivery system and technique for medical procedures".

U.S. Appl. No. 09/580,767, filed May 30, 2000 in the name of Shadduck, entitled "Microjoule electrical discharge catheter for thrombolysis in stroke patients".

(Continued)

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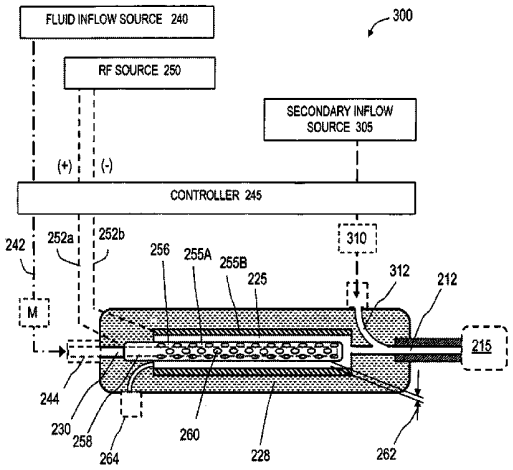
(57) **ABSTRACT**

This invention relates to surgical instruments for applying energy to tissue using a a vapor-to-liquid phase transition which delivers large amount of energy to the targeted tissue. In one embodiment, the system is configured for volumetric removal of tissue by means of high velocity ejection of a vapor media from a first vapor port proximate to soft tissue wherein the vapor-to-liquid phase change of the media applies energy to the tissue. The system provides a second port coupled to a suction source that cooperates with the first vapor port to suction tissue debris from the targeted site.

36 Claims, 16 Drawing Sheets



U.S. PATENT DOCUMENTS

4,793,352 A 12/1988 Eichenlaub
4,872,920 A 10/1989 Flynn et al.
4,898,574 A 2/1990 Uchiyama et al.
4,915,113 A 4/1990 Holman
4,950,266 A 8/1990 Sinofsky
4,985,027 A 1/1991 Dressel
5,006,119 A 4/1991 Acker et al.
5,011,566 A 4/1991 Hoffman
5,084,043 A 1/1992 Hertzmann et al.
5,102,410 A 4/1992 Dressel
5,112,328 A 5/1992 Taboada et al.
5,122,138 A 6/1992 Manwaring
5,158,536 A 10/1992 Sekins et al.
5,190,539 A 3/1993 Fletcher et al.
5,217,459 A 6/1993 Kamerling
5,217,465 A 6/1993 Steppe
5,263,951 A 11/1993 Spears et al.
5,277,696 A 1/1994 Hagen
5,298,298 A 3/1994 Hoffman
5,318,014 A 6/1994 Carter
5,331,947 A 7/1994 Shturman
5,334,190 A 8/1994 Seiler
5,348,551 A 9/1994 Spears et al.
5,352,512 A 10/1994 Hoffman
5,417,686 A 5/1995 Peterson et al.
5,424,620 A 6/1995 Cheon et al.
5,433,708 A 7/1995 Nichols et al.
5,433,739 A 7/1995 Sluijter
5,462,521 A 10/1995 Brucker et al.
5,500,012 A 3/1996 Brucker et al.
5,503,638 A 4/1996 Cooper et al.
5,524,620 A 6/1996 Rosenschein
5,529,076 A 6/1996 Schachar
5,542,928 A 8/1996 Evans et al.
5,549,628 A 8/1996 Cooper et al.
5,554,172 A 9/1996 Horner et al.
5,562,608 A 10/1996 Sekins et al.
5,575,803 A 11/1996 Cooper et al.
5,584,872 A 12/1996 LaFontaine et al.
5,591,157 A 1/1997 Hennings et al.
5,591,162 A 1/1997 Fletcher et al.
5,616,120 A 4/1997 Andrew et al.
5,620,440 A 4/1997 Heckele et al.
5,669,907 A 9/1997 Platt et al.
5,681,282 A 10/1997 Eggers et al.
5,683,366 A 11/1997 Eggers et al.
5,695,507 A 12/1997 Auth et al.
5,697,281 A 12/1997 Eggers et al.
5,697,536 A 12/1997 Eggers et al.
5,697,882 A 12/1997 Eggers et al.
5,697,909 A 12/1997 Eggers et al.
5,700,262 A 12/1997 Acosta et al.
5,707,352 A 1/1998 Sekins et al.
5,735,811 A 4/1998 Brisken
5,741,247 A 4/1998 Rizoiu et al.
5,741,248 A 4/1998 Stern et al.
5,752,965 A 5/1998 Francis et al.
5,755,753 A 5/1998 Knowlton
5,782,914 A 7/1998 Schankereli
5,785,521 A 7/1998 Rizoiu et al.
5,800,482 A 9/1998 Pomeranz et al.
5,810,764 A 9/1998 Eggers et al.
5,824,703 A 10/1998 Clark, Jr.
5,827,268 A 10/1998 Laufer
5,843,019 A 12/1998 Eggers et al.
5,843,073 A 12/1998 Sinofsky
5,871,469 A 2/1999 Eggers
5,879,329 A 3/1999 Ginsburg
5,885,243 A 3/1999 Capetan et al.
5,888,198 A 3/1999 Eggers et al.
5,891,095 A 4/1999 Eggers et al.
5,891,134 A 4/1999 Goble et al.
5,913,856 A 6/1999 Chia et al.
5,944,686 A 8/1999 Patterson et al.
5,944,715 A 8/1999 Goble et al.
5,957,919 A 9/1999 Laufer
5,964,752 A 10/1999 Stone
5,968,037 A 10/1999 Rizoiu
5,980,504 A 11/1999 Sharkey et al.
5,986,662 A 11/1999 Argiro et al.
5,989,212 A 11/1999 Sussman et al.
5,989,238 A 11/1999 Ginsburg
5,989,249 A 11/1999 Kirwan
5,989,445 A 11/1999 Wise et al.
5,997,499 A 12/1999 Sussman et al.
6,024,733 A 2/2000 Eggers et al.
6,027,501 A 2/2000 Goble et al.
6,032,077 A 2/2000 Pomeranz
6,032,674 A 3/2000 Eggers et al.
6,047,700 A 4/2000 Eggers et al.
6,053,909 A 4/2000 Shadduck
6,056,746 A 5/2000 Goble et al.
6,059,011 A 5/2000 Giolo
6,063,079 A 5/2000 Hovda et al.
6,063,081 A 5/2000 Mulier et al.
6,066,134 A 5/2000 Eggers et al.
6,074,358 A 6/2000 Andrew et al.
6,080,128 A 6/2000 Sussman et al.
6,080,151 A 6/2000 Swartz et al.
6,083,255 A 7/2000 Laufer et al.
6,095,149 A 8/2000 Sharkey et al.
6,099,251 A 8/2000 LaFleur
6,102,046 A 8/2000 Weinstein et al.
6,102,885 A 8/2000 Bass
6,106,516 A 8/2000 Bmassengill
6,110,162 A 8/2000 Sussman et al.
6,113,722 A 9/2000 Hoffman et al.
6,126,682 A 10/2000 Sharkey et al.
6,130,671 A 10/2000 Argiro
6,139,571 A 10/2000 Fuller et al.
6,149,620 A 11/2000 Eggers et al.
6,156,036 A 12/2000 Sussman et al.
6,159,194 A 12/2000 Eggers et al.
6,162,232 A 12/2000 Shadduck
6,168,594 B1 1/2001 LaFontaine et al.
6,174,308 B1 1/2001 Goble et al.
6,179,805 B1 1/2001 Sussman et al.
6,190,381 B1 2/2001 Olsen et al.
6,194,066 B1 2/2001 Hoffman
6,196,989 B1 3/2001 Padget et al.
6,200,333 B1 3/2001 Laufer
6,206,848 B1 3/2001 Sussman et al.
6,210,404 B1 4/2001 Shadduck
6,210,405 B1 4/2001 Goble et al.
6,219,059 B1 4/2001 Argiro
6,224,592 B1 5/2001 Eggers et al.
6,231,567 B1 5/2001 Rizoiu et al.
6,235,020 B1 5/2001 Cheng et al.
6,238,391 B1 5/2001 Olsen et al.
6,254,597 B1 7/2001 Rizoiu et al.
6,261,286 B1 7/2001 Goble et al.
6,261,311 B1 7/2001 Sharkey et al.
6,264,650 B1 7/2001 Hovda et al.
6,264,651 B1 7/2001 Underwood et al.
6,264,654 B1 7/2001 Swartz et al.
6,277,112 B1 8/2001 Underwood et al.
6,283,961 B1 9/2001 Underwood et al.
6,283,989 B1 9/2001 Laufer et al.
6,287,274 B1 9/2001 Sussman et al.
6,290,715 B1 9/2001 Sharkey et al.
6,296,636 B1 10/2001 Cheng et al.
6,296,638 B1 10/2001 Davison et al.
6,299,633 B1 10/2001 Laufer
6,300,150 B1 10/2001 Venkatasubramanian
6,312,408 B1 11/2001 Eggers et al.
6,312,474 B1 11/2001 Francis et al.
6,315,755 B1 11/2001 Sussman
6,319,222 B1 11/2001 Andrew et al.
6,327,505 B1 12/2001 Medhkour et al.
6,331,171 B1 12/2001 Cohen
6,355,032 B1 3/2002 Hovda et al.
6,375,635 B1 4/2002 Moutafis et al.
6,379,350 B1 4/2002 Sharkey et al.
6,391,025 B1 5/2002 Weinstein et al.
6,394,949 B1 5/2002 Crowley et al.
6,394,996 B1 5/2002 Lawrence et al.
6,398,759 B1 6/2002 Sussman et al.

6,398,775 B1 6/2002 Perkins et al.
6,409,723 B1 6/2002 Edwards
6,416,508 B1 7/2002 Eggers et al.
6,458,231 B1 10/2002 Wapner et al.
6,461,350 B1 10/2002 Underwood et al.
6,464,694 B1 10/2002 Massengill
6,464,695 B2 10/2002 Hovda et al.
6,468,270 B1 10/2002 Hovda et al.
6,468,274 B1 10/2002 Alleyne et al.
6,468,313 B1 10/2002 Claeson et al.
6,482,201 B1 11/2002 Olsen et al.
6,482,202 B1 11/2002 Goble et al.
6,488,673 B1 12/2002 Laufer et al.
6,493,589 B1 12/2002 Medhkour et al.
6,500,173 B2 12/2002 Underwood et al.
6,508,816 B2 1/2003 Shadduck
6,517,568 B1 2/2003 Sharkey et al.
6,522,930 B1 2/2003 Schaer et al.
6,527,761 B1 3/2003 Soltesz et al. et al.
6,527,766 B1 3/2003 Bair
6,540,741 B1 4/2003 Underwood et al.
6,544,211 B1 4/2003 Andrew et al.
6,544,248 B1 4/2003 Bass
6,547,810 B1 4/2003 Sharkey et al.
6,558,379 B1 5/2003 Batchelor et al.
6,575,929 B2 6/2003 Sussman et al.
6,575,968 B1 6/2003 Eggers et al.
6,579,270 B2 6/2003 Sussman et al.
6,582,423 B1 6/2003 Thapliyal et al.
6,585,639 B1 7/2003 Kotmel et al.
6,588,613 B1 7/2003 Pechenik et al.
6,589,201 B1 7/2003 Sussman et al.
6,589,204 B1 7/2003 Sussman et al.
6,592,594 B2 7/2003 Rimbaugh et al.
6,595,990 B1 7/2003 Weinstein et al.
6,599,311 B1 7/2003 Biggs et al.
6,602,248 B1 8/2003 Sharps et al.
6,605,087 B2 8/2003 Swartz et al.
6,610,043 B1 8/2003 Ingenito
6,620,130 B1 9/2003 Ginsburg
6,620,155 B2 9/2003 Underwood et al.
6,623,444 B2 9/2003 Babaev
6,632,193 B1 10/2003 Davison et al.
6,632,220 B1 10/2003 Eggers et al.
6,634,363 B1 10/2003 Danek et al.
6,648,847 B2 11/2003 Sussman et al.
6,652,594 B2 11/2003 Francis et al.
6,653,525 B2 11/2003 Ingenito et al.
6,659,106 B1 12/2003 Hovda et al.
6,669,685 B1 12/2003 Rizoiu et al.
6,669,694 B2 12/2003 Shadduck
6,676,628 B2 1/2004 Sussman et al.
6,676,629 B2 1/2004 Andrew et al.
6,679,264 B1 1/2004 Deem et al.
6,679,879 B2 1/2004 Shadduck
6,682,520 B2 1/2004 Ingenito
6,692,494 B1 2/2004 Cooper et al.
6,695,839 B2 2/2004 Sharkey et al.
6,699,212 B1 3/2004 Kadziauskas et al.
6,699,244 B2 3/2004 Carranza et al.
6,712,811 B2 3/2004 Underwood et al.
6,712,812 B2 3/2004 Roschak et al.
6,719,738 B2 4/2004 Mehier
6,719,754 B2 4/2004 Underwood et al.
6,723,064 B2 4/2004 Babaev
6,726,684 B1 4/2004 Woloszko et al.
6,726,708 B2 4/2004 Lasheras
6,746,447 B2 6/2004 Davison et al.
6,755,794 B2 6/2004 Soukup
6,758,846 B2 7/2004 Goble et al.
6,763,836 B2 7/2004 Novak et al.
6,764,487 B2 7/2004 Mulier et al.
6,766,202 B2 7/2004 Underwood et al.
6,770,070 B1 8/2004 Balbierz
6,770,071 B2 8/2004 Woloszko et al.
6,772,012 B2 8/2004 Ricart et al.
6,776,765 B2 8/2004 Soukup et al.
6,780,180 B1 8/2004 Goble et al.
6,805,130 B2 10/2004 Tasto et al.
6,832,996 B2 12/2004 Woloszko et al.
6,837,884 B2 1/2005 Woloszko
6,837,888 B2 1/2005 Ciarrocca et al.
6,852,108 B2 2/2005 Barry et al.
6,860,847 B2 3/2005 Alferness et al.
6,860,868 B1 3/2005 Sussman et al.
6,875,194 B2 4/2005 MacKool
6,896,674 B1 5/2005 Woloszko et al.
6,896,675 B2 5/2005 Leung et al.
6,901,927 B2 6/2005 Deem et al.
6,904,909 B2 6/2005 Andreas et al.
6,907,881 B2 6/2005 Suki et al.
6,911,028 B2 6/2005 Shadduck
6,918,903 B2 7/2005 Bass
6,921,385 B2 7/2005 Clements et al.
6,929,640 B1 8/2005 Underwood et al.
6,949,096 B2 9/2005 Davison et al.
6,955,675 B2 * 10/2005 Jain 606/41
6,960,182 B2 11/2005 Moutafis et al.
6,972,014 B2 12/2005 Eum et al.
6,986,769 B2 1/2006 Nelson et al.
6,991,631 B2 1/2006 Woloszko et al.
7,022,088 B2 4/2006 Keast et al.
7,031,504 B1 4/2006 Argiro et al.
7,083,612 B2 8/2006 Littrup et al.
7,128,748 B2 10/2006 Mooradian et al.
7,136,064 B2 11/2006 Zuiderveld
7,144,402 B2 12/2006 Kuester, III
7,144,588 B2 12/2006 Oray et al.
7,192,400 B2 3/2007 Campbell et al.
7,233,820 B2 6/2007 Gilboa
7,235,070 B2 6/2007 Vanney
7,335,195 B2 2/2008 Mehier
7,347,859 B2 3/2008 Garabedian et al.
7,549,987 B2 6/2009 Shadduck
7,674,259 B2 3/2010 Shadduck
2001/0020167 A1 9/2001 Woloszko et al.
2001/0029370 A1 10/2001 Hovda et al.
2001/0037106 A1 11/2001 Shadduck
2002/0049438 A1 4/2002 Sharkey et al.
2002/0077516 A1 6/2002 Flanigan
2002/0082667 A1 6/2002 Shadduck
2002/0095152 A1 7/2002 Ciarrocca et al.
2002/0111386 A1 8/2002 Sekins et al.
2002/0161326 A1 10/2002 Sussman et al.
2002/0177846 A1 * 11/2002 Mulier et al. 606/27
2002/0193789 A1 12/2002 Underwood et al.
2003/0028189 A1 2/2003 Woloszko et al.
2003/0040742 A1 2/2003 Underwood et al.
2003/0097126 A1 5/2003 Woloszko et al.
2003/0099279 A1 5/2003 Venkatasubramanian et al.
2003/0109869 A1 6/2003 Shadduck
2003/0130655 A1 7/2003 Woloszko et al.
2003/0130738 A1 7/2003 Hovda et al.
2003/0158545 A1 8/2003 Hovda et al.
2003/0163178 A1 8/2003 Davison et al.
2003/0181922 A1 9/2003 Alferness
2003/0212395 A1 11/2003 Woloszko et al.
2003/0225364 A1 12/2003 Kraft et al.
2004/0024398 A1 2/2004 Hovda et al.
2004/0024399 A1 2/2004 Sharps et al.
2004/0031494 A1 2/2004 Danek et al.
2004/0038868 A1 2/2004 Ingenito
2004/0047855 A1 3/2004 Ingenito
2004/0049180 A1 3/2004 Sharps et al.
2004/0054366 A1 3/2004 Davison et al.
2004/0055606 A1 3/2004 Hendricksen et al.
2004/0068256 A1 4/2004 Rizoiu et al.
2004/0068306 A1 4/2004 Shadduck
2004/0087937 A1 5/2004 Eggers et al.
2004/0116922 A1 6/2004 Hovda et al.
2004/0193150 A1 9/2004 Sharkey et al.
2004/0199226 A1 10/2004 Shadduck
2004/0230190 A1 11/2004 Dahla et al.
2004/0254532 A1 12/2004 Mehier
2005/0004634 A1 1/2005 Ricart et al.
2005/0010205 A1 1/2005 Hovda et al.
2005/0119650 A1 6/2005 Sanders et al.
2005/0166925 A1 8/2005 Wilson et al.

2005/0171582	A1	8/2005	Matlock
2005/0187543	A1	8/2005	Underwood et al.
2005/0215991	A1	9/2005	Altman et al.
2005/0222485	A1	10/2005	Shaw et al.
2005/0228423	A1	10/2005	Khashayar et al.
2005/0228424	A1	10/2005	Khashayar et al.
2005/0240171	A1	10/2005	Forrest
2005/0283143	A1	12/2005	Rizoiu
2006/0004400	A1	1/2006	McGurk et al.
2006/0047291	A1	3/2006	Barry
2006/0100619	A1	5/2006	McClurken et al.
2006/0130830	A1	6/2006	Barry
2006/0161233	A1	7/2006	Barry et al.
2006/0200076	A1	9/2006	Gonzalez et al.
2006/0224154	A1	10/2006	Shadduck et al.
2007/0036417	A1	2/2007	Argiro et al.
2007/0091087	A1	4/2007	Zuiderveld
2008/0033493	A1	2/2008	Deckman et al.
2008/0103566	A1	5/2008	Mehier
2008/0110457	A1	5/2008	Barry et al.
2008/0114297	A1	5/2008	Barry et al.
2008/0132826	A1	6/2008	Shadduck et al.
2009/0105702	A1	4/2009	Shadduck
2009/0105703	A1	4/2009	Shadduck
2009/0149846	A1	6/2009	Hoey et al.
2009/0216220	A1	8/2009	Hoey et al.
2009/0312753	A1	12/2009	Shadduck
2010/0076416	A1	3/2010	Hoey et al.
2010/0160905	A1	6/2010	Shadduck
2010/0204688	A1	8/2010	Hoey et al.

FOREIGN PATENT DOCUMENTS

WO	WO 00/29055	5/2000
WO	WO 02/069821	9/2002
WO	WO 03/070302	8/2003
WO	WO 03/086498	10/2003
WO	WO 2005/025635	3/2005
WO	WO 2005/102175	11/2005
WO	WO 2006/003665	1/2006
WO	WO 20091009398	1/2009

OTHER PUBLICATIONS

U.S. Appl. No. 09/762,649, filed Feb. 12, 2001, in the name of Shadduck, Notice of Allowance mailed Sep. 9, 2002.

U.S. Appl. No. 10/017,582, filed Dec. 7, 2001, in the name of Shadduck, Non-Final Rejection mailed Dec. 10, 2002.

U.S. Appl. No. 10/017,582, filed Dec. 7, 2001, in the name of Shadduck, Non-Final Rejection mailed Jul. 17, 2003.

U.S. Appl. No. 10/346,877, filed Jan. 16, 2003, in the name of Shadduck, Examiner's Amendment mailed Mar. 7, 2005.

U.S. Appl. No. 10/346,877, filed Jan. 18, 2003, in the name of Shadduck, Non-Final Rejection mailed Sep. 30, 2004.

U.S. Appl. No. 10/346,877, filed Jan. 18, 2003, in the name of Shadduck, Notice of Allowance mailed Mar. 7, 2005.

U.S. Appl. No. 10/681,625, filed Oct. 7, 2003, in the name of Shadduck, Final Rejection mailed Jun. 3, 2008.

U.S. Appl. No. 10/681,625, filed Oct. 7, 2003, in the name of Shadduck, Non-Final Rejection mailed Aug. 15, 2007.

U.S. Appl. No. 10/681,625, filed Oct. 7, 2003, in the name of Shadduck, Non-Final Rejection mailed Mar. 13, 2009.

U.S. Appl. No. 10/681,625, filed Oct. 7, 2003, in the name of Shadduck, Notice of Allowance mailed Dec. 30, 2009.

U.S. Appl. No. 11/158,930, filed Jun. 22, 2005, in the name of Shadduck, Non-Final Rejection mailed Jun. 24, 2009.

U.S. Appl. No. 12/465,927, filed May 14, 2009, in the name of Shadduck, entitled "Thermotherapy device".

Coda, et al., "Effects of pulmonary reventilation on gas exchange after cryolytic disobstruction of endobronchial tumors," *Minerva Medical*, vol. 72, pp. 1627-1631, Jun. 1981 (with English translation).

Fishman et al., "A randomized trial comparing lung-volume-reduction surgery with medical therapy for severe emphysema," *N Engl J Med*, vol. 348, No. 21, pp. 2059-2073, May 22, 2003.

Homasson. et al., "Bronchoscopic cryotherapy for airway strictures caused by tumors," *Chest*, vol. 90, No. 2, pp. 159-164, Aug. 1986.

International Patent Application No. PCT/US2008/069094 in the name of TSUNAMI MEDTECH, LLC, filed Jul. 2, 2008, International Search Report and Written Opinion mailed Oct. 9, 2008.

Li, K., "Efficient optimal net surface detection for image segmentation— from theory to practice," M.Sc. Thesis, The University of Iowa, 2003.

Marasso, et al., "Cryosurgery in bronchoscopic treatment of tracheobronchial stenosis," *Chest*, vol. 103, No. 2, pp. 472-474, Feb. 1993.

Marasso, et al., "Radiofrequency resection of bronchial tumours in combination, with cryotherapy: evaluation of a new technique," *Thorax*, vol, 53, pp. 106-109, 1998.

Mathur et al., "Fiberoptic bronchoscopic cryotherapy in the management of tracheobronchial obstruction," *Chest*, vol, 110, No. 3, pp. 718-723, Sep. 1996.

Morice et al. "Endobrinchial argon plasma coagulation for treatment of hemotysis and neoptastic airway obstruction," *Chest*, vol, 119, No. 3, pp. 781-787, Mar. 2001.

Quin, J., "Use of neodymium yttrium aluminum garnet laser in long-term palliation of airway obstruction," *Connecticut Medicine*, vol. 59, No. 7, pp. 407-412, Jul. 1995.

Sutedja, et al., "Bronchoscopic treatment of lung tumors," *Elsevier, Lung Cancer*, 11, pp. 1-17, 1994.

Topaz, et al., "Acute Results, Complications, and Effect of Lesion Characteristics on Outcome With the Solid-State, Pulsed Wave, Mid-Infrared Laser Angioplasty System", *Laser in Surg. & Med.*, vol. 22, pp. 228-239, 1998.

Tschirren et al.; "Intrathoracic airway trees: segmentation and airway morphology analysis from low-dose CT scans;" *IEEE Trans. Med. Imaging*, vol, 24, No. 12; pp. 1529-1539. Dec. 2005.

Tschirren, J., "Segmentation, anatomical labeling, branchpoint matching, and quantitative analysis of human airway trees in volumetric CT images," Ph,D. Thesis, The University of Iowa, 231 pages, Aug. 2003.

Tschirren, J., "Segmentation, anatomical labeling, branchpoint matching, and quantitative analysis of human airway trees in volumetric CT images," Slides from Ph.D defense, University of Iowa, 130 pages, Aug. 2003.

U.S. Appl. No. 09/782,649 filed Feb. 12, 2001, in the name of Shadduck, Notice of Allowance mailed Sep. 10, 2002.

U.S. Appl. No. 10/346,877 filed Jan. 18, 2003, in the name of Shadduck, Examiner's Amendment mailed Mar. 2, 2005.

U.S. Appl. No. 10/830,372 filed Apr. 22, 2004, in the name of Shadduck, Examiner Interview Summary mailed Feb. 12, 2008.

U.S. Appl. No. 10/830,372 filed Apr. 22, 2004, in the name of Shadduck, final Office Action mailed May 21, 2008.

U.S. Appl. No. 10/830.372 filed Apr. 22, 2004, in the name of Shadduck, non-final Office Action mailed Aug. 15, 2007.

U.S. Appl. No. 10/830,372 filed Apr. 22, 2004, in the name of Shadduck, Notice of Allowance mailed Apr. 7, 2009.

U.S. Appl. No. 11/158,930 filed Jun. 22, 2005, in the name of Shadduck, non-Office Action mailed Dec. 24. 2009.

U.S. Appl. No. 11/158,930 filed Jun. 22, 2005, in the name of Shadduck, Notice of Allowance mailed Jul. 22, 2010.

U.S. Appl. No. 11/158,930 filed Jun. 22, 2005, in the name of Shadduck, Notice of Allowance mailed Oct. 7, 2010.

U.S. Appl. No. 11/329.381 filed Jan. 10, 2006, in the name of Shadduck, final Office Action mailed Jul. 14, 2010.

U.S. Appl. No.11/329,381 filed Jan. 10. 2006, in the name of Shadduck, non-final Office Action mailed Dec. 9, 2009.

Unger, M. et al. "Monolithic Microfabricated Valves and Pumps by Multilayer Soft Lithography," *Science*, vol. 288, pp. 113-116, Apr. 7, 2000, accessed at http://web.mit.edu/thorsen/www/113.pdf.

Xia, Y. et al. "Soft Lithography," *Annu. Rev. Mater. Sci.*, vol. 28, pp. 153-184, 1998, accessed at http://www.bwfoundry.com/xia.pdf.

* cited by examiner

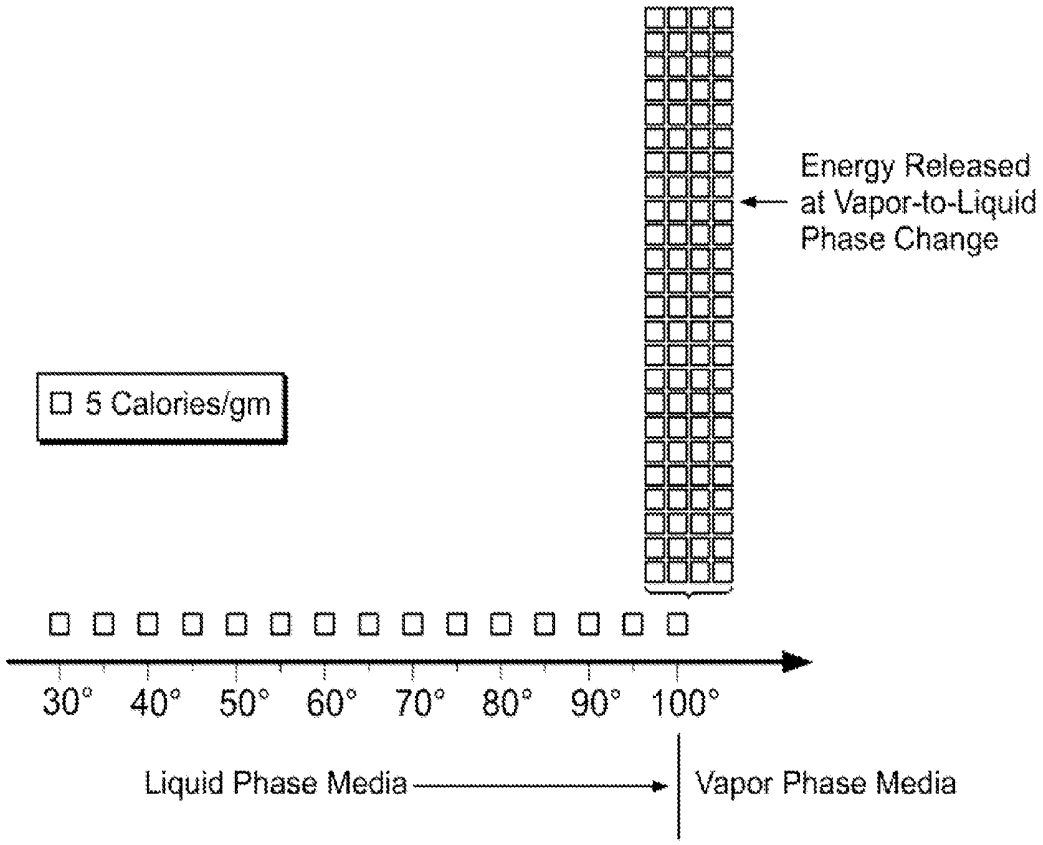

Energy Released
at Vapor-to-Liquid
Phase Change
5 Calories/gm
30°
40°
50°
60°
70°
80°
90°
100°
Liquid Phase Media
Vapor Phase Media

FIG. 1A

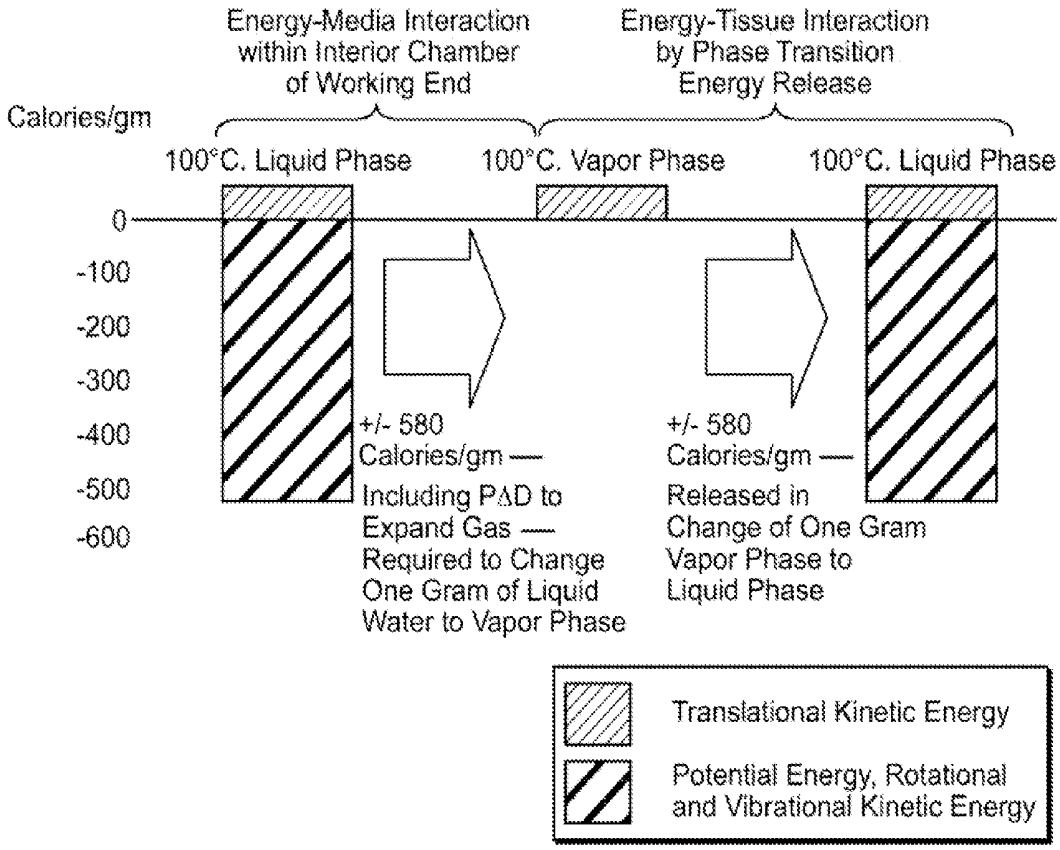

Energy-Media Interaction within Interior Chamber of Working End
Energy-Tissue Interaction by Phase Transition Energy Release
Calories/gm
100°C. Liquid Phase
100°C. Vapor Phase
100°C. Liquid Phase
0
-100
-200
-300
-400
-500
-600
+/- 580 Calories/gm — Including PΔD to Expand Gas — Required to Change One Gram of Liquid Water to Vapor Phase
+/- 580 Calories/gm — Released in Change of One Gram Vapor Phase to Liquid Phase
Translational Kinetic Energy
Potential Energy, Rotational and Vibrational Kinetic Energy

FIG. 1B

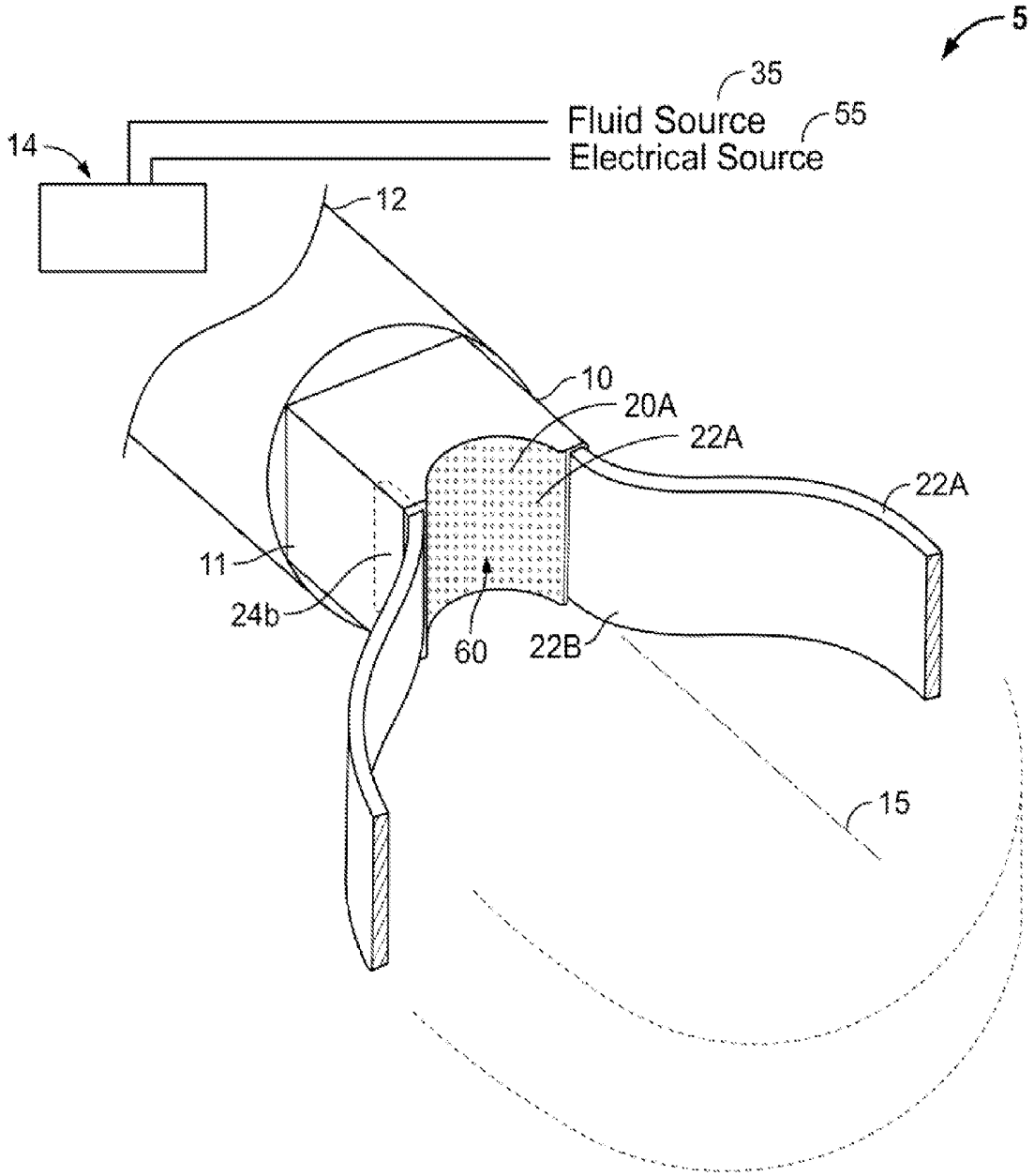

5
35
Fluid Source
55
Electrical Source
14
12
10
20A
22A
22A
11
24b
60
22B
15

FIG. 2A

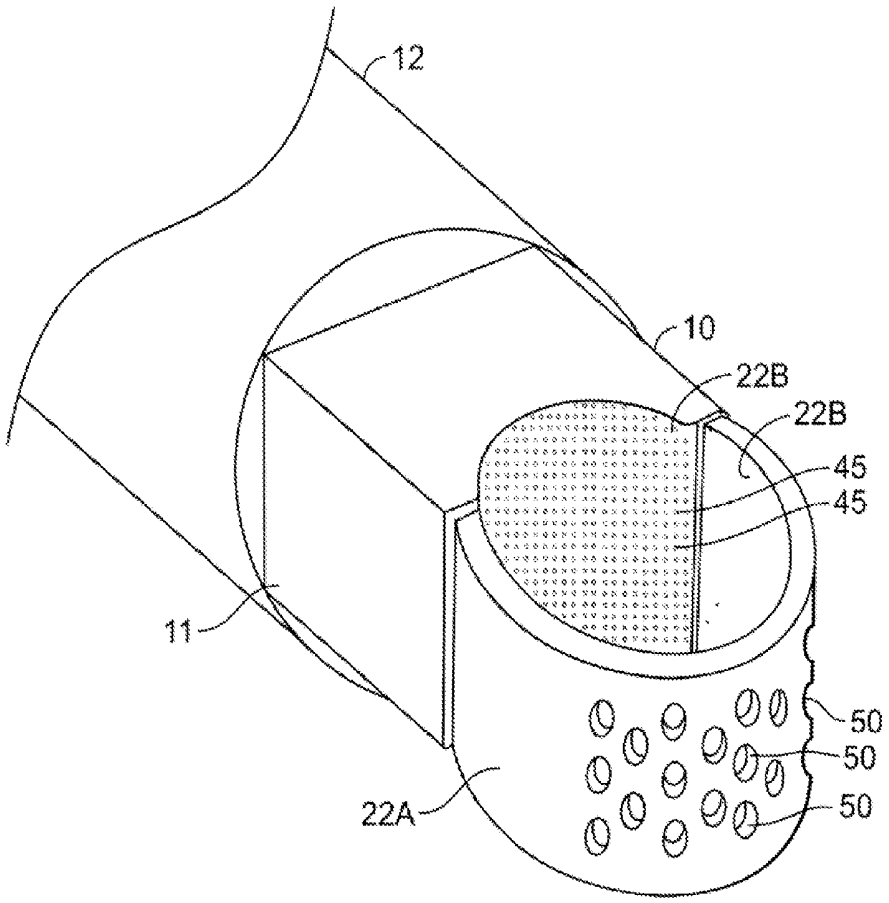


FIG. 2B

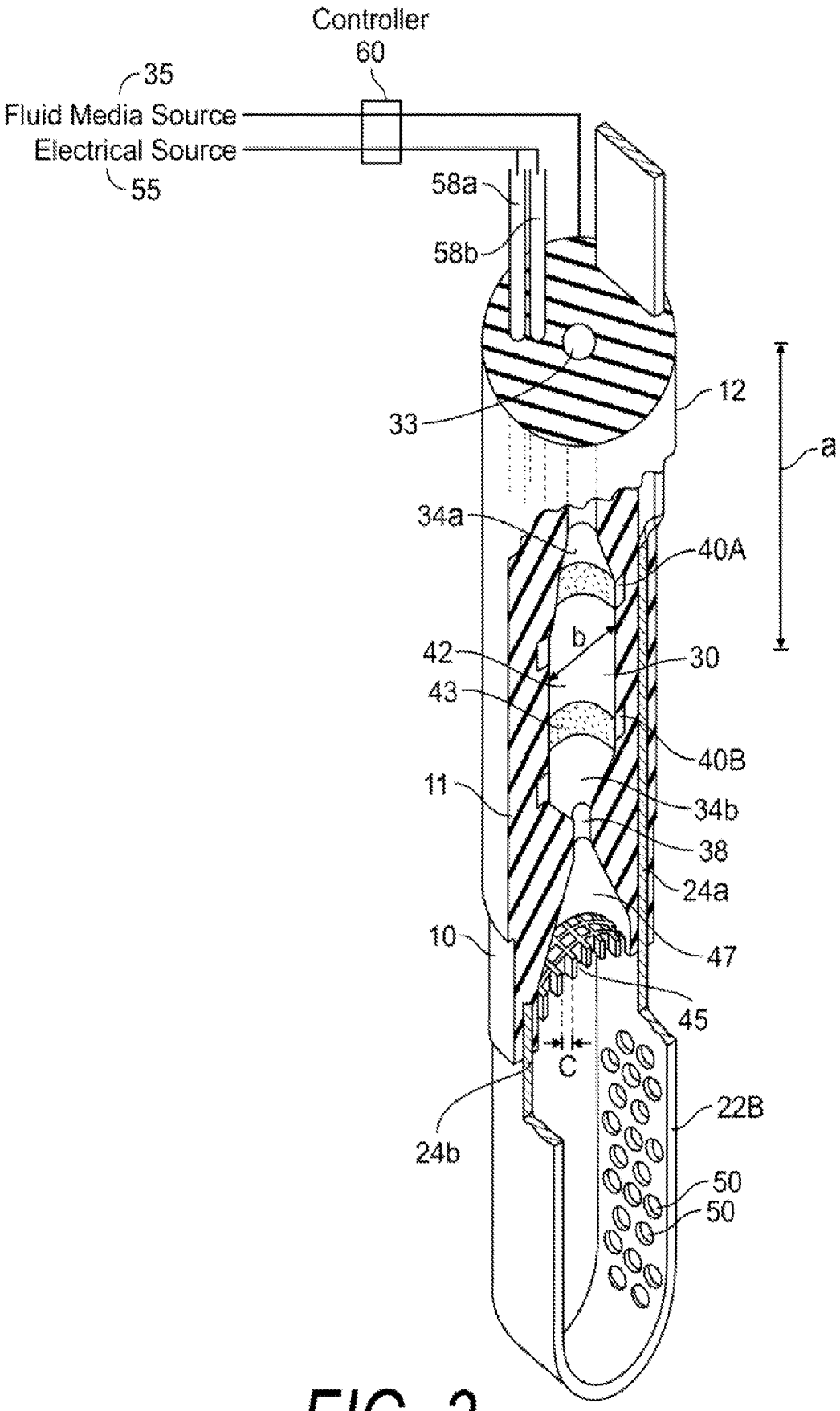

Controller
60
35
Fluid Media Source
Electrical Source
55
58a
58b
33
12
a
34a
40A
b
42
30
43
40B
11
34b
38
24a
10
47
45
C
22B
24b
50
50

FIG. 3

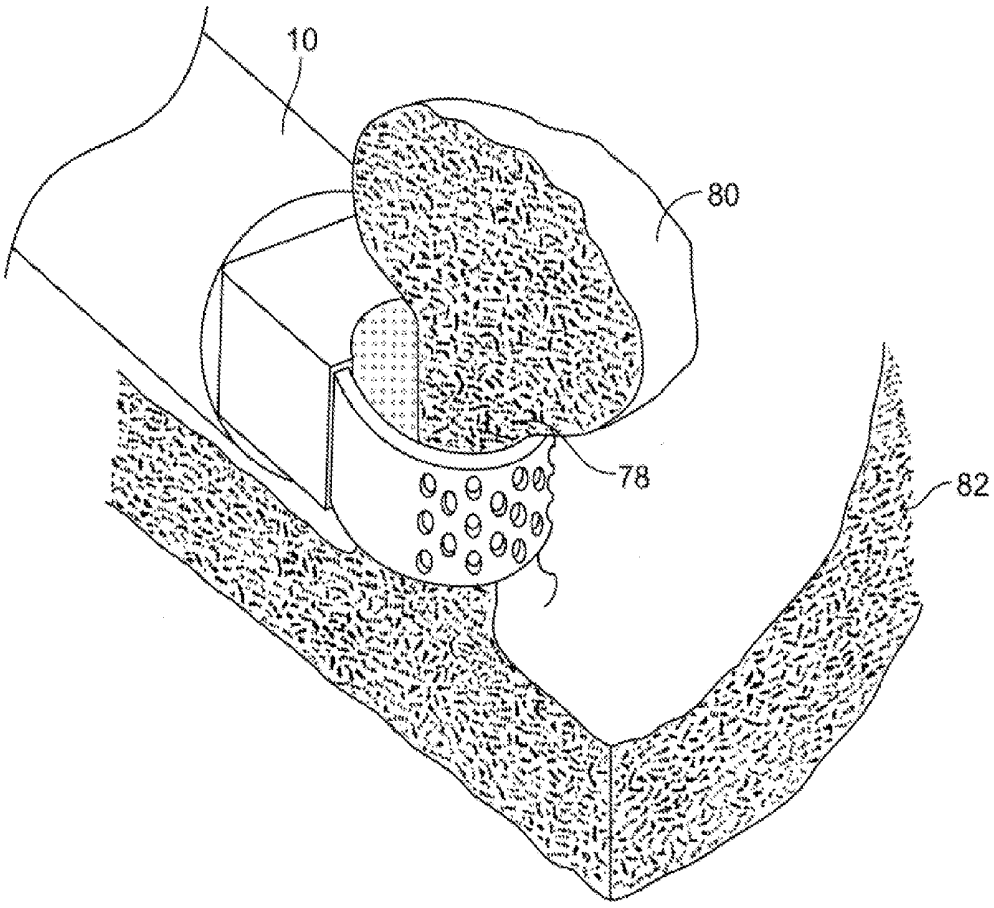


FIG. 4

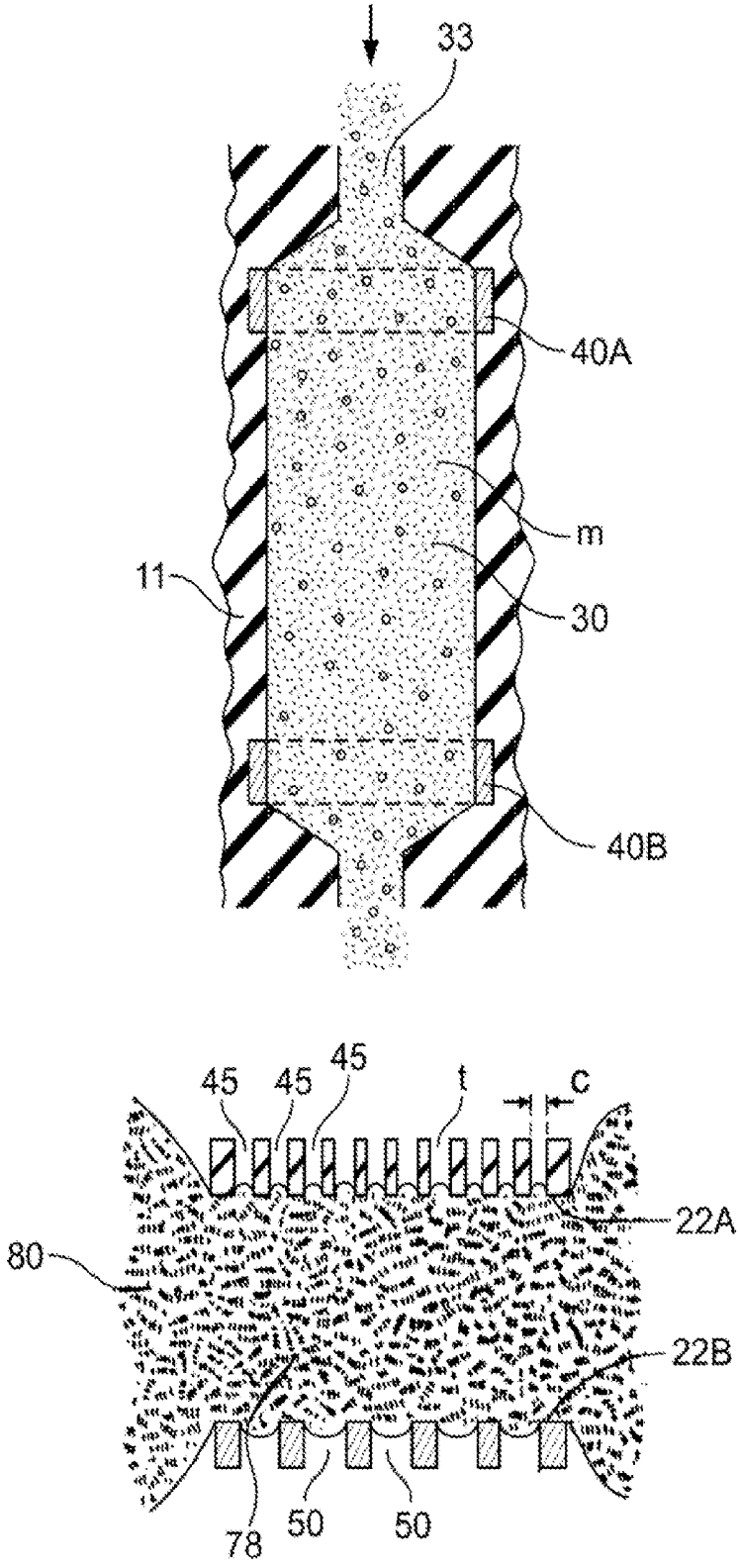


FIG. 5

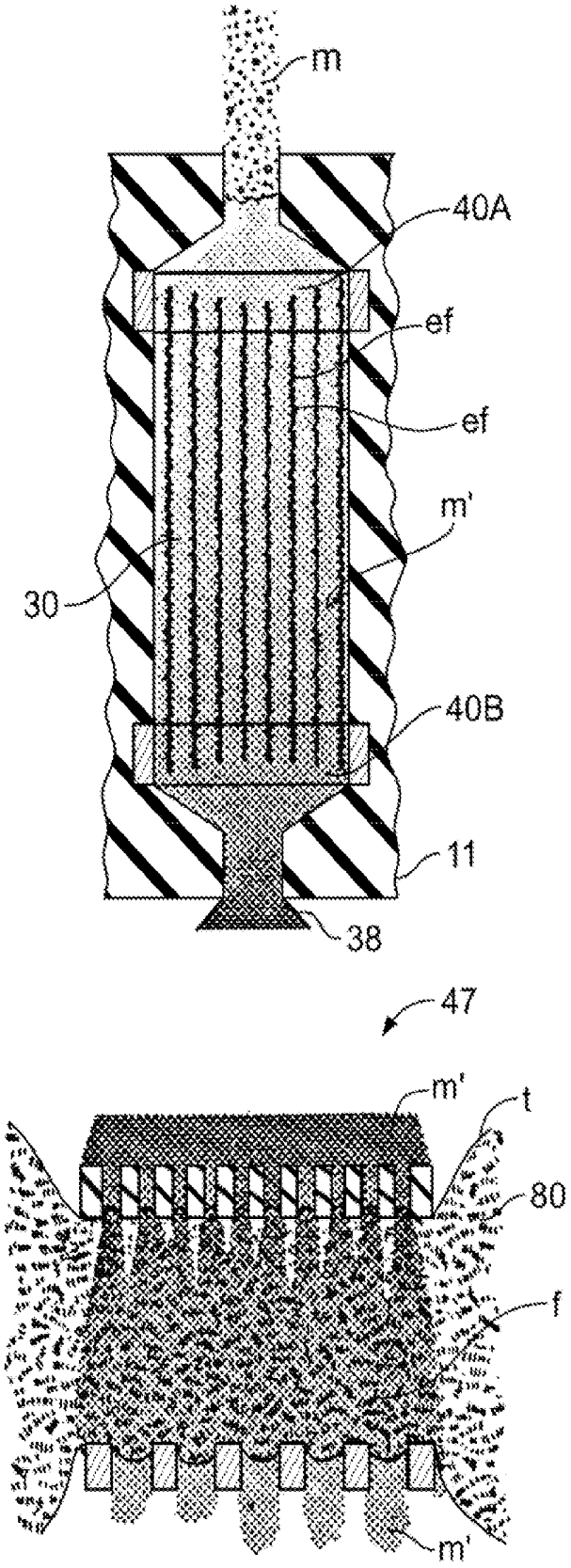


FIG. 6

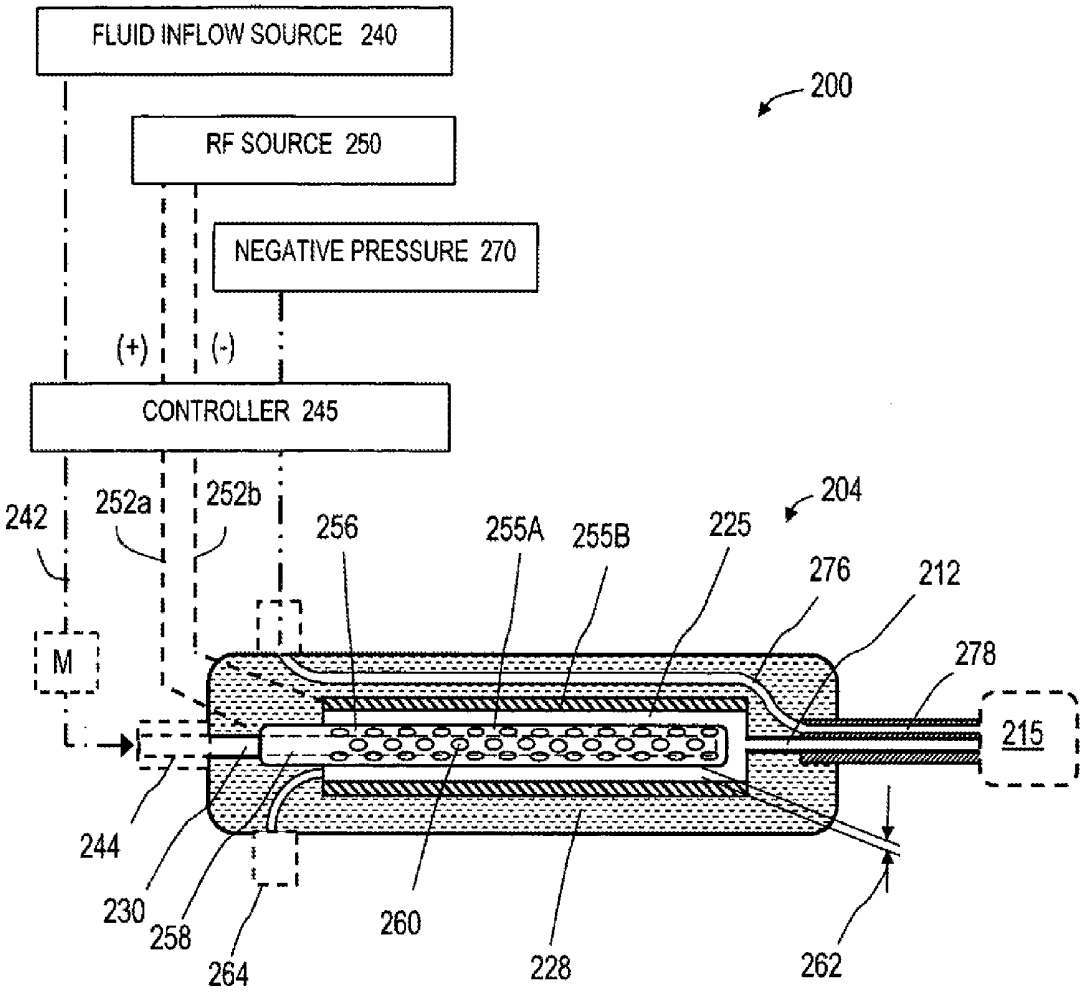

FLUID INFLOW SOURCE 240
200
RF SOURCE 250
NEGATIVE PRESSURE 270
(+)
(-)
CONTROLLER 245
242
252a
252b
256
255A
255B
225
204
276
212
278
M
215
244
230
258
264
260
228
262

FIG. 7

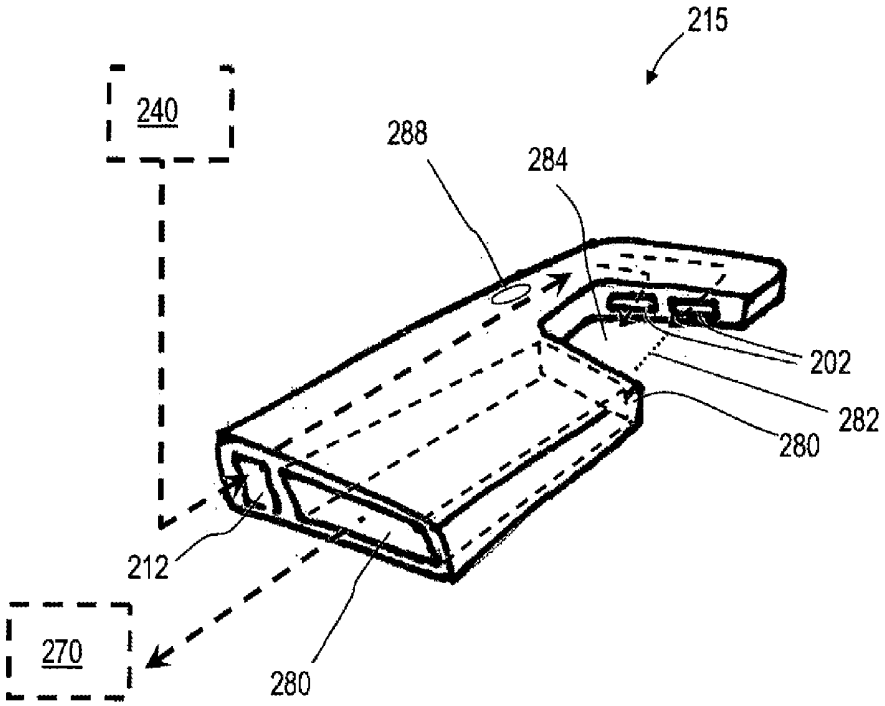


FIG. 8

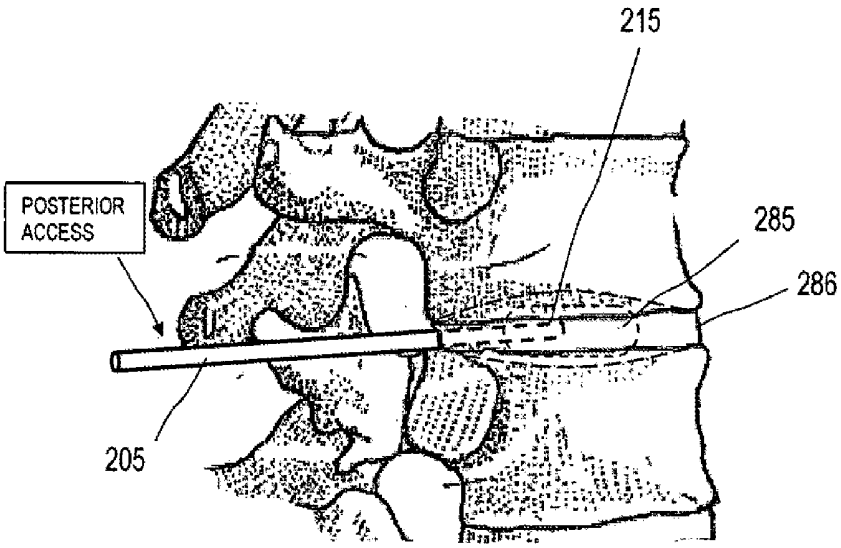


FIG. 9A

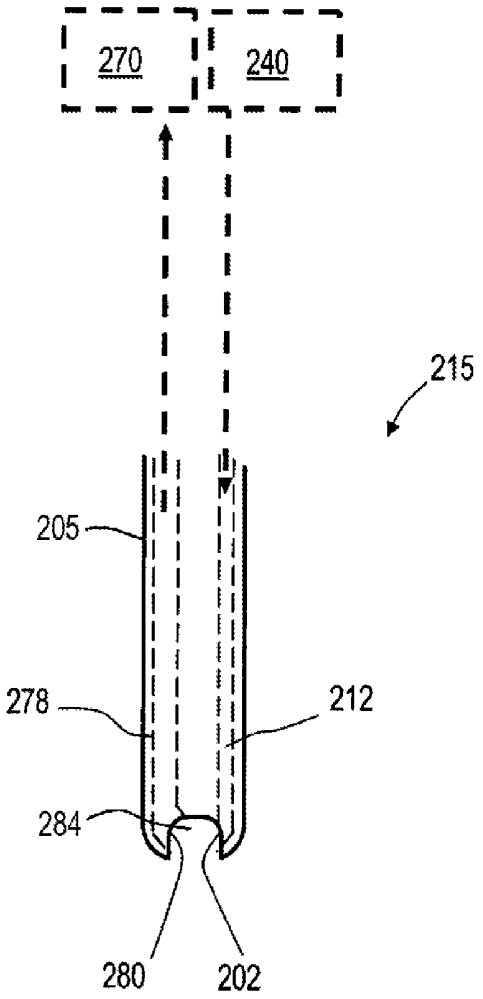


FIG. 9B

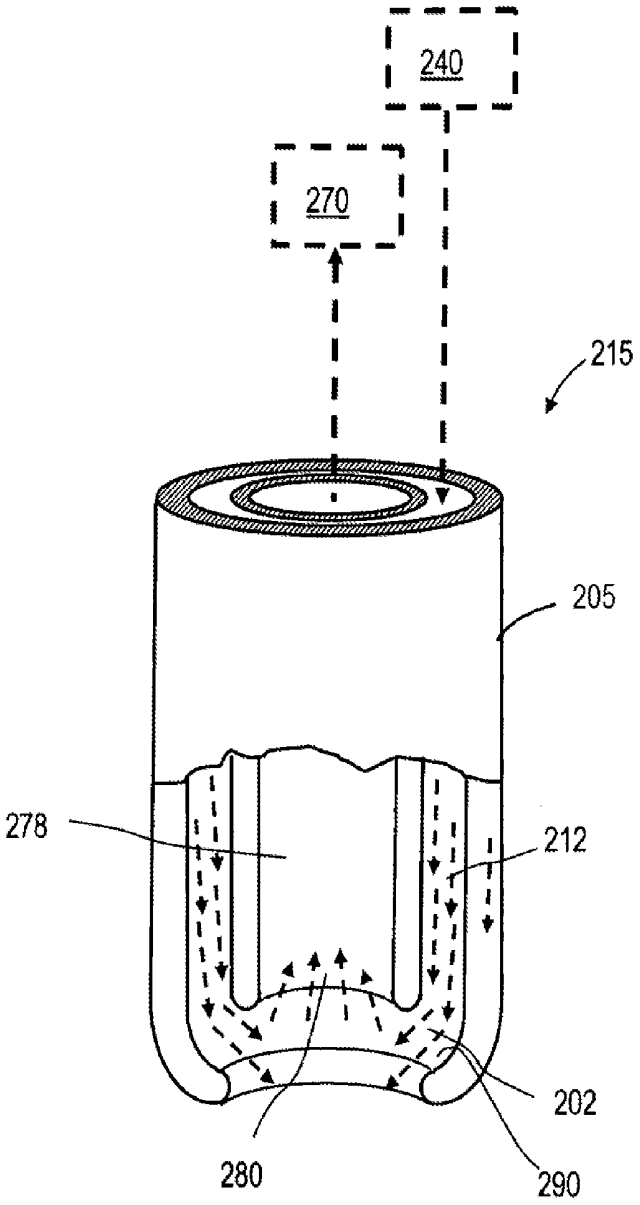


FIG. 9C

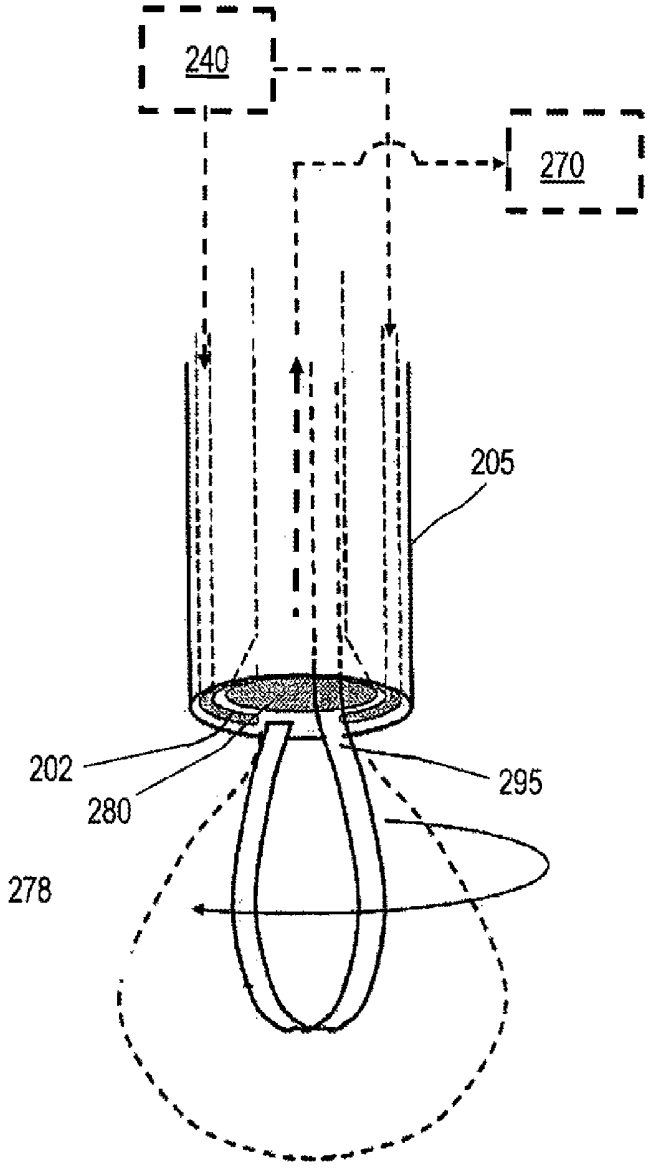


FIG. 9D

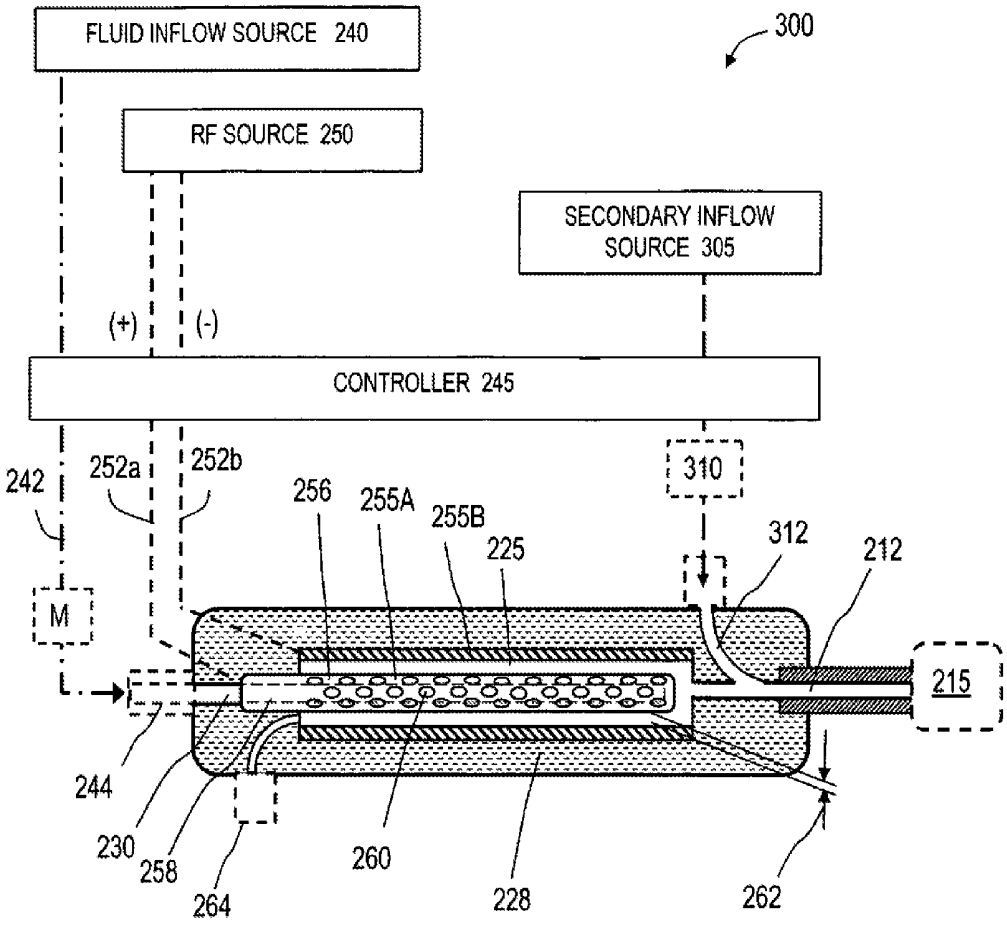

FLUID INFLOW SOURCE 240
300
RF SOURCE 250
SECONDARY INFLOW SOURCE 305
(+)
(-)
CONTROLLER 245
242
252a
252b
256
255A
255B
225
310
312
212
M
215
244
230
258
264
260
228
262

FIG. 10

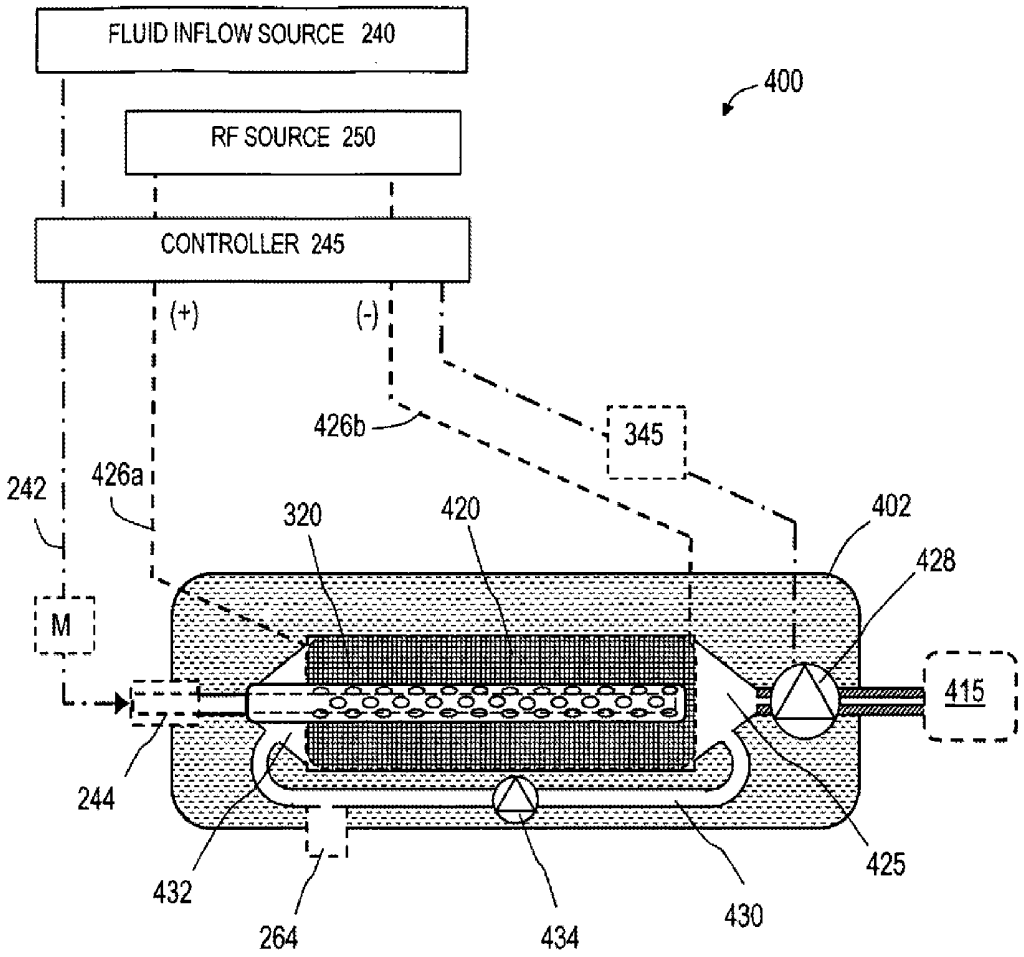

FLUID INFLOW SOURCE 240
400
RF SOURCE 250
CONTROLLER 245
(+)
(-)
426b
345
242
426a
320
420
402
428
M
415
244
432
264
434
430
425

FIG. 11

MEDICAL INSTRUMENT AND METHOD OF USE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims benefit of Provisional U.S. Patent Application Ser. No. 60/615,900 filed Oct. 5, 2004 titled Medical Instruments and Techniques for Thermally-Mediated Procedures. This application is also a continuation-in-part of U.S. patent application Ser. No. 10/346,877 filed Jan. 18, 2003 now U.S. Pat. No. 6,911,028 titled Medical Instrument Working End and Method for Endoluminal Treatment. This application is also a continuation-in-part of U.S. patent application Ser. No. 10/681,625 filed Oct. 7, 2003 now U.S. Pat. No. 7,674,259 titled Medical Instruments and Techniques for Thermally-Mediated Therapies. The entire contents of the above U.S. patent applications are incorporated herein by this reference and should be considered a part of this specification.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to surgical instruments for applying energy to tissue, and more particularly relates to a system for volumetric removal of tissue by means of high velocity ejection of a vapor media from a first vapor port proximate to soft tissue wherein the vapor-to-liquid phase change of the media applies energy to the tissue. Contemporaneously, the system provides a second port coupled to a suction source that cooperates with the first vapor port to suction tissue debris from the targeted site.

2. Description of the Related Art

Various types of radiofrequency (Rf) and laser surgical instruments have been developed for delivering thermal energy to tissue, for example to ablate tissue, to cause hemostasis, to weld tissue or to cause a thermoplastic remodeling of tissue. While such prior art forms of energy delivery are suitable for some applications, Rf and laser energy typically cannot cause highly "controlled" and "localized" thermal effects that are desirable in microsurgeries or other precision surgeries. In general, the non-linear or non-uniform characteristics of tissue affect both laser and Rf energy distributions in tissue.

What is needed for many surgical procedures is an instrument and technique that can controllably deliver energy to tissue for volumetric tissue removal or tissue cutting without the possibility of desiccation or charring of adjacent tissues, and without collateral thermal damage.

SUMMARY OF THE INVENTION

The present invention is adapted to provide improved methods of controlled energy delivery to localized tissue volumes, for example for volumetric tissue removal or thermoplastic remodeling of tissue.

In general, the thermally-mediated treatment method comprises causing a vapor-to-liquid phase state change in a selected media at a targeted tissue site thereby applying thermal energy substantially equal to the heat of vaporization of the selected media to said tissue site. The thermally-mediated therapy can be delivered to tissue by such vapor-to-liquid phase transitions, or "internal energy" releases, about the working surfaces of several types of instruments for endoluminal treatments or for soft tissue thermotherapies. FIGS. **1**A and **1**B illustrate the phenomena of phase transitional releases

of internal energies. Such internal energy involves energy on the molecular and atomic scale and in polyatomic gases is directly related to intermolecular attractive forces, as well as rotational and vibrational kinetic energy. In other words, the method of the invention exploits the phenomenon of internal energy transitions between gaseous and liquid phases that involve very large amounts of energy compared to specific heat.

It has been found that the controlled application of internal energies in an introduced media-tissue interaction solves many of the vexing problems associated with energy-tissue interactions in Rf, laser and ultrasound modalities. The apparatus of the invention provides a fluid-carrying chamber in the interior of the device or working end. A source provides liquid media to the interior chamber wherein energy is applied to instantly vaporize the media. In the process of the liquid-to-vapor phase transition of a saline media in the interior of the working end, large amounts of energy are added to overcome the cohesive forces between molecules in the liquid, and an additional amount of energy is requires to expand the liquid 1000+ percent (PΔD) into a resulting vapor phase (see FIG. **1**A). Conversely, in the vapor-to-liquid transition, such energy will be released at the phase transitions at the targeted tissue interface. That is, the heat of vaporization is released in tissue when the media transitioning from gaseous phase to liquid phase wherein the random, disordered motion of molecules in the vapor regain cohesion to convert to a liquid media. This release of energy (defined as the capacity for doing work) relating to intermolecular attractive forces is transformed into therapeutic heat for a thermotherapy within a targeted body structure. Heat flow and work are both ways of transferring energy.

In FIG. **1**A, the simplified visualization of internal energy is useful for understanding phase transition phenomena that involve internal energy transitions between liquid and vapor phases. If heat were added at a constant rate in FIG. **1**A (graphically represented as 5 calories/gm blocks) to elevate the temperature of water through its phase change to a vapor phase, the additional energy required to achieve the phase change (latent heat of vaporization) is represented by the large number of 110+ blocks of energy at 100° C. in FIG. **1**A. Still referring to FIG. **1**A, it can be easily understood that all other prior art ablation modalities—Rf, laser, microwave and ultrasound—create energy densities by simply ramping up calories/gm as indicated by the temperature range from 37° C. through 100° C. as in FIG. **1**A. The prior art modalities make no use of the phenomenon of phase transition energies as depicted in FIG. **1**A.

FIG. **1**B graphically represents a block diagram relating to energy delivery aspects of the present invention. The system provides for insulative containment of an initial primary energy-media within an interior chamber of an instrument's working end. The initial, ascendant energy-media interaction delivers energy sufficient to achieve the heat of vaporization of a selected liquid media such as saline within an interior of the instrument body. This aspect of the technology requires an inventive energy source and controller-since energy application from the source to the selected media (Rf, laser, microwave etc.) must be modulated between very large energy densities to initially surpass the latent heat of vaporization of the media within milliseconds, and possible subsequent lesser energy densities for maintaining the media in its vapor phase. Additionally, the energy delivery system is coupled to a pressure control system for replenishing the selected liquid phase media at the required rate—and optionally for controlling propagation velocity of the vapor phase media from the working end surface of the instrument. In use, the method of

the invention comprises the controlled deposition of a large amount of energy—the heat of vaporization as in FIG. **1**A—when the vapor-to-liquid phase transition is controlled at the vapor media-tissue interface. The vapor-to-liquid phase transition deposits about 580 cal/gram within the targeted tissue site to perform the thermal ablation.

In one embodiment, the system is configured for ablation and extraction of soft tissue, for example in treating a disc. The flow of vapor is controlled by a computer controller to cause a selected pressure, a selected volume of vapor to be ejected from a working end port. Contemporaneous with tissue contact, the vapor undergoes a vapor-to-liquid phase transition which delivers large amount of energy to the targeted tissue to obliterate or ablate the tissue. In one embodiment, the system causes volumetric removal of tissue by high velocity ejection of the vapor media from a first vapor port. The system provides a second port coupled to a suction source that cooperates with the first vapor port to suction tissue debris from the targeted site.

Additional advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a graphical depiction of the quantity of energy needed to achieve the heat of vaporization of water.

FIG. **1**B is a diagram of phase change energy release that underlies one method of the invention.

FIG. **2**A is a perspective view of the working end of an exemplary Type "A" probe of the present invention with an openable-closeable tissue engaging structure in a first open position.

FIG. **2**B is a perspective view similar to FIG. **2**A probe of the present invention in a second closed position.

FIG. **3** is a cut-away view of the working end of FIGS. **2**A-**2**B.

FIG. **4** is a perspective view of the working end of FIG. **3** capturing an exemplary tissue volume.

FIGS. **5-6** are sectional schematic views of working end of FIG. **3** depicting, in sequence, the steps of a method of the present invention to seal or weld a targeted tissue volume, FIG. **5** illustrating the pressurized delivery of a liquid media to an interior channel, and FIG. **6** depicting an electrical discharge that causes a liquid-to-gas phase change as well as the ejection of the vapor media into the targeted tissue to thermally seal engaged tissue.

FIG. **7** a cut-away of a Type "B" system with a thermal energy delivery mechanism for a liquid-to-vapor conversion of a pressurized inflow of a saline solution in a probe handle that is coupled to an elongated introducer with a working end configured for delivery of vapor to soft tissue, such as a disc nucleus.

FIG. **8** is view of a working end of the probe of FIG. **7**.

FIG. **9**A is a view of a method of using the probe working end of FIG. **8** to volumetrically remove disc nucleus tissue.

FIG. **9**B is a view of an alternative working end similar to FIG. **8**.

FIG. **9**C is a view of another alternative working end similar to FIGS. **8** and **9**B.

FIG. **9**D is a view of another alternative working end similar to that of FIG. **9**C with a cutting loop for cutting soft tissue.

FIG. **10** is another embodiment similar to that of FIG. **7** with an alternative system for delivering vapor to soft tissue together with introducing a second media to control the mass average temperature of the vapor.

FIG. **11** is another embodiment similar to that of FIG. **7** with an alternative system for delivering thermal energy.

DETAILED DESCRIPTION OF THE INVENTION

1. Type "A" Thermotherapy Instrument. Referring to FIGS. **2**A, **2**B and **3**, the working end **10** of a Type "A" system **5** of the present invention is shown that is adapted for endoscopic procedures in which a tissue volume T targeted for treatment (a thermoplasty) can be captured by a loop structure. The working end **10** comprises a body **11** of insulator material (see FIG. **3**) coupled to the distal end of introducer member **12** extending along axis **15**. In this exemplary embodiment, the working end **10** has a generally cylindrical cross-section and is made of any suitable material such as plastic, ceramic, glass, metal or a combination thereof. The working end **10** is substantially small in diameter (e.g., 2 mm to 5 mm) and in this embodiment is coupled to an elongate flexible introducer member **12** to cooperate with a working channel in an endoscope. Alternatively, the working end **10** may be coupled to a rigid shaft member having a suitable 1 mm to 5 mm or larger diameter to cooperate with a trocar sleeve for use in endoscopic or microsurgical procedures. A proximal handle portion **14** of the instrument indicated by the block diagram of FIG. **2**A carries the various actuator mechanisms known in the art for actuating components of the instrument.

In FIGS. **2**A, **2**B and **3**, it can be seen that the working end **10** carries an openable and closeable structure for capturing tissue between a first tissue-engaging surface **20**A and a second tissue-engaging surface **20**B. In this exemplary embodiment, the working end **10** and first tissue-engaging surface **20**A comprises a non-moving component indicated at **22**A that is defined by the exposed distal end of body **11** of working end **10**. The second tissue-engaging surface **20**B is carried in a moving component that comprises a flexible loop structure indicated at **22**B.

The second moving component or flexible loop **22**B is actuatable by a slidable portion **24***a* of the loop that extends through a slot **25** in the working end to an actuator in the handle portion **14** as is known in the art (see FIG. **3**). The other end **24***b* of the loop structure **22**B is fixed in body **11**. While such an in-line (or axial) flexible slidable member is preferred as the tissue-capturing mechanism for a small diameter flexible catheter-type instrument, it should be appreciated that any openable and closable jaw structure known in the art falls within the scope of the invention, including forms of paired jaws with cam-surface actuation or conventional pin-type hinges and actuator mechanisms. FIG. **2**A illustrates the first and second tissue-engaging surfaces **20**A and **20**B in a first spaced apart or open position. FIG. **2**B shows the first and second surfaces **20**A and **20**B moved toward a second closed position.

Now turning to the fluid-to-gas energy delivery means of the invention, referring to FIG. **3**, it can be seen that the insulated or non-conductive body **11** of working end **10** carries an interior chamber indicated at **30** communicating with lumen **33** that are together adapted for delivery and transient confinement of a fluid media M that flows into chamber **30**. The chamber **30** communicates via lumen **33** with a fluid media source **35** that may be remote from the device, or a fluid reservoir (coupled to a remote pressure source) carried within introducer **12** or carried within a handle portion **14**. The term fluid or flowable media source **35** is defined to include a positive pressure inflow system which preferably is any suitable high pressure pump means known in the art. The fluid delivery lumen **33** transitions to chamber **30** at proximal end

portion **34***a* thereof. The distal end portion **34***b* of chamber **30** has a reduced cross-section that functions to direct vapor media through a small outlet or nozzle indicated at **38**.

Of particular interest, still referring to FIG. **3**, paired spaced apart electrode elements **40**A and **40**B are exposed in surface **42** of interior fluid confinement chamber **30**. In this exemplary embodiment, the electrode elements **40**A and **40**B comprise circumferential exposed surfaces of a conductive material positioned at opposing proximal and distal ends of interior chamber **30**, but other arrangements are possible. The invention can utilize any suitable configuration of spaced apart electrodes (e.g., such as concentric electrode surfaces, intertwined helical electrode surfaces, adjustable spaced apart surfaces, or porous electrodes) about at least one confinement chamber **30** or lumen portion of the system. Alternatively, each electrode can comprise one or more projecting elements that project into the chamber. The exemplary embodiment of FIG. **3** shows an elongate chamber having an axial dimension indicated at A and diameter or cross-section indicated at B. The axial dimension may range from about 0.1 mm to 20.0 mm and may be singular or plural as described below. The diameter B may range from micron dimensions (e.g., 0.5 μm) for miniaturized instruments to a larger dimension (e.g., 5.0 mm) for larger instruments for causing the thermally induced liquid-to-vapor transformation required to enable the novel phase change energy-tissue interaction of the invention. The electrodes are of any suitable material such as stainless steel, aluminum, nickel titanium, platinum, gold, or copper. Each electrode surface preferably has a toothed surface texture indicated at **43** that includes hatching, projecting elements or surface asperities for better delivering high energy densities in the fluid proximate to the electrode. The electrical current to the working end **10** may be switched on and off by a foot pedal or any other suitable means such as a switch in handle **14**.

FIG. **3** further shows that a preferred shape is formed into the tissue-engaging surface **20**A to better perform the method of fusing tissue. As can be seen in FIGS. **2**B and **3**, the first tissue-engaging surface **20**A is generally concave so as to be adapted to receive a greater tissue volume in the central portion of surface **20**A. The second tissue-engaging surface **20**B is flexible and naturally will be concave in the distal or opposite direction when tissue is engaged between surfaces **20**A and **20**B. This preferred shape structure allows for controllable compression of the thick targeted tissue volumes T centrally exposed to the energy delivery means and helps prevent conductance of thermal effects to collateral tissue regions CT (see FIG. **4**) and as will be described in greater detail below.

FIGS. **2**A and **3** show that first tissue-engaging surface **20**A defines an open structure of at least one aperture or passageway indicated at **45** that allows vapor to pass therethrough. The apertures **45** may have any cross-sectional shape and linear or angular route through surface **20**A with a sectional dimension C in this embodiment ranging upwards from micron dimensions (e.g., 0.5 μm) to about 2.0 mm in a large surface **20**A. The exemplary embodiment of FIG. **3** has an expanding cross-section transition chamber **47** proximate to the aperture grid that transitions between the distal end **34***b* of chamber **30** and the apertures **45**. However, it should be appreciated that such a transition chamber **47** is optional and the terminal portion of chamber **30** may directly exit into a plurality of passageways that each communicate with an aperture **45** in the grid of the first engaging surface **20**A. In a preferred embodiment, the second tissue-engaging surface **20**B defines (optionally) a grid of apertures indicated at **50** that pass through the loop **22**B. These apertures **50** may be any suitable dimension (cf. apertures **45**) and are adapted to generally oppose the first tissue-engaging surface **20**A when the surfaces **20**A and **20**B are in the second closed position, as shown in FIG. **2**B.

The electrodes **40**A and **40**B of working end **10** have opposing polarities and are coupled to Rf generator or electrical source **55**. FIG. **3** shows current-carrying wire leads **58***a* and **58***b* that are coupled to electrodes **40**A and **40**B and extend to electrical source **55** and controller **60**. In a preferred embodiment of the invention, either tissue-engaging surface optionally includes a sensor **62** (or sensor array) that is in contact with the targeted tissue surface (see FIG. **2**A). Such a sensor, for example a thermocouple known in the art, can measure temperature at the surface of the captured tissue. The sensor is coupled to controller **60** by a lead (not shown) and can be used to modulate or terminate power delivery as will be described next in the method of the invention.

Operation and use of the working end of FIGS. **2**A, **2**B and **3** in performing a method of treating tissue can be briefly described as follows, for example in an endoscopic polyp removal procedure. As can be understood from FIG. **4**, the working end **10** is carried by an elongate catheter-type member **12** that is introduced through a working channel **70** of an endoscope **72** to a working space. In this case, the tissue T targeted for sealing is a medial portion **78** of a polyp **80** in a colon **82**. It can be easily understood that the slidable movement of the loop member **22**B can capture the polyp **80** in the device as shown in FIG. **4** after being lassoed. The objective of the tissue treatment is to seal the medial portion of the polyp with the inventive thermotherapy. Thereafter, utilize a separate cutting instrument is used to cut through the sealed portion, and the excised polyp is retrieved for biopsy purposes.

Now turning to FIGS. **5** and **6**, two sequential schematic views of the working end engaging tissue T are provided to illustrate the energy-tissue interaction caused by the method of the invention. FIG. **5** depicts an initial step of the method wherein the operator sends a signal to the controller **60** to delivery fluid media M (e.g., saline solution or sterile water) through lumen **33** into chamber **30**. FIG. **6** depicts the next step of the method wherein the controller delivers an intense discharge of electrical energy to the paired electrode elements **40**A and **40**B within chamber **30** indicated by electric arc or electric field EF. The electrical discharge provides energy exceeding the heat of vaporization of the contained fluid volume. The explosive vaporization of fluid media M (of FIG. **5**) into a vapor or gas media is indicated at M' in FIG. **6**. The greatly increased volume of gas media M' results in the gas being ejected from chamber **30** at high velocity through apertures **45** of surface **20**A into the targeted tissue T. The liquid-to-vapor transition caused by the electrical discharge results in the vapor media M' having a temperature of 100° C. or more as well as carrying the heat of vaporization to deliver thermal effects into or through the targeted tissue T, as indicated graphically by the shaded regions of gas flow in FIG. **6**. The fluid source and its pressure mechanism can provide any desired level of vapor ejection pressure. Depending on the character of the introduced liquid media, the media is altered from a first lesser temperature to a second greater temperature in the range of 100° C. or higher depending on pressure. The ejection of vapor media M' and its condensation will uniformly and very rapidly elevate the temperature of the engaged tissue to the desired range of about 65° C. to 100° C. to cause hydrothermal denaturation of proteins in the tissue, and to cause optimal fluid inter-mixing of tissue constituents that will result in an effective seal. In effect, the vapor-to-liquid phase transition of the ejected media M' will deposit

heat equal to the heat of vaporization (also sometimes called the heat of condensation) in the tissue. At the same time, as the heat of vaporization of media M' is absorbed by water in the targeted tissue, the media converts back to a liquid thus hydrating the targeted tissue T. Such protein denaturation by hydrothermal effects differentiates this method of tissue sealing or fusion from all other forms of energy delivery, such as radiofrequency energy delivery. All other forms of energy delivery vaporize intra- and extracellular fluids and cause tissue desiccation, dehydration or charring which is undesirable for the intermixing of denatured tissue constituents into a proteinaceous amalgam.

The above electrical energy deliver step is continuous or can be repeated at a high repetition rate to cause a pulsed form of thermal energy delivery in the engaged tissue. The fluid media M inflow may be continuous or pulsed to substantially fill chamber **30** before an electrical discharge is caused therein. The repetition rate of electrical discharges may be from about 1 Hz to 1000 Hz. More preferably, the repetition rate is from about 10 Hz to 200 Hz. The selected repetition rate preferably provides an interval between electrical discharges that allows for thermal relaxation of tissue, that may range from about 10 ms to 500 ms. The electrical source or voltage source **55** may provide a voltage ranging between about 20 volts and 10,000 volts to cause instant vaporization of the volume of fluid media M captured between the electrode elements **40**A and **40**B. After a selected time interval of such energy application to tissue T, that may range from about 1 second to 30 seconds, and preferably from about 5 to 20 seconds, the engaged tissue will be contain a core region in which the tissue constituents are denatured and intermixed under relatively high compression between surfaces **20**A and **20**B. Upon disengagement and cooling of the targeted tissue T, the treated tissue will be fused or welded. Over time, the body's wound healing response will reconstitute the treated tissue by means of fibrosis to create a collagenous volume or scar-like tissue.

2. Type "B" Thermotherapy Instrument. Now referring to FIGS. **7** and **8**, another embodiment of vapor generation and delivery system **200** is shown. In the previous embodiment, the working end was optimized for engaging and sealing tissue with a working surface that is in contact with tissue. In the embodiment of FIGS. **7** and **8**, the working end ejects vapor from port **202** for the controlled application of energy by means of a vapor-to liquid phase change energy release for soft tissue removal, for example, to remove disc nucleus tissue. The system can also be used for removal of other soft tissue such as adipose tissue, tumors and the like. In one embodiment, the vapor quality is adapted for collapse (condensation) as well the high velocity vapor (and vapor droplets) applying mechanical force to the soft tissue to assist in the tissue obliteration. The system and introducer sleeve **205** as shown in FIGS. **7** and **8** also includes a negative pressure source coupled to an outflow lumen or channel for extracting condensed vapor and tissue debris from the targeted site, as will be described in more detail below.

In FIG. **7**, it can be seen that system **200** includes a handle portion **204** that transitions into an introducer sleeve **205** that has an elongated dimension for introduction into a patient's body percutaneously, or through a body cavity or a body lumen. The diameter of introducer sleeve **205** can range from about 1 mm to 6 mm or more. In one embodiment, the introducer sleeve is configured for introduction percutaneously into patient's disc as indicated in FIG. **9**.

In one embodiment, the introducer sleeve **205** is fabricated of a temperature resistant polymer or a metal in combination with a polymeric coating. The introducer sleeve **205** can be rigid, deformable or articulatable as in known in the art. In one embodiment, the introducer sleeve **205** is a metal coated with a polymer having a low thermal conductivity, for example less than about 1.0 W/m-K, and preferably less than about 0.50 W/m-K. In one example, an unreinforced polyetheretherketone (PEEK) has a thermal conductivity of about 0.25 W/m-K and can be used for inner and/or outer layers of the introducer. Alternatively, the introducer sleeve **205** can be of PEEK. PEEK is high temperature resistant engineered thermoplastic with excellent chemical and fatigue resistance plus thermal stability. PEEK had a maximum continuous working temperature of 480° F. and retains its mechanical properties up to 570° F. in high-pressure environments. Other materials used in the introducer can comprise formulations or blends of polymers that include, but are not limited to PTFE, polyethylene terephthalate (PET), or PEBAX. PTFE (polytetrafluoroethylene) is a fluoropolymer which has high thermal stability (up to 260° C.), is chemically inert, has a very low dielectric constant, a very low surface friction and is inherently flame retardant. A range of homo and co-fluoropolymers are commercialized under such names as Teflon®, Tefzel®, Neoflon®, Polyflon® and Hyflon®. In another embodiment, the introducer sleeve can carry another layer of a suitable thickness that comprises a low thermal conductivity region such as an air gaps, a layer of an insulative ceramic or glass microspheres or fibers, or at least one lumen that carries a cryofluid in communication with a cryogenic fluid source as in known in the art.

Now turning to FIG. **7**, the cut-away view of handle **204** shows that an interior chamber **225** is formed within the interior of an insulator material indicated at **228** such as a ceramic or a combination of materials to insulate the interior chamber **225** from the surface of the handle. An inflow channel **230** communicates with pressurized inflow source **240** of fluid or liquid media via flexible tube **242** coupled to fitting **244**. A computer controller **245** is provided to control parameters of fluid inflows to the interior chamber **225**. The interior chamber **225** has a distal region in which media flows transition to outflow channel **212** that extends to the working end **215**. In FIG. **8**, it can be seen that Rf source **250** (also operatively connected to controller **245**) has first polarity (+) lead **252***a* and opposing second polarity (−) lead **252***b* that are coupled respectively to first and second conductive surfaces or electrodes **255**A and **255**B exposed in interior chamber **225** that serve as a thermal energy delivery mechanism. The first conductive surface **255**A is the outer surface of elongated sleeve **256** with bore **258** therein having diffuser ports **260** in the sleeve wall for introducing pressurized liquid media M into the interior chamber **225**. The diffuser ports **260** have a suitable dimension and configuration for diffusing or atomizing a high pressure inflow of flow media M from source **240**, which preferably is a saline solution. The second polarity (−) lead is coupled to conductive surface **255**B which comprises a radially outward surface of interior chamber **225**. In the embodiment shown in FIG. **7**, it can be seen that the first and second conductive surfaces **255**A and **255**B are concentric, extend over a substantial length of the handle and have a large surface area with a fixed spaced apart radial dimension indicated at **262**. The radial dimension **262** between the electrode surfaces is selected to match the particular impedance and other operating characteristics of the Rf generator.

The system also includes a negative pressure source **270** that communicates with an outflow channel **276** and outflow lumen **278** in the introducer sleeve, as can be seen in the cut-away view of FIG. **7**. In FIG. **8**, it can be seen that the working end **215** has a suction port **280** that is configured for the aspiration of tissue debris from the targeted site. The

ablation, obliteration and volumetric removal of soft tissue is enabled by the phase change energy release of the vapor transitioning to a liquid as well as mechanical effect of vapor engaging the soft tissue. In the embodiment of FIG. **8**, the vapor outlet (or a plurality of outlets) **202** (i) eject vapor along an axis **282** in a recess **284** that is at least in partly oriented toward an axis of the aspiration port **280**, or (ii) that deflect vapor toward at least one aspiration port **280**. In any embodiment, the inflow pressure of the media can range upward from about 5 psi. In this embodiment, the inflow pressure is elevate greatly to the range of about 5,000 psi to 50,000 psi with a very small media outlet in the range of 0.005" to 0.025" or other suitable dimension and pressure wherein water droplets can apply mechanical energy to scour, damage or obliterate soft tissue. In this embodiment, the system includes the Rf source **250** described above that are operatively coupled to the media inflow pressure source **240** and controller **245** that can apply energy to cause a selected level of vaporization. Optionally, the system can be configured to pulse the energy delivery or the vapor flows at 10 Hz to 500 Hz which it has been found is useful for soft tissue removal. In one method of use, the system can control pressure and flow volume for allowing the vapor flow to obliterate or scour soft disc nucleus tissue while not allowing obliteration of the disc annulus. The system thus allows for tissue-discrimination and ablation based on tissue characteristics such as tissue density, tissue fibrous level and the like. The working end **215** of FIG. **8** is thus well suited for volumetric removal of disc nucleus tissue. Such treatments are needed for new procedures that implant an artificial nucleus, for annulus repair treatments.

Referring to FIG. **7**, in a method of operation, the system injects a volume of liquid saline flow media M at a selected rate under pressure from source **240** which is diffused and atomized by ports **260** as the media enters interior chamber **225**. Contemporaneous with injection and diffusion of the volume of saline, the system delivers sufficient current from source **250** and controller **245** to the conductive atomized saline via the opposing polarity surfaces **255**A and **250**B which instantly vaporize the H_2O in the flow media M to generate a vapor M' that is injected from interior chamber **225** into lumen or channel **212** of introducer sleeve **205**. The instantaneous increase in volume of media in the liquid-to-vapor phase transition greatly increases interior pressures in interior chamber **225** to thereby accelerate the flow into and through the introducer sleeve to working end **215**. Contemporaneous with the ejection of vapor from the working end, the negative pressure source **270** is actuated to suction the collapsing vapor and tissue debris into port **280** and aspiration channel **278**. In any embodiment, the vapor aspiration port or ports **280** are substantially larger in cross-section than the vapor outlet or outlets **202** to accommodate the increase in volume of the condensate as well as tissue debris.

Turning back to FIG. **7**, the system and handle **204** can include an optional pressure relief valve schematically indicated at **264** so that any overpressures in the interior chamber are released. The release of any overpressure can be vented through an additional lumen in the supply tube **242** or to another chamber in the handle.

FIG. **9**A further depicts a method of the invention in treating a patient's disc for removal of a disc nucleus. In FIG. **9**A, it can be seen that the physician has navigated the working end **215** to the targeted nucleus region **285** of a disc **286** as in known in the art under imaging such as fluoroscopy. In one embodiment, the working end carries radiopaque marking to allow the physician to see the angular orientation of the working end. In a next step, the physician sets the pressure, volume of vapor and rate of vapor delivery in the fluid inflow controller **245** that is operatively coupled to the fluid source **240**, Rf source **250** and negative pressure source **270**. The controller **245** operates from pre-sets that select a power level and duration of Rf energy delivery to cooperate with the selected volume of inflowing media M. The controller **245** also operates using pre-sets for simultaneous actuation of the negative pressure source **270** that communicates with lumen **278** in introducer sleeve **205** for suction of tissue debris and vapor condensate. The physician then can move the working end **215** axially, rotationally and angularly to remove the disc nucleus while the preventing damage to the annulus.

FIGS. **9**B and **9**C illustrate working ends **215** that are similar to that of FIG. **8** with different arrangements of vapor outlets **220** and aspiration ports **280**. In FIG. **9**B, a recess **284** is at the distal end the introducer sleeve **205** with the vapor outlet **220** and aspiration port **280** generally opposing on another in the recess. In FIG. **9**C, the introducer **205** includes a deflector portion indicated at **290** proximate the vapor outlet **202** for deflecting the flow of vapor toward the aspiration port. In the embodiment of FIG. **9**C, the vapor inflow channel **212** and the aspiration channel **278** are in a concentric configuration. FIG. **9**D illustrates a working end wherein the introducer sleeve **205** is rotatable at high speed together with a loop element **295** that can be deployed from the working end to cut or scour tissue contemporaneous with energy delivery as described above. The loop element can rotate at any speed from about 20 rpm to 10,000 rpm. In one embodiment, the loop **295** is made of a flexible, round cross-section polymer filament. In use, the filament will operate to cut soft tissue but flex to discriminate against cutting harder tissue. This system is useful in discriminating, for example, between the disc nucleus and the annulus. In another embodiment, the loop **295** is a metal with option blade edge that can be used, for example, to excise and extract soft tumor tissue in a breast, liver, lung or the like. The energy delivered by the vapor contemporaneously obliterates the tissue and can thermally seal the cavity created by the tissue extraction.

An optional pressure sensor **288** located at the distal end of the introducer **205** (FIG. **8**) can be used to assist in determining pressures in the interior of the patient in a working region. MEMS-fabricated pressure sensors are known in the art and can be carried in the surface of the introducer or the balloon surface, for example, of the type fabricated by Integrated Sensing Systems, Inc., 391 Airport Industrial Drive, Ypsilanti, Mich. 48198. Such sensor can be linked back to controller **245** to adjust aspiration pressures or to terminate vapor flow. The MEMS sensor also can be an accelerometer linked to the controller for modulating or terminating vapor delivery in response to unwanted movement of the working end caused by the high pressure ejection of vapor.

In another embodiment and method of the invention, referring to FIG. **10**, the system **300** can include a secondary pressurized media inflow source **305** that is adapted to introduce media or substance **310** (in the form of at least one of a gas, liquid or particulate) through channel **312** in the handle into channel **212** to combine with vapor media M' after it is ejected from chamber **225**. In a method of the invention, the system thus allows for controlling the average mass temperature of the vapor. In one embodiment, the additional media **310** comprises a bioinert gas or atomized fluid that is depressurized and introduced into the vapor for the purpose of reducing the mass average temperature of the injected media to lower than about 100° C. For example, the introduced media **310** can be depressurized CO_2, N_2, or O_2 or atomized H_2O. By this means, the mass average temperature can be less than 100° C., for example in the range of about 45° C. to 100° C. More preferably, the mass average temperature can be in

the range of about 60° C. to 95° C. Still more preferably, the mass average temperature can be in the range of about 70° C. to 90° C.

FIG. **11** illustrates another system embodiment **400** with handle **402** that utilizes a resistive element **420** in interior chamber **425** to cause the liquid-to-vapor phase change in the inflowing media M. All other system components are similar to the previous embodiments and have similar reference numbers. The electrical leads **426***a* and **426***b* in this embodiment are coupled to opposing ends of resistive element **420**. In one embodiment, the resistive element **420** comprises a flow permeable structure such as a syntactic material or open-cell material (FIG. **11**). The terms "syntactic", "open-cell" and "flow permeable" as used herein refer to any structure that has substantial porosity for allowing fluid flow therethrough. Such materials have the advantage of providing very high surface areas for conducting heat from an I^2R heated material to pressurized media flows therein. The syntactic structure is further selected to provide an internal pore dimension that causes diffusion and atomization of high pressure inflows, for example of sterile water or saline. For example, the resistive element **420** can comprise a syntactic metal, resistive ceramic composite, or include a carbon portion. Such materials are available from ERG Materials and Aerospace Corp., 900 Stanford Avenue, Oakland, Calif. 94608 and Poco Graphite (http://www.poco.com). The open-cell material also can be an open cell foam that is metal plated, a sintered material, a plated entangled filament material, or any ordered or disordered structure commonly known in the art.

In the embodiment of FIG. **11**, the system further includes a valve system **428** and recirculating channel **430** that are adapted for controlling the generation and release of vapor from working end **415**. In the previous embodiments, the use of Rf energy delivery for vapor generation in chamber **225** (FIG. **7**) can cause instantaneous high pressure flows of vapor. In the system embodiment of FIG. **11**, the delivery of energy by means of resistive element **420** can require a fraction of a second or more to produce vapor from high pressure inflows of liquid media M. For this reason, the interior chamber **425** includes a recirculation channel **430** for a looped flow of vapor—or vapor and water droplets—that circulates back to inflow channel or the proximal end **432** of interior chamber **425**. It should be appreciated that the recirculation channel **430** can be entirely housed in handle **402** or can circulate back to the source **245** or another intermediate chamber. The recirculation channel **430** also is operatively coupled to a pressure relief valve **262** as described above, and can further include a one-way valve indicated at **434**. In operation of the embodiment, the system is actuated to create vapor which can circulate until a switch **435** coupled to controller **245** and valve **428** is actuated to release vapor M' from interior chamber **425**. In all other respects, the method of the invention is the same as described above.

The schematic view of system **400** in FIG. **11** depicts the valve **428** in the handle, but the valve can also be located in working end **415** or elsewhere in introducer sleeve **205**. Such valve systems can be linked to controller **245** by electrical leads in the introducer wall. In another embodiment, the valve **428** can be in the working end **415** and the recirculation channel **430** also can extend through the introducer sleeve **205** to the working end **415**. This system thus assures that high quality vapor will be ejected from the working end.

The scope of the invention includes the use valve system **428** and recirculating channel **430** in other embodiments that utilize Rf, laser microwave or other energy deliver mechanisms. For example, in an Rf energy system as in FIG. **7**, the valve and recirculating channel **430** systems can be used to control slight inconsistencies in vapor generation due to varied liquid inflow rates that sometimes results in sputtering and incomplete vaporization or inflowing media.

In another embodiment similar to that of FIG. **11**, the system can infuse heated water (or saline or another liquid) from an external source under high pressure into an enclosed interior chamber of the system. The system also includes a valve similar to valve **428** in FIG. **11**. Upon opening of the valve, the release of pressurized fluid will in part release the energy that was exerted on the fluid in the form of pressure—which will be converted into the energy required to vaporize the heated fluid. This type of system has the advantage of not requiring a thermal energy source with sufficient capacity for vaporizing needed volumes of vapor. Instead, a pressurization mechanism combined with a less robust thermal energy delivery system can be used to produce the required volume of vapor. Such sources can be external to the handle of the introducer.

The scope of the invention included use of the system to apply energy from a phase-change release to tissue for tissue modification in various procedures. The system can be configured with a needle-like working end to treat tumor tissue in a prostate, liver, kidney, breast, lung, vertebra and the like. The system can be configured with a needle-like working end for ablating fibroids. In another embodiment, a very small gauge needle (e.g., 36 ga.) can be used with fiber optic viewing to treat macular degeneration for shrinking and sealing leaking microvasculature. As very small gauge needle also can be used in a vision correction treatment to treat the cornea. A series of spots around the cornea can be targeted with vapor to shrink collagen to create a steepened cornea for treating presbyopia or to treat hyperopia. In another embodiment, the system can use a phase change energy release in an endometrial ablation procedure. In another embodiment, the system can use a small gauge blunt-tipped vapor delivery device that used pulses of vapor to cut brain tissue without causing any collateral thermal damage. A similar device can be used in orthopedic surgery to cut ligaments, cartilage and the like. The system can use in a cutting loop for TURP procedures. The system also can be used for delivering energy to a body lumen such as a blood vessel. In another embodiment, the system can be used to shrink lung tissue to cause lung volume reduction.

Although particular embodiments of the present invention have been described above in detail, it will be understood that this description is merely for purposes of illustration and the above description of the invention is not exhaustive. Specific features of the invention are shown in some drawings and not in others, and this is for convenience only and any feature may be combined with another in accordance with the invention. A number of variations and alternatives will be apparent to one having ordinary skills in the art. Such alternatives and variations are intended to be included within the scope of the claims. Particular features that are presented in dependent claims can be combined and fall within the scope of the invention. The invention also encompasses embodiments as if dependent claims were alternatively written in a multiple dependent claim format with reference to other independent claims.

What is claimed is:

1. A method of applying energy to soft tissue comprising:

generating a flow of vapor such that the vapor is ejected from a device in a flow of vapor;

generating a second flow of a second media and combining the second media with the vapor where the second media is depressurized; and

introducing the flow of vapor to interfacing soft tissue wherein the vapor and second media deliver energy sufficient to modify the tissue.

2. The method of claim **1** wherein the introducing step includes the vapor undergoing a vapor-to-liquid phase transition thereby delivering thermal energy to the tissue.

3. The method of claim **1** wherein the introducing step includes injecting the vapor at a high velocity sufficient to deliver mechanical energy to the soft tissue.

4. The method of claim **1** further comprising controlling the parameters of the flow of vapor, the parameters selected from the group of the heat of vaporization of the vapor, the pressure of the flow of vapor, the volume of the flow of vapor and the duration of the flow of vapor.

5. The method of claim **1**, where the second media comprises a media consisting of at least one of a liquid or a particulate matter and where generating the second flow media and combining the second flow media comprises reducing the mass average temperature of the flow of vapor.

6. The method of claim **1**, wherein the second media comprises at least one of a depressurized CO2, N2, O2 or H2O.

7. A method as in claim **1** further comprising applying aspiration forces about the interface of the flow of vapor with the soft tissue.

8. The method of claim **1** wherein modifying tissue includes at least one of tissue ablation, obliteration, scouring and volumetric removal.

9. The method of claim **4** including controlling the parameters of the flow of vapor to obliterate a selected softer tissue while preventing obliteration of a selected harder tissue.

10. The method of claim **1** wherein the tissue includes at least one of disc tissue, adipose tissue, tumorous tissue and ocular tissue.

11. The method of claim **1** further comprising generating the flow of vapor by at least one of resistive heating means, radiofrequency (Rt) energy means, microwave energy means, photonic energy means, magnetic induction energy means, compression and decompression means, and ultrasonic energy means.

12. A method of applying energy to mammalian tissue comprising the steps of generating a flow of vapor, introducing a flow of vapor into an interface with tissue, and controlling the parameters of the flow for discriminating between first tissue and second adjacent tissues for volumetric removal of the first tissue without volumetric removal of the second tissue.

13. A method as in claim **12** further comprising applying aspiration forces about the interface of the flow of vapor with the tissue for extracting the tissue.

14. A method as in claim **12** wherein the first tissue is a less fibrous tissue and the second tissue is more fibrous tissue.

15. A method as in claim **12** wherein the first tissue is a disc nucleus portion and the second tissue is a disc annulus portion.

16. A method as in claim **12** wherein the first tissue is adipose tissue and the second tissue is non-adipose tissue.

17. A method as in claim **12** wherein the first tissue is less dense tissue and the second tissue is more dense tissue.

18. A method as in claim **12** wherein the first tissue is soft tissue and the second tissue is vascular tissue.

19. A method as in claim **12** wherein the first tissue is tumorous tissue and the second tissue is non-tumorous tissue.

20. A surgical system for applying energy to tissue, the system comprising:

a probe having a handle end that extends to a working end;

a source of a vaporized fluid media that communicates with at least one vapor outlet in the working end;

a negative pressure source that communicates with at least one aspiration port in the working end

where the vapor outlet and aspiration port are recessed in the working end and the at least one vapor outlet is directed toward the at least one aspiration port.

21. The surgical system of claim **20** wherein the at least one aspiration port has an open cross-section that is substantially larger than the open cross-section of the at least one vapor outlet.

22. The surgical system of claim **20** further including an element that is extendable from the working end and a rotation mechanism for rotating the working end, where the element is adapted to mechanically cut or scour tissue.

23. The surgical system of claim **20** further comprising a controller for controlling at least on of the pressure of the source of a vaporized fluid media and the pressure of the negative pressure source.

24. The surgical system of claim **20** further comprising a MEMS sensor in the working end.

25. The method of claim **1** wherein the second media allows for controlling the average mass temperature of the vapor.

26. The method of claim **1** wherein the second media is introduced into the vapor to reduce the mass average temperature of the vapor.

27. The method of claim **20**, where the vapor outlet and aspiration port are arranged in a concentric configuration within the working end.

28. The method of claim **20**, where the vapor outlet and aspiration port are positioned in opposition to each other in the working end.

29. A surgical system for applying energy to tissue,

a probe having a handle end that extends to a working end;

a source of a vaporized fluid media that communicates with at least one vapor outlet in the working end;

a negative pressure source that communicates with at least one aspiration port in the working end; and

an extendable cutting loop extendable from the working end and a rotation mechanism for rotating the working end.

30. The surgical system of claim **29** wherein the at least one vapor outlet is directed toward the at least one aspiration port.

31. The surgical system of claim **29** wherein the at least one vapor outlet is in a recessed portion of the working end.

32. The surgical system of claim **29** wherein at least one aspiration port is in a recessed portion of the working end.

33. The surgical system of claim **29** wherein the at least one aspiration port has an open cross-section that is substantially larger than the open cross-section of the at least one vapor outlet.

34. The surgical system of claim **29** further comprising a controller for controlling at least on of the pressure of the source of a vaporized fluid media and the pressure of the negative pressure source.

35. The surgical system of claim **29** further comprising a MEMS sensor in the working end.

36. A method of applying energy to soft tissue comprising:

generating a flow of vapor such that the vapor is ejected from a device in a flow of vapor;

generating a second flow of a second media and combining the second media with the vapor where the second media comprises a liquid or a particulate substance; and

introducing the flow of vapor to interfacing soft tissue wherein the vapor and second media deliver energy sufficient to modify the tissue.

* * * * *

专利名称(译)	医疗器械和使用方法		
公开(公告)号	US8016823	公开(公告)日	2011-09-13
申请号	US11/244329	申请日	2005-10-05
[标]申请(专利权)人(译)	SHADDUCK约翰•H•		
申请(专利权)人(译)	SHADDUCK约翰•H•		
当前申请(专利权)人(译)	海啸MEDTECH，LLC		
[标]发明人	SHADDUCK JOHN H		
发明人	SHADDUCK, JOHN H.		
IPC分类号	A61B18/18		
CPC分类号	A61B18/04 A61B18/1492 A61B17/3203 A61B18/042 A61B2017/00504 A61B2018/0041 A61B2018/00559 A61B2018/1213 A61B2218/002 A61B2018/00541 A61B2018/00404 A61B2018/048		
优先权	60/615900 2004-10-05 US		
其他公开文献	US20060135955A1		
外部链接	Espacenet USPTO		

摘要(译)

本发明涉及使用气 - 液相变向组织施加能量的手术器械，该相变向目标组织输送大量能量。在一个实施例中，该系统被配置用于通过从靠近软组织的第一蒸汽端口高速喷射蒸汽介质来体积地移除组织，其中介质的蒸汽 - 液体相变将能量施加到组织。该系统提供连接到抽吸源的第二端口，该抽吸源与第一蒸汽端口配合以从目标部位抽吸组织碎片。