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(54) **PIPELINE**

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(63) Continuation of application No. 10/199,524, filed on Jul. 19, 2002, which is a continuation of application No. 09/454,139, filed on Dec. 3, 1999, now Pat. No. 6,497,289.

(60) Provisional application No. 60/111,293, filed on Dec. 7, 1998.

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(73) Assignee: **Shell Oil Company**, Houston, TX (US)

(51) **Int. Cl.**

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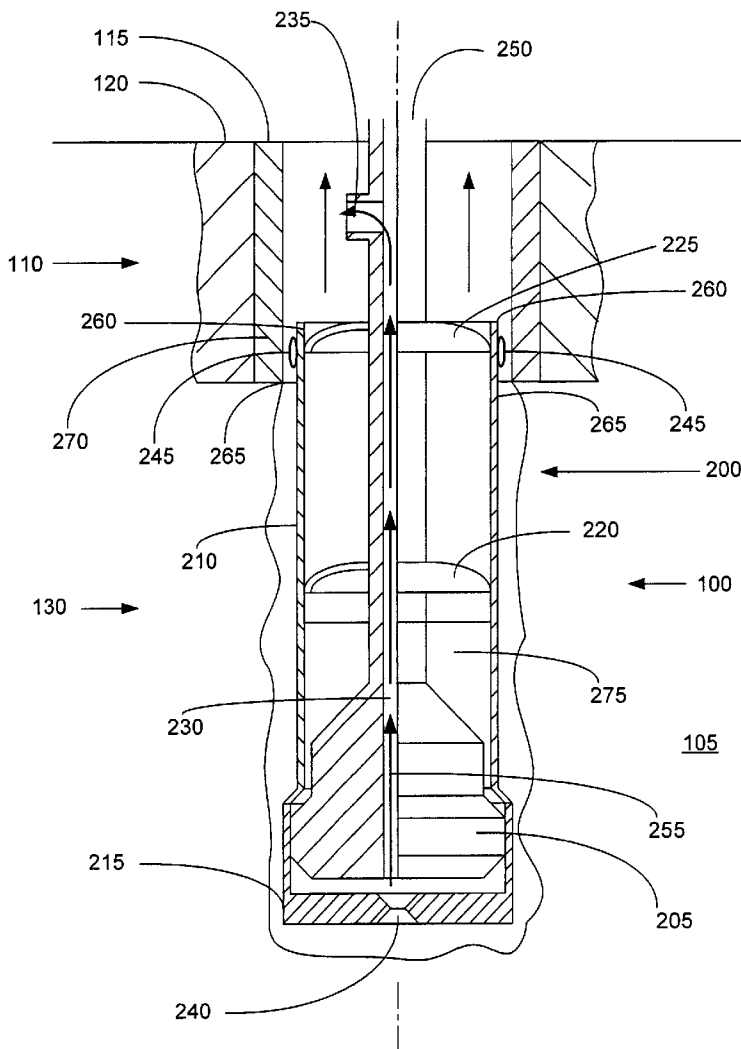
(21) Appl. No.: **11/456,584**

(52) **U.S. Cl.** **137/15.09**

(22) Filed: **Jul. 11, 2006**

(57) **ABSTRACT**

A pipeline.



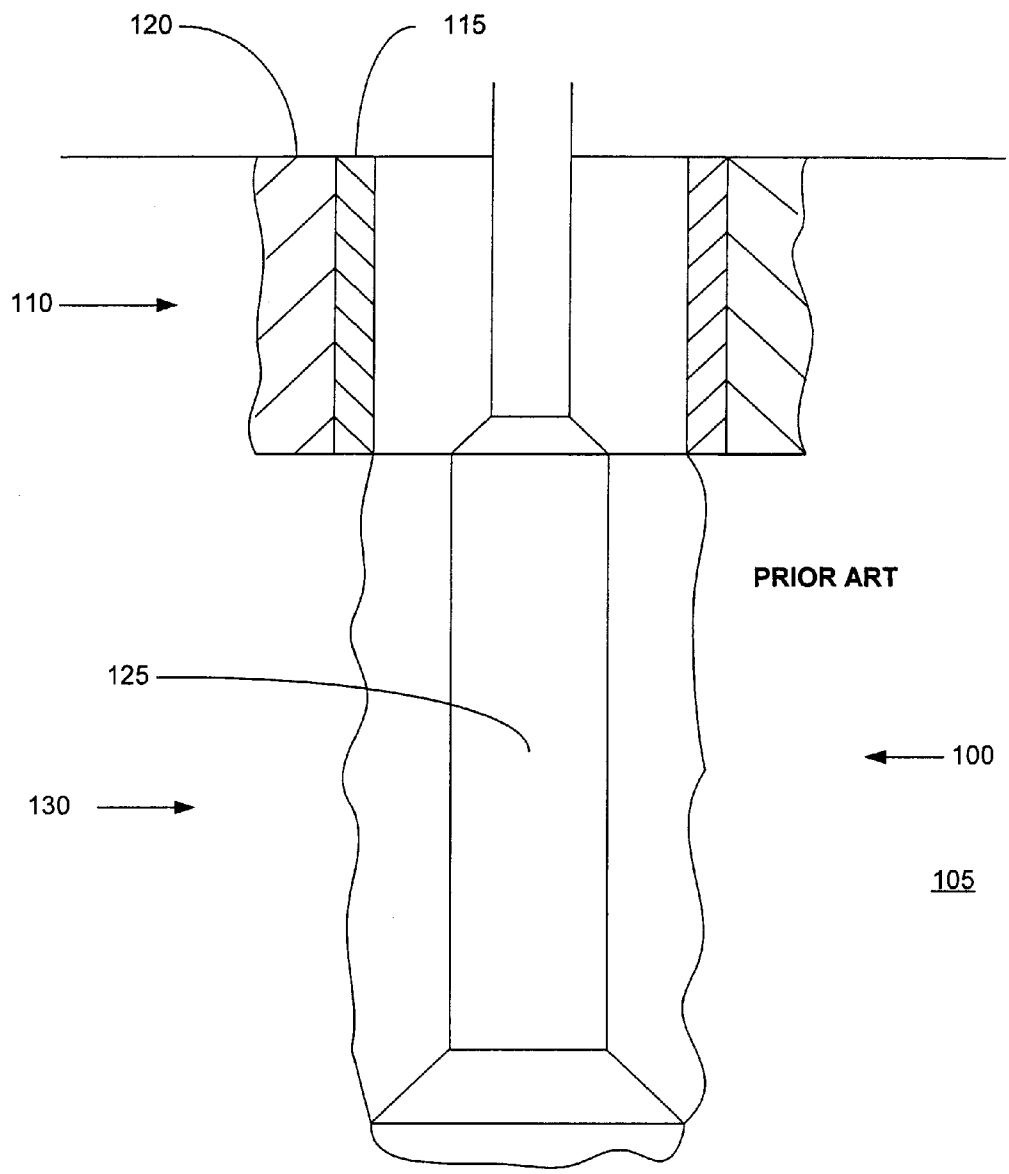


FIGURE 1

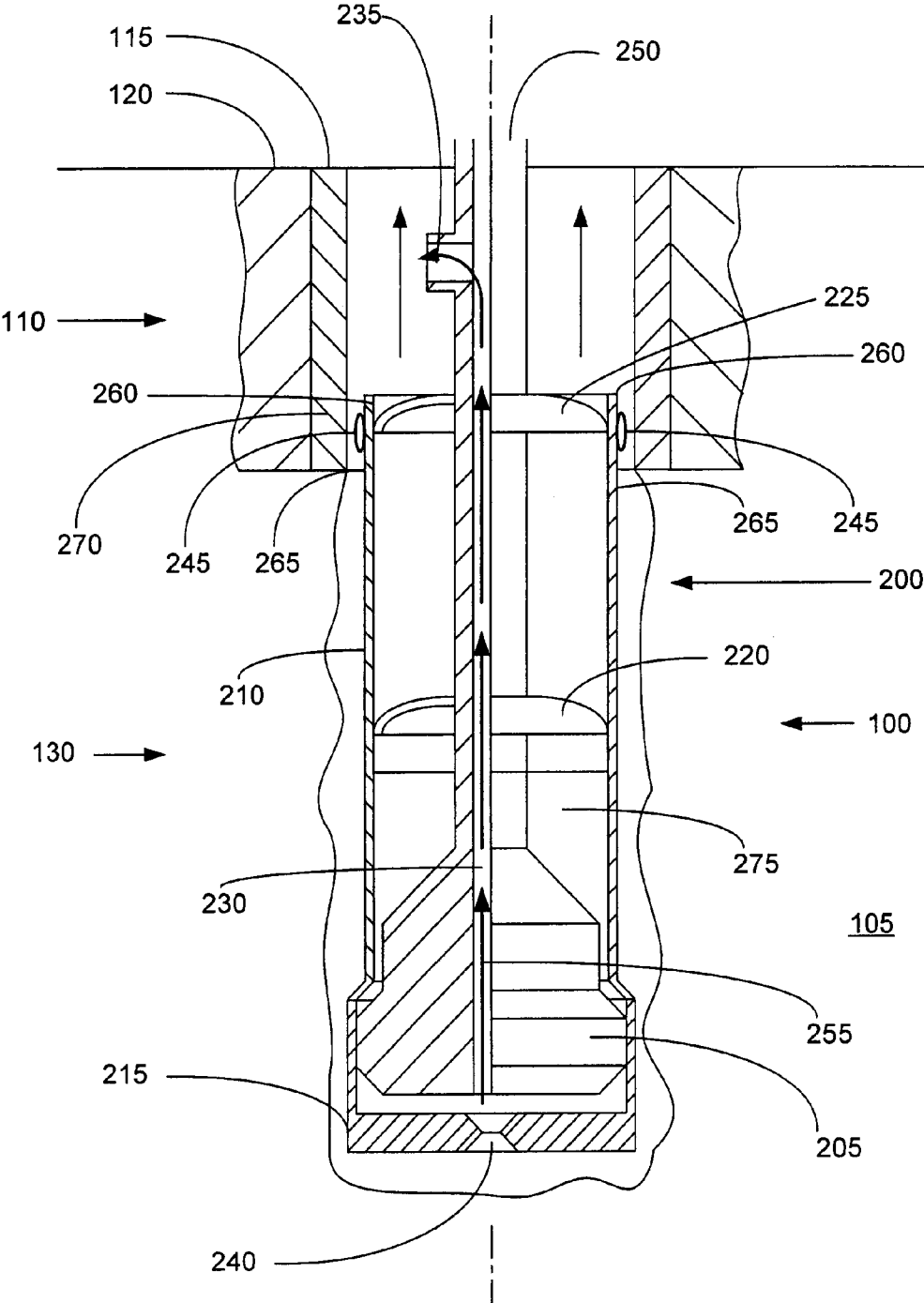


FIGURE 2

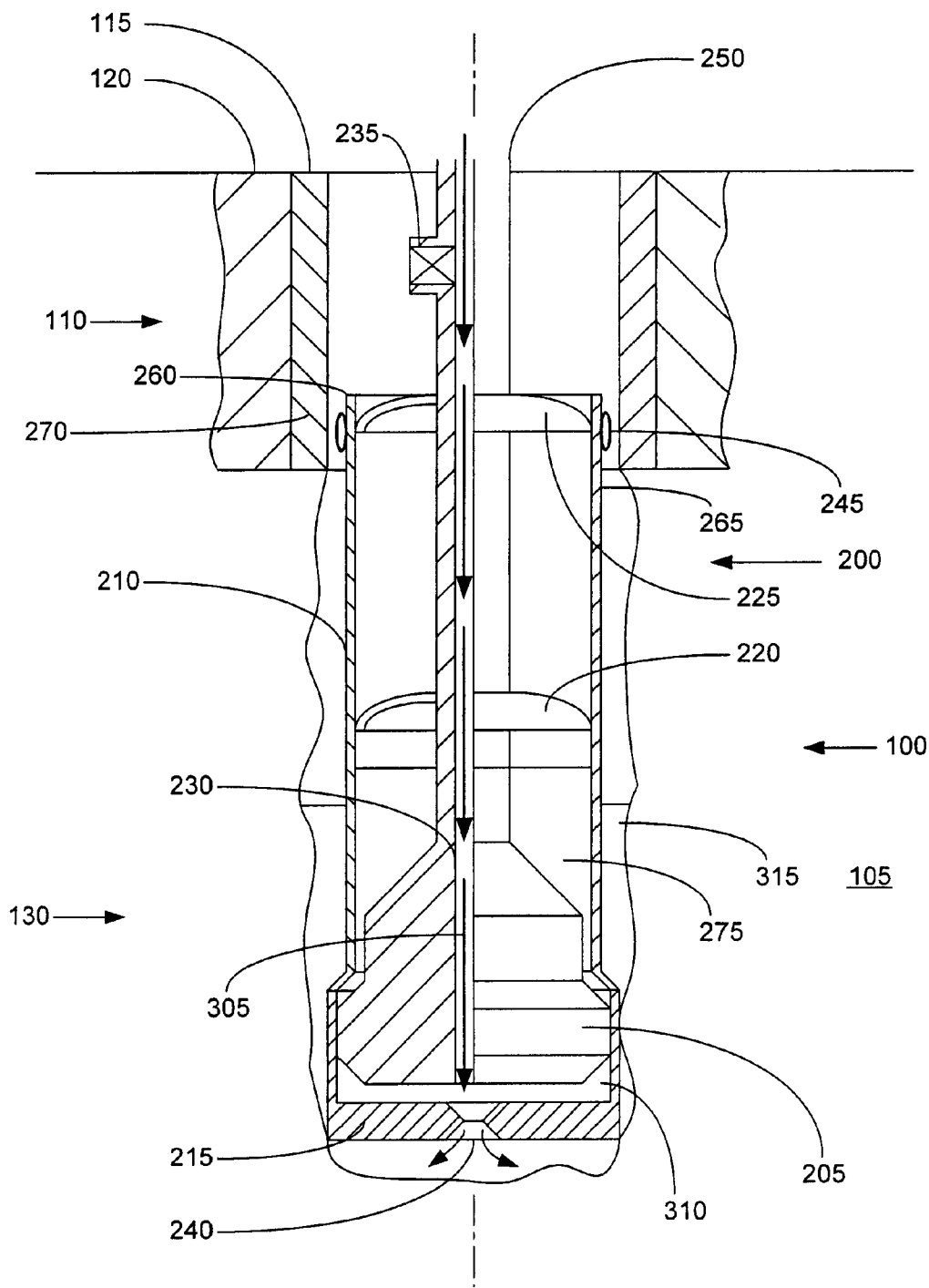


FIGURE 3

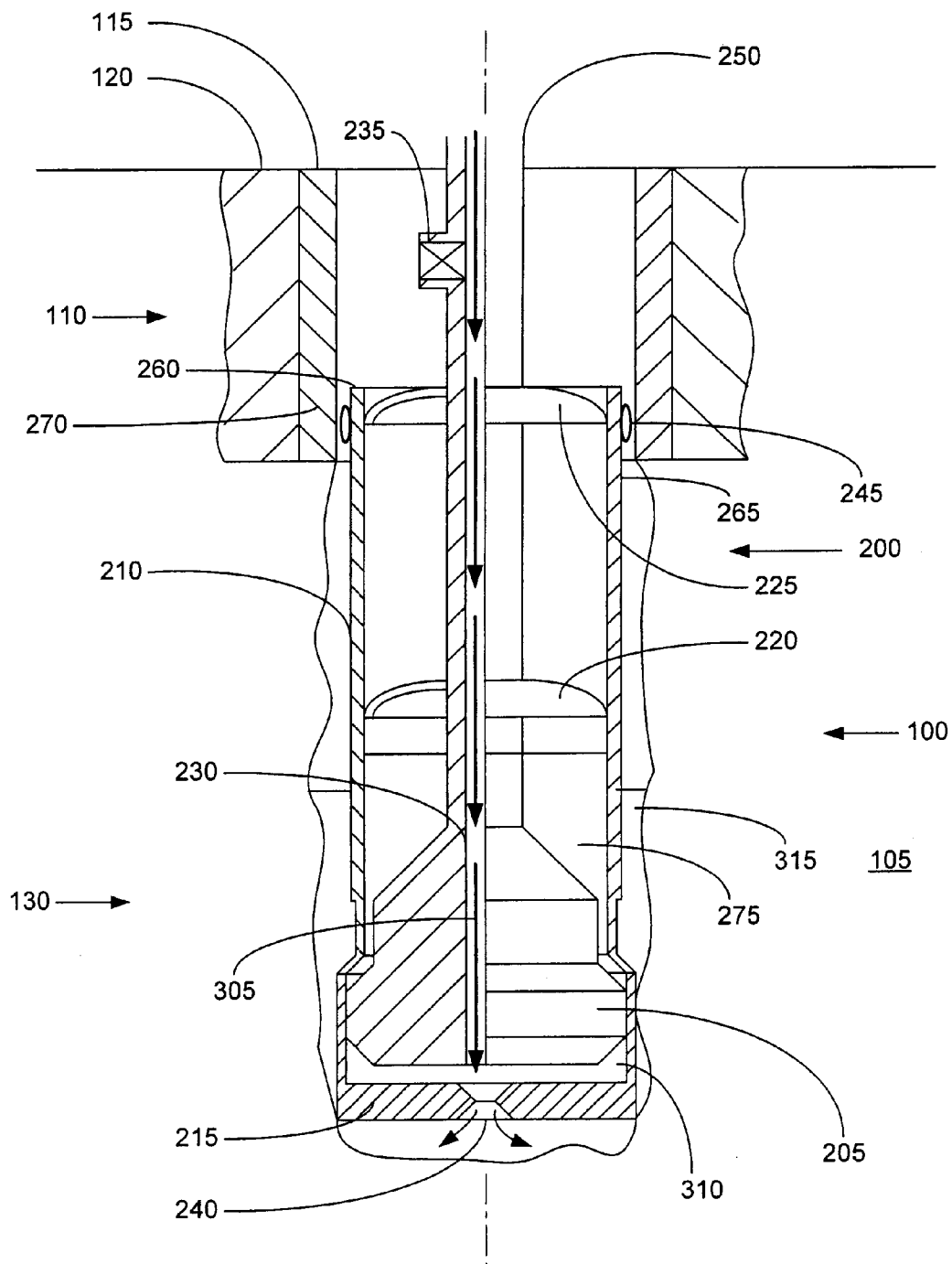


FIGURE 3a

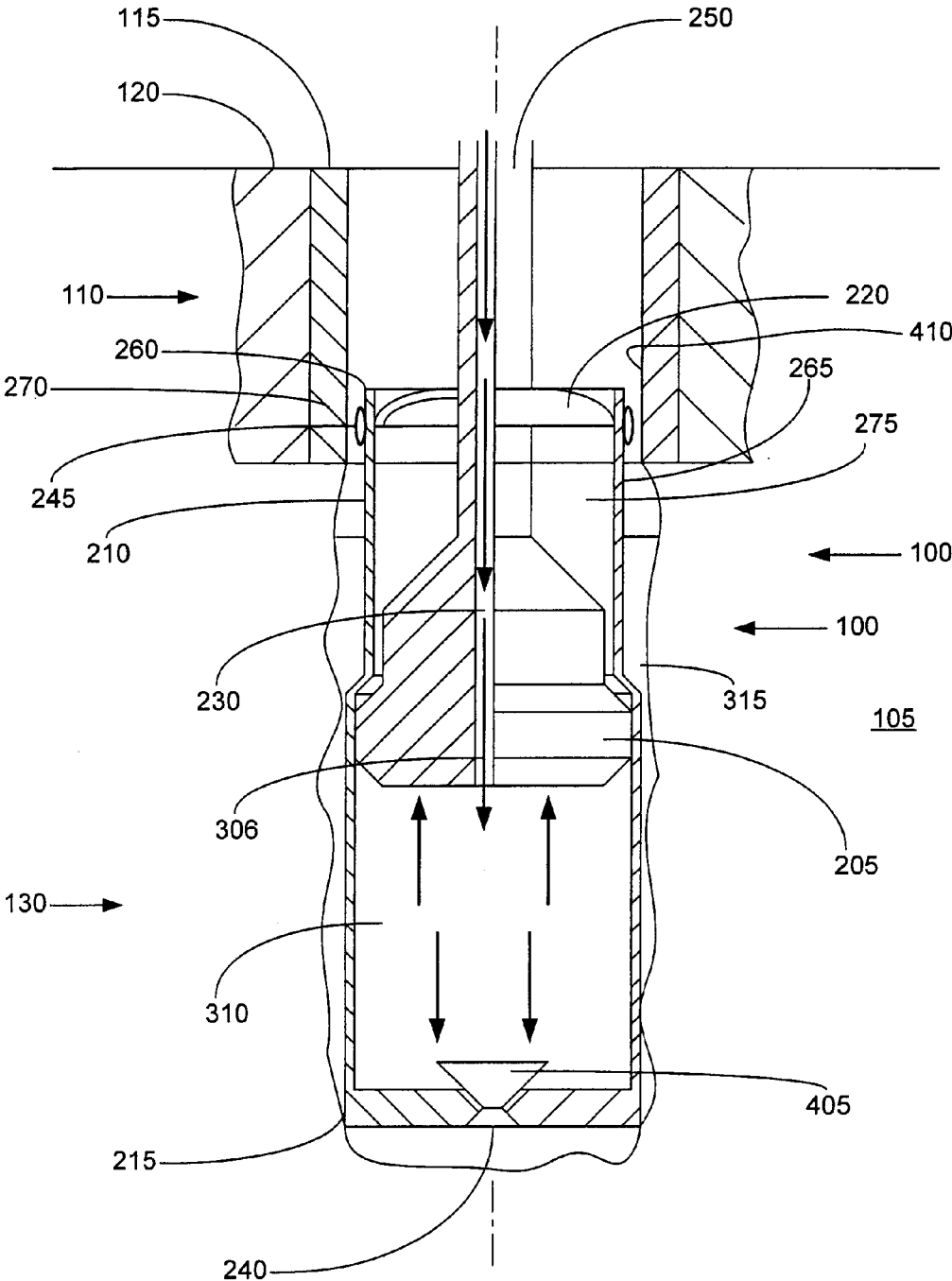


FIGURE 4

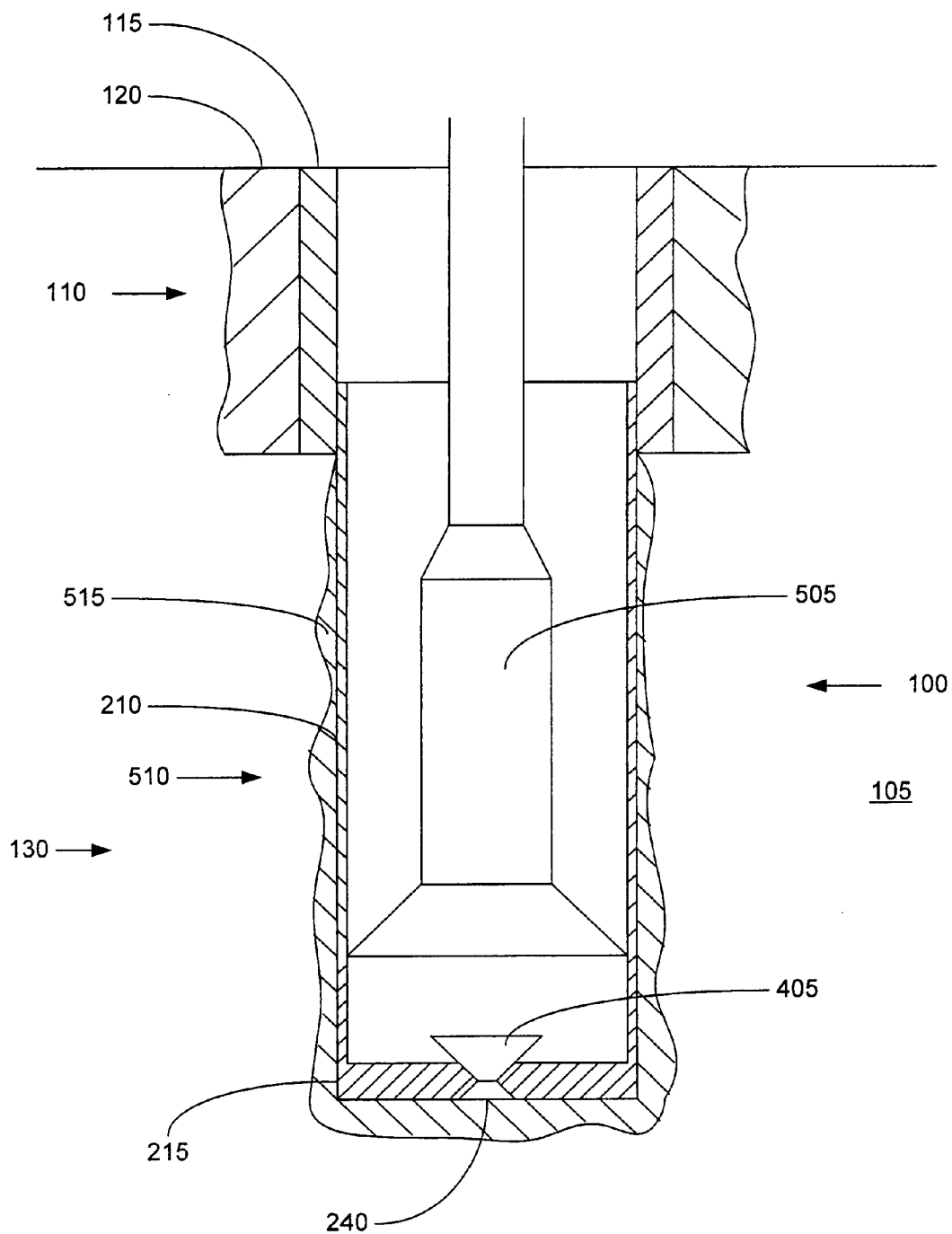


FIGURE 5

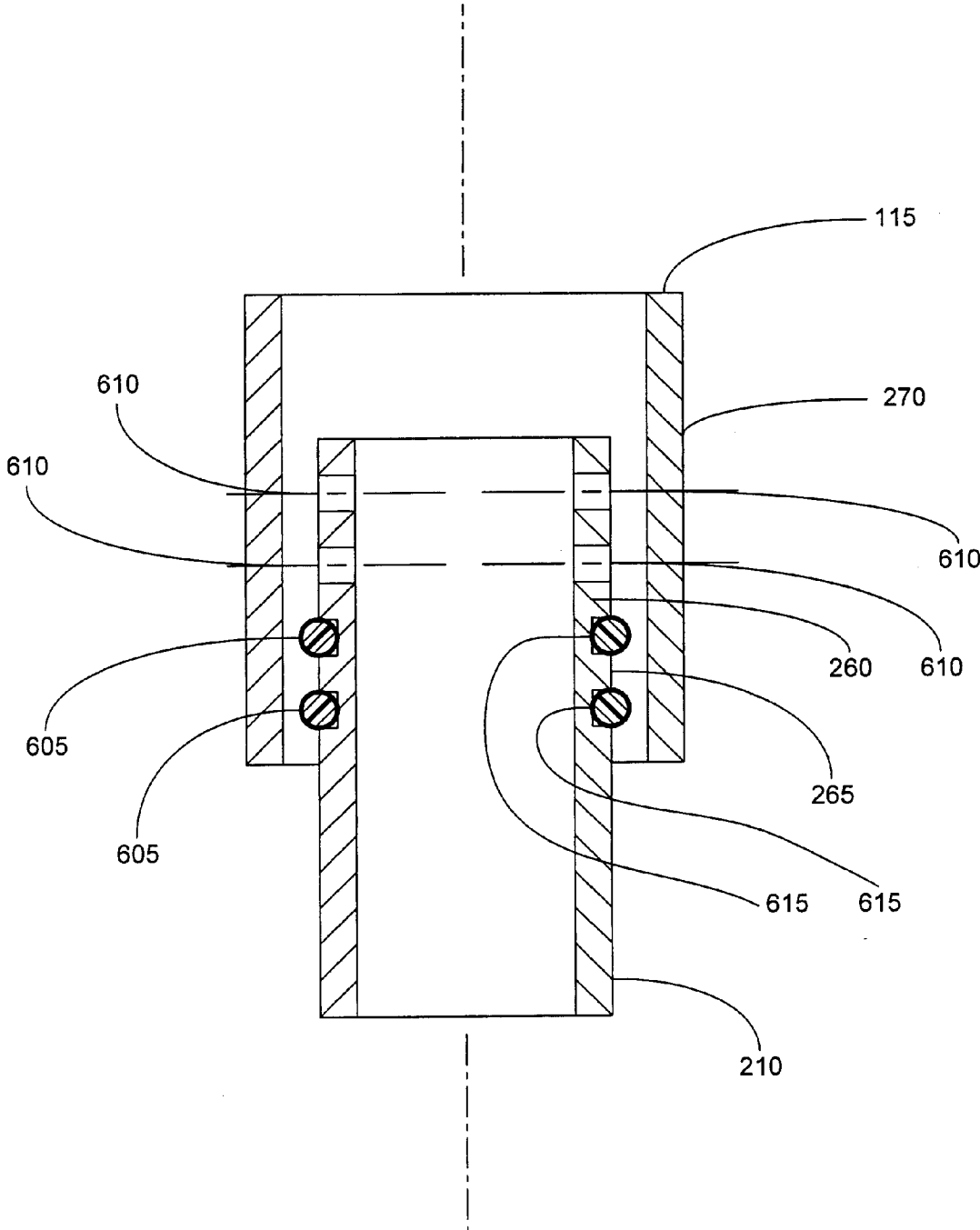


FIGURE 6

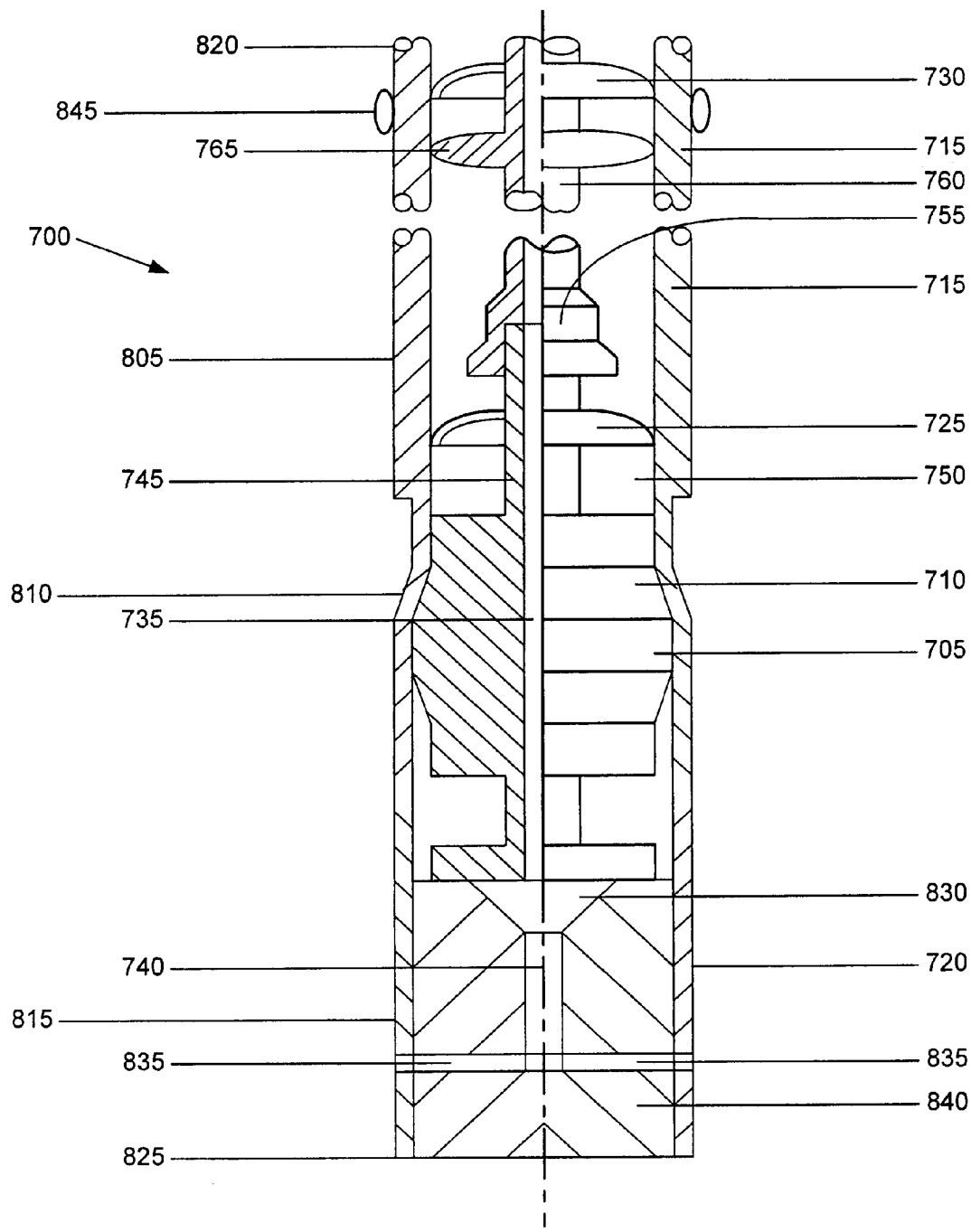


FIGURE 7

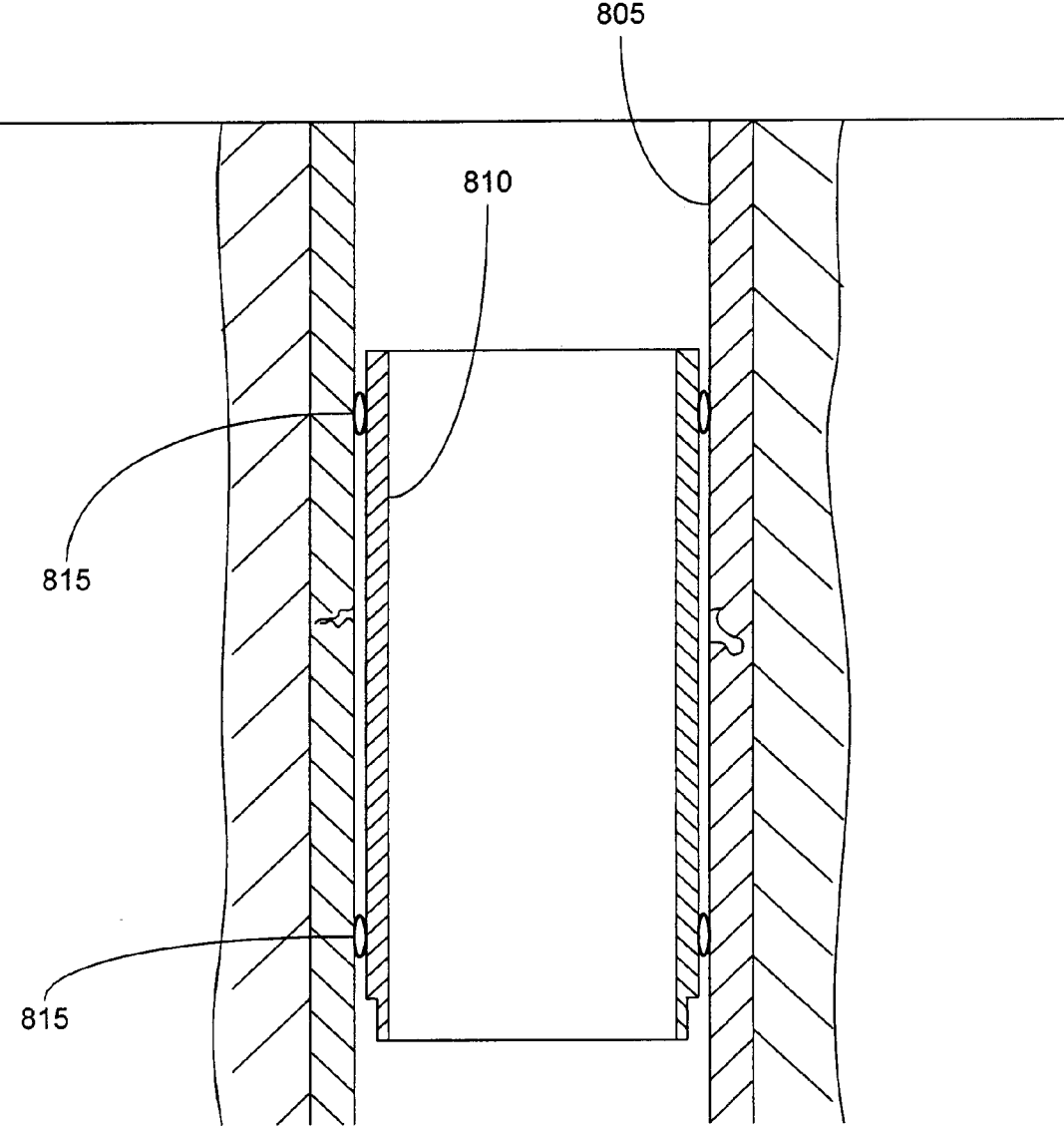


FIGURE 8

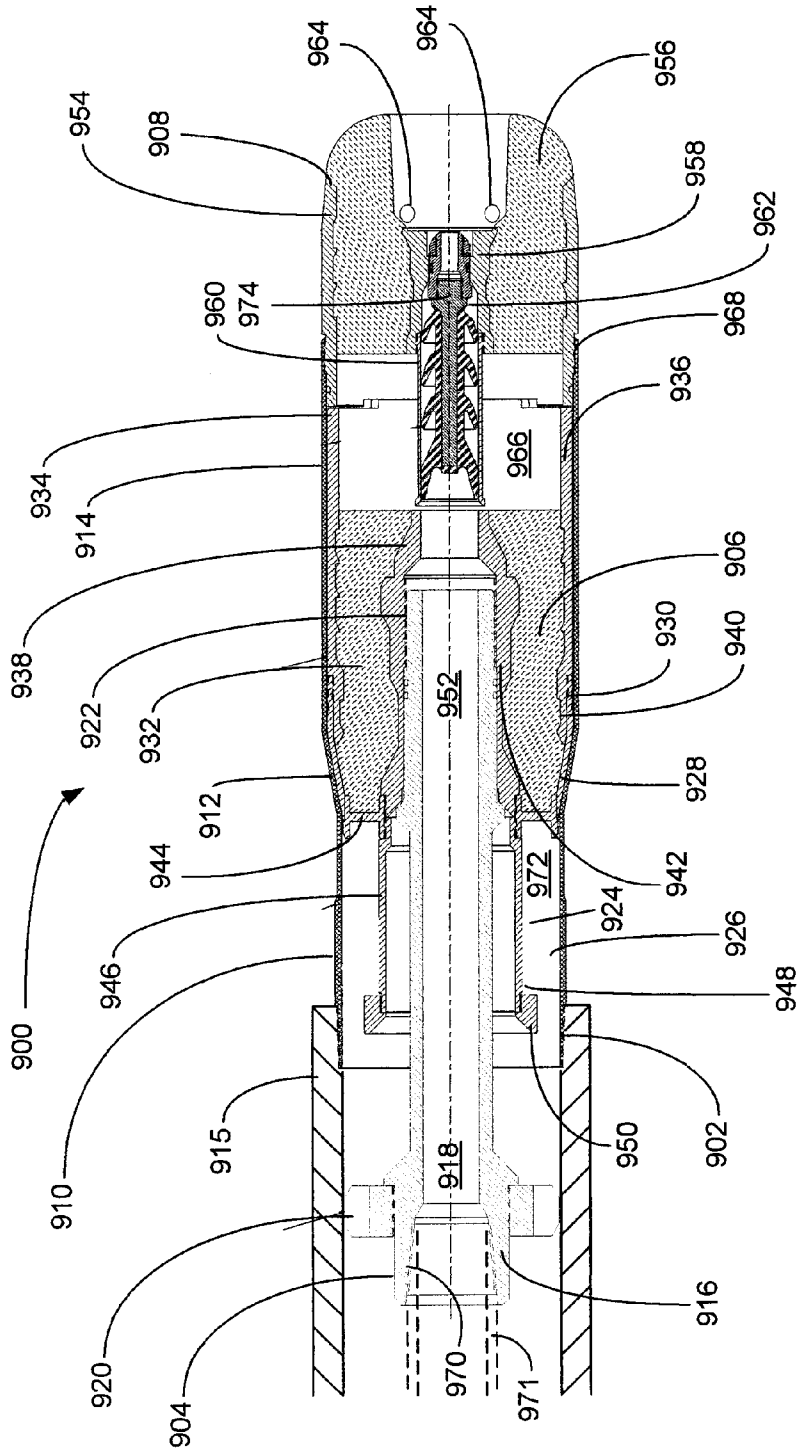


FIGURE 9

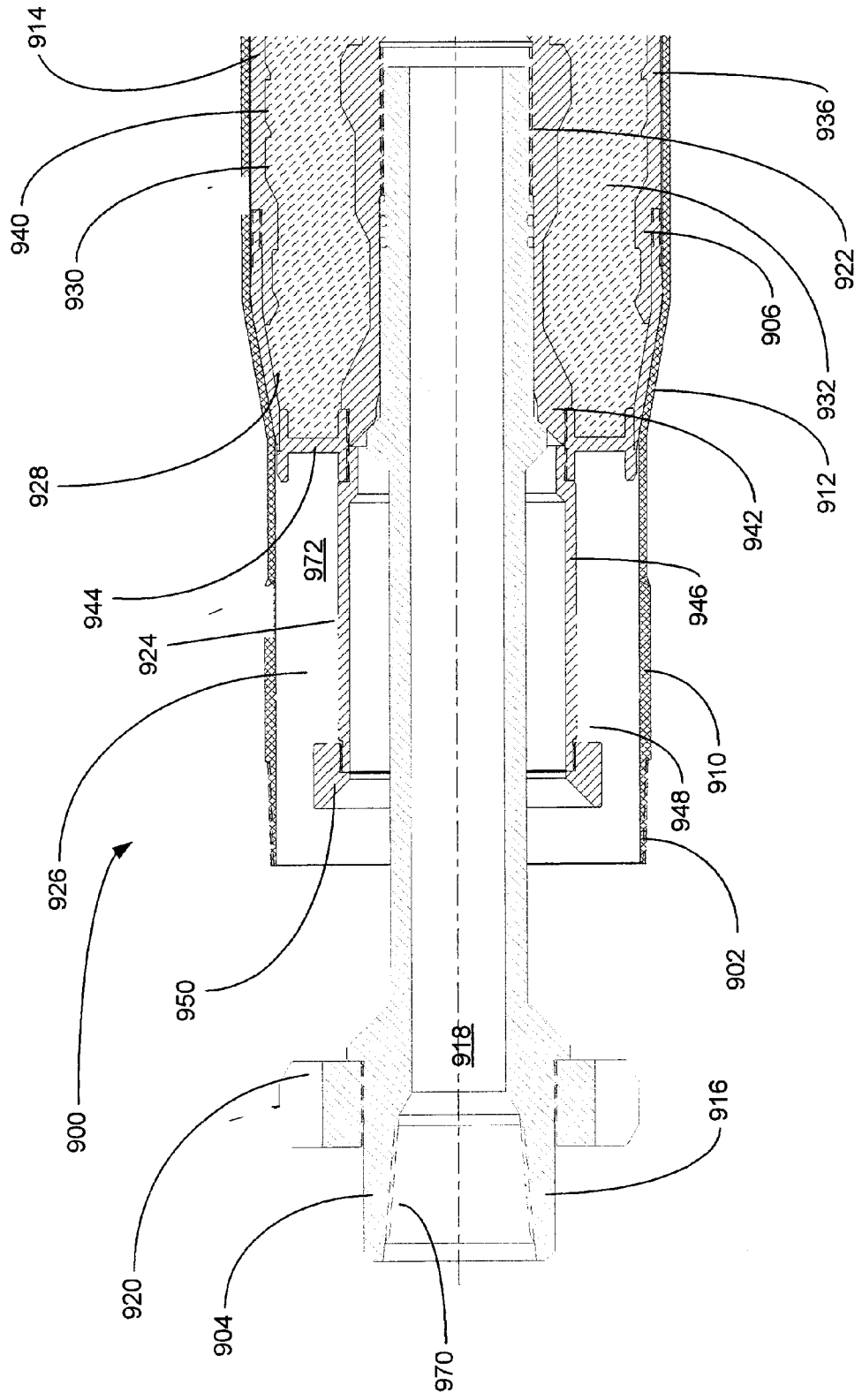


FIGURE 9a

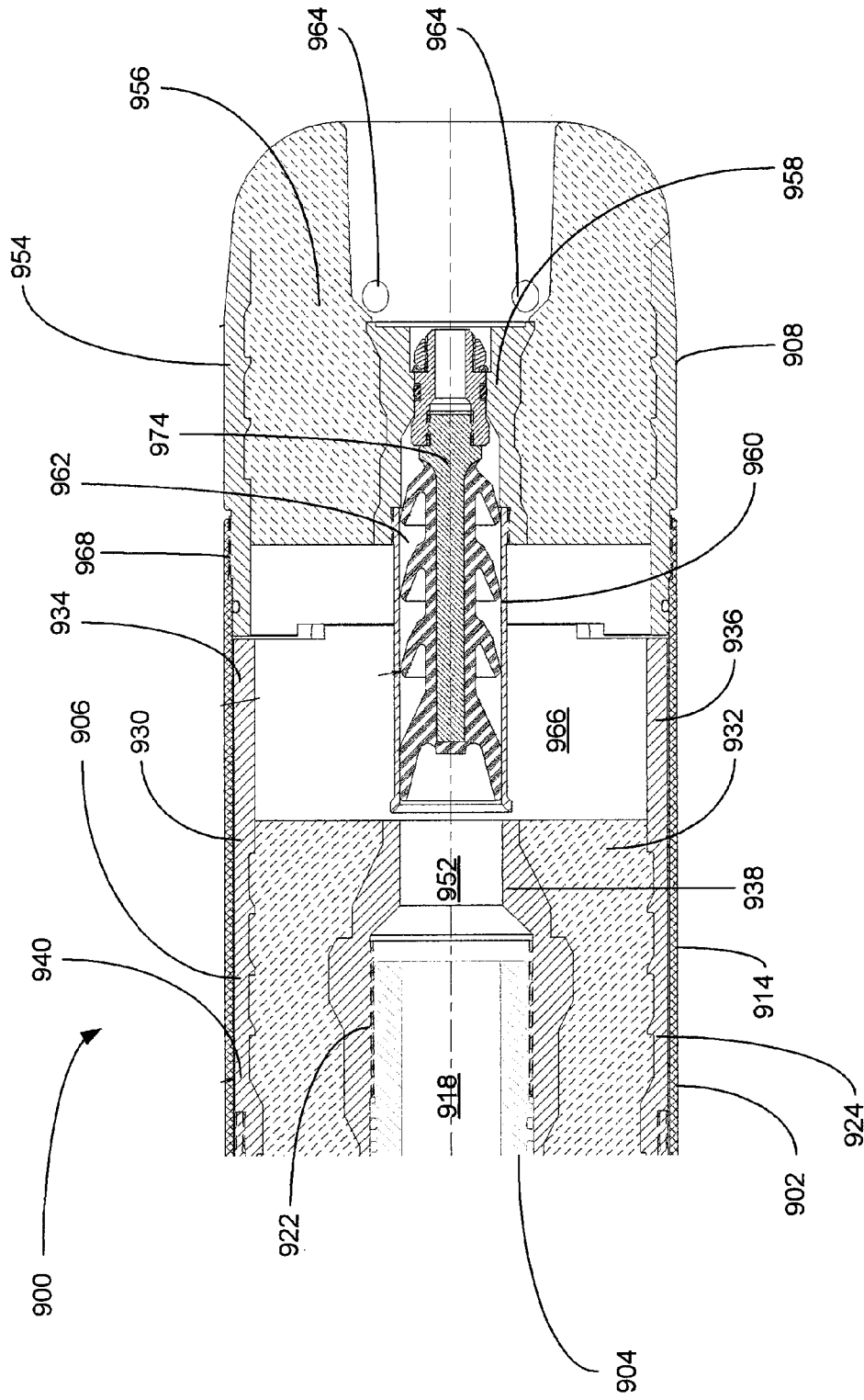


FIGURE 9b

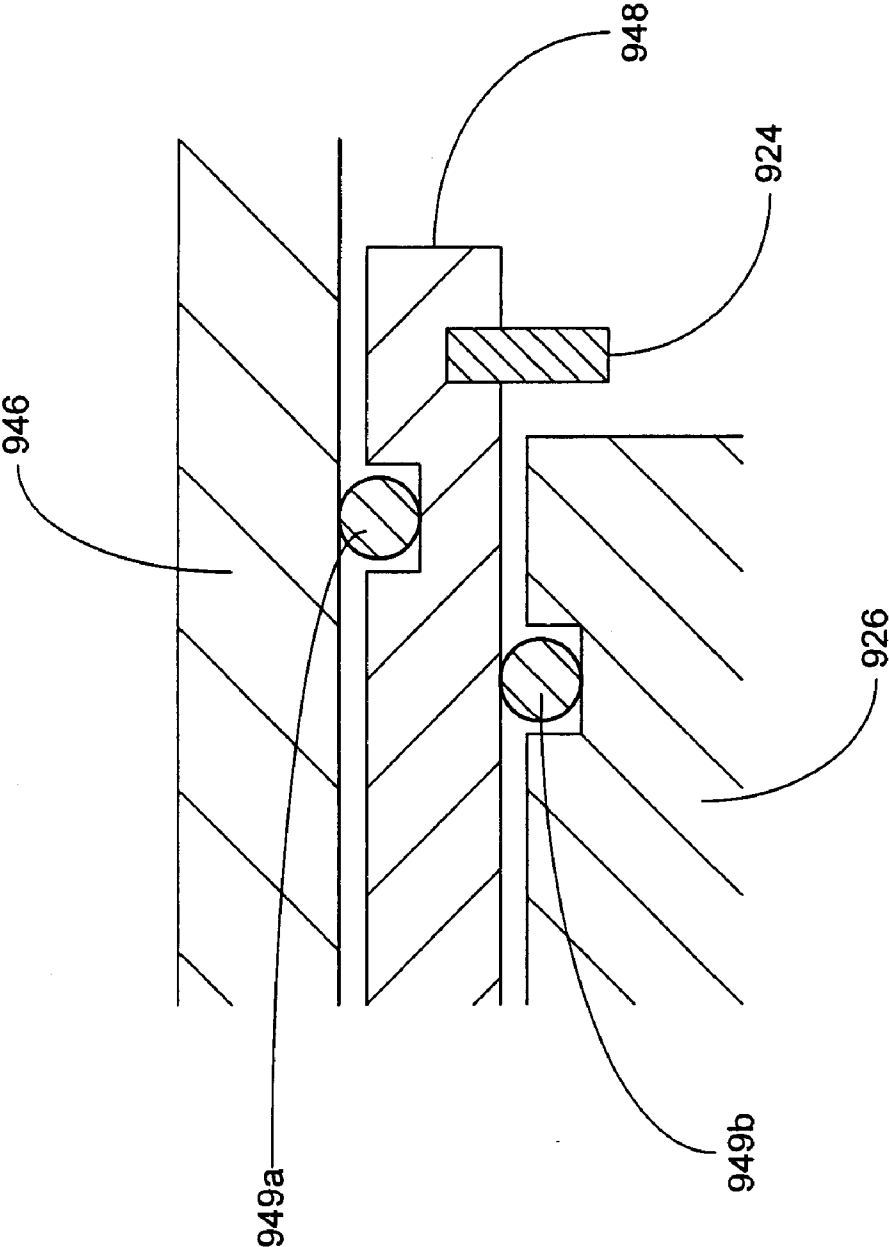


FIGURE 9C

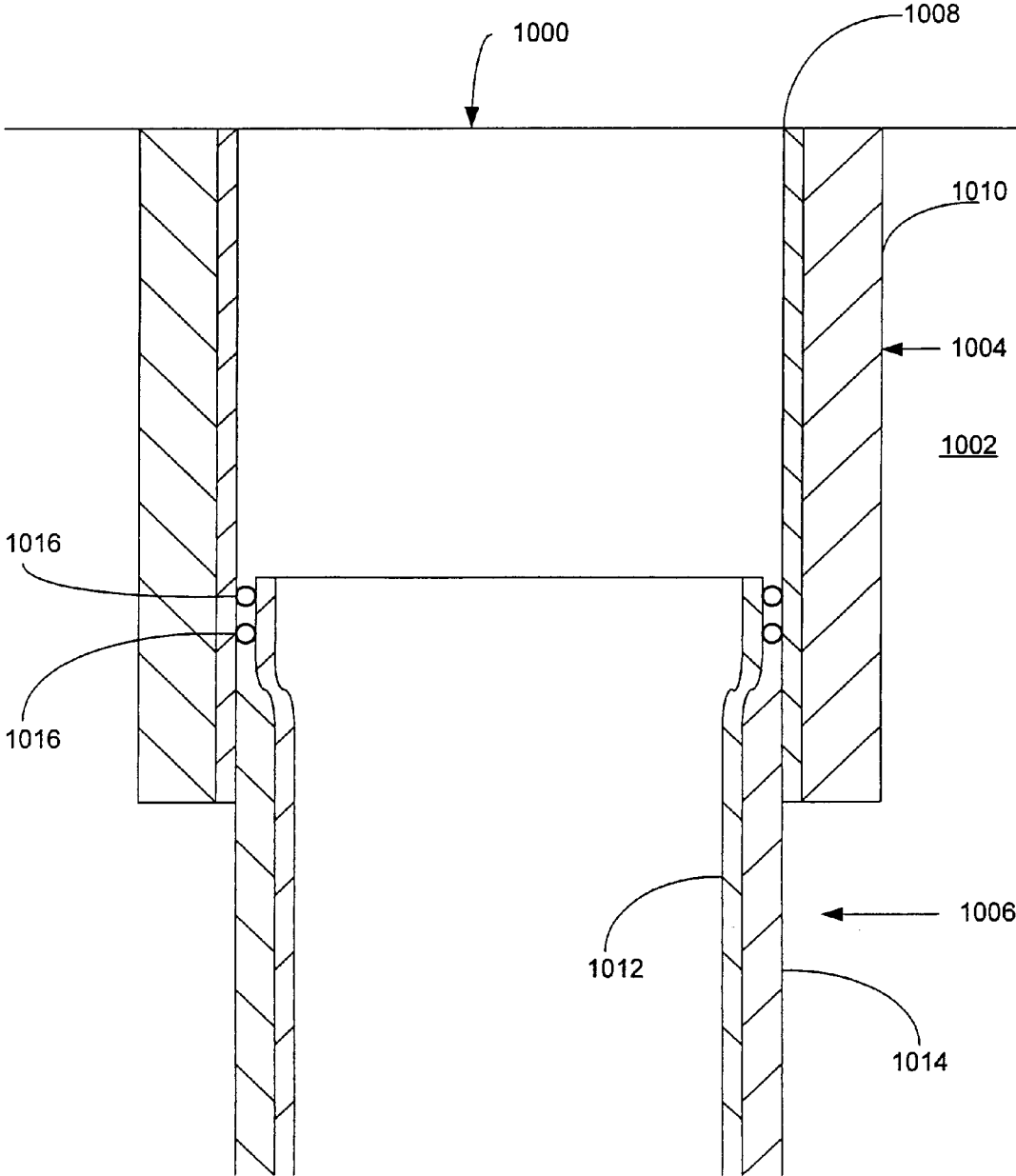


FIGURE 10a

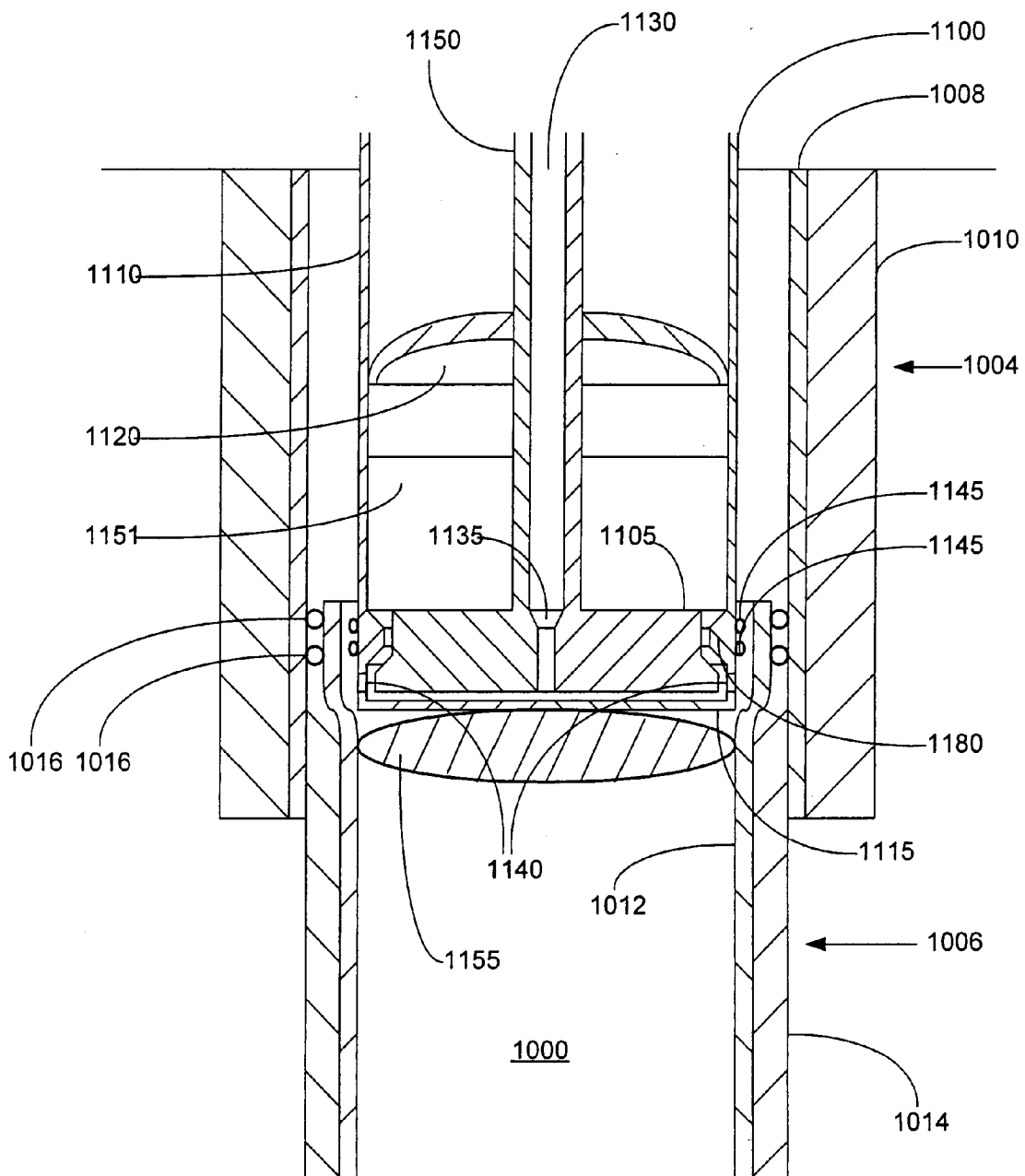


FIGURE 10b

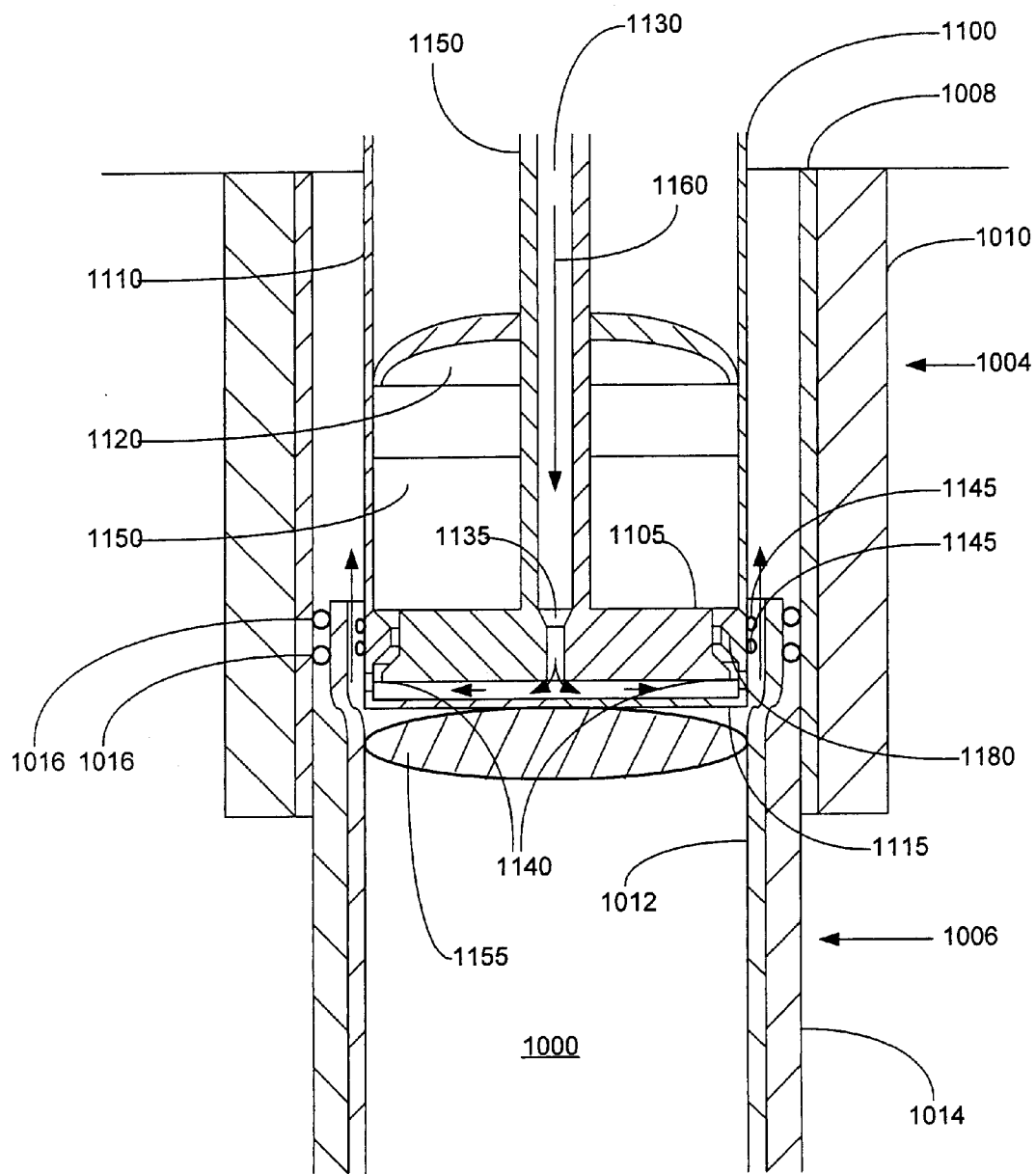


FIGURE 10c

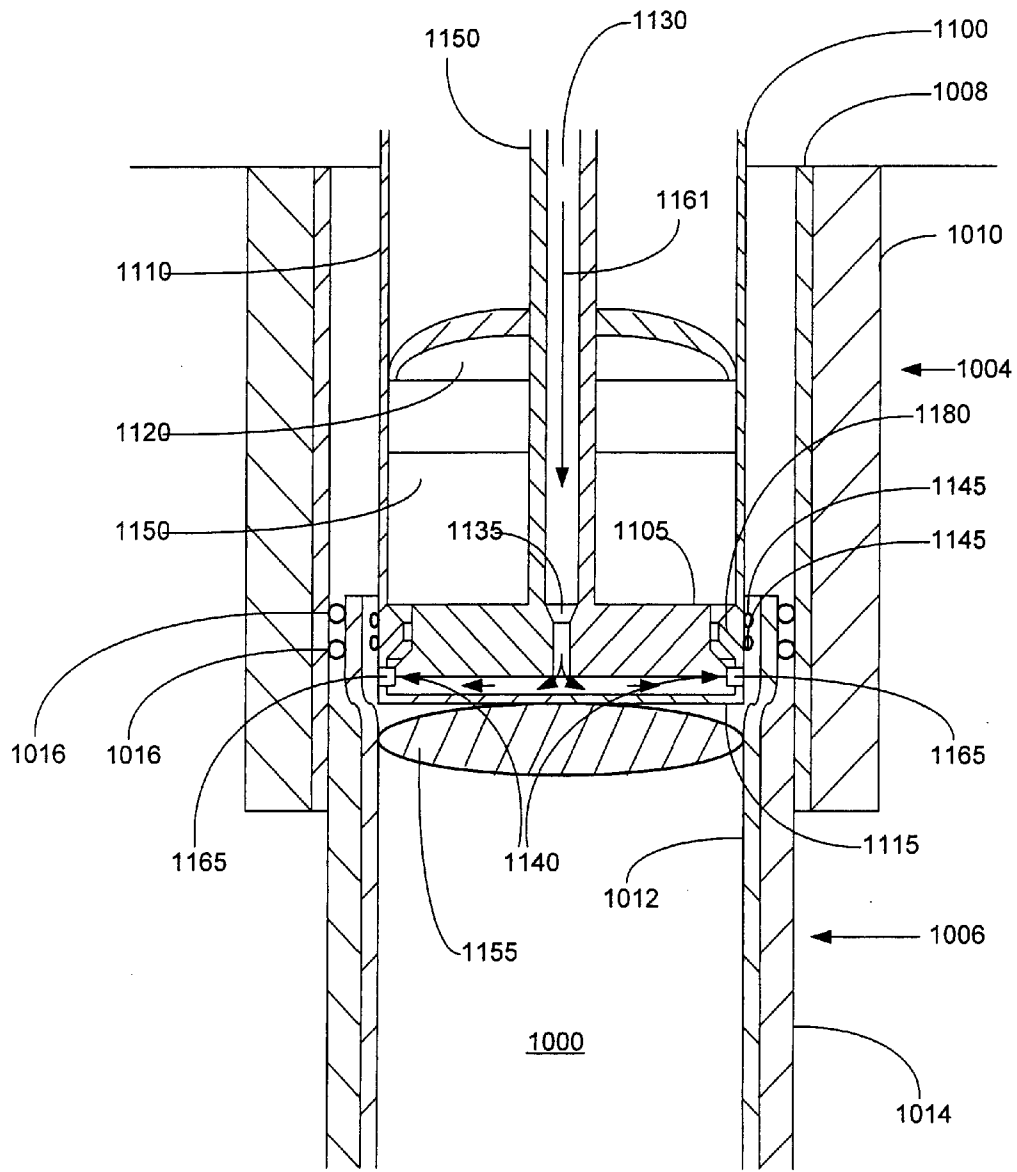


FIGURE 10d

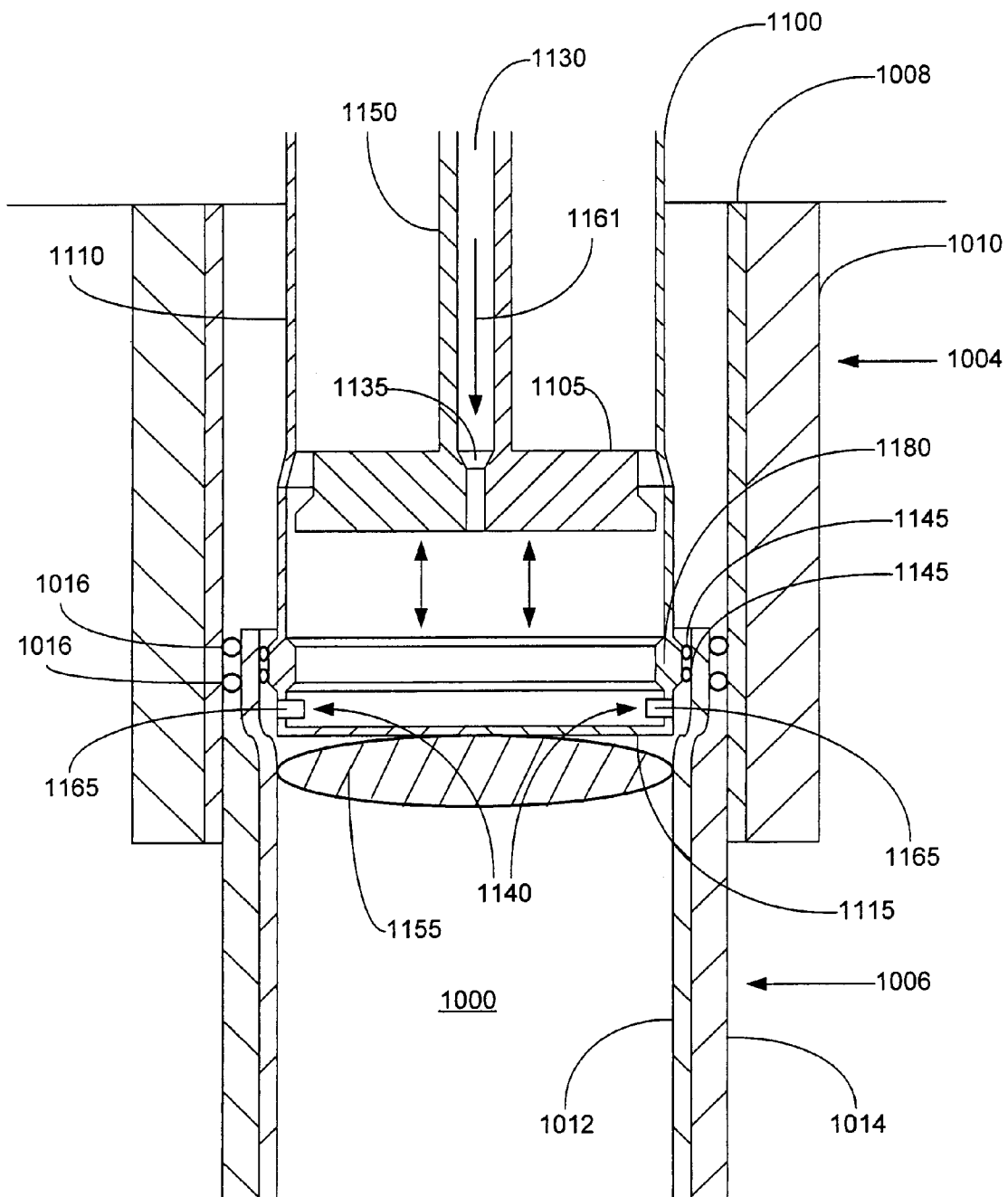


FIGURE 10e

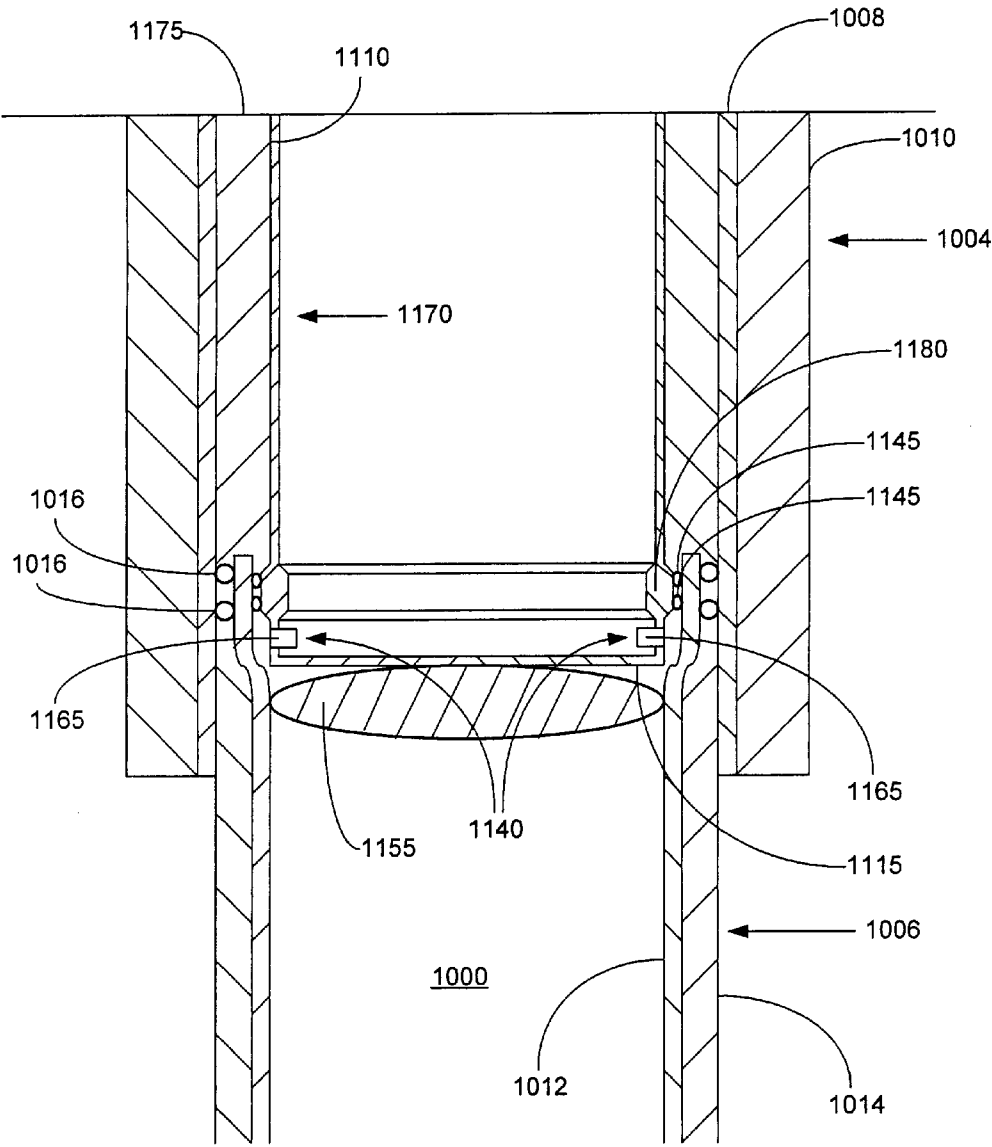


FIGURE 10f

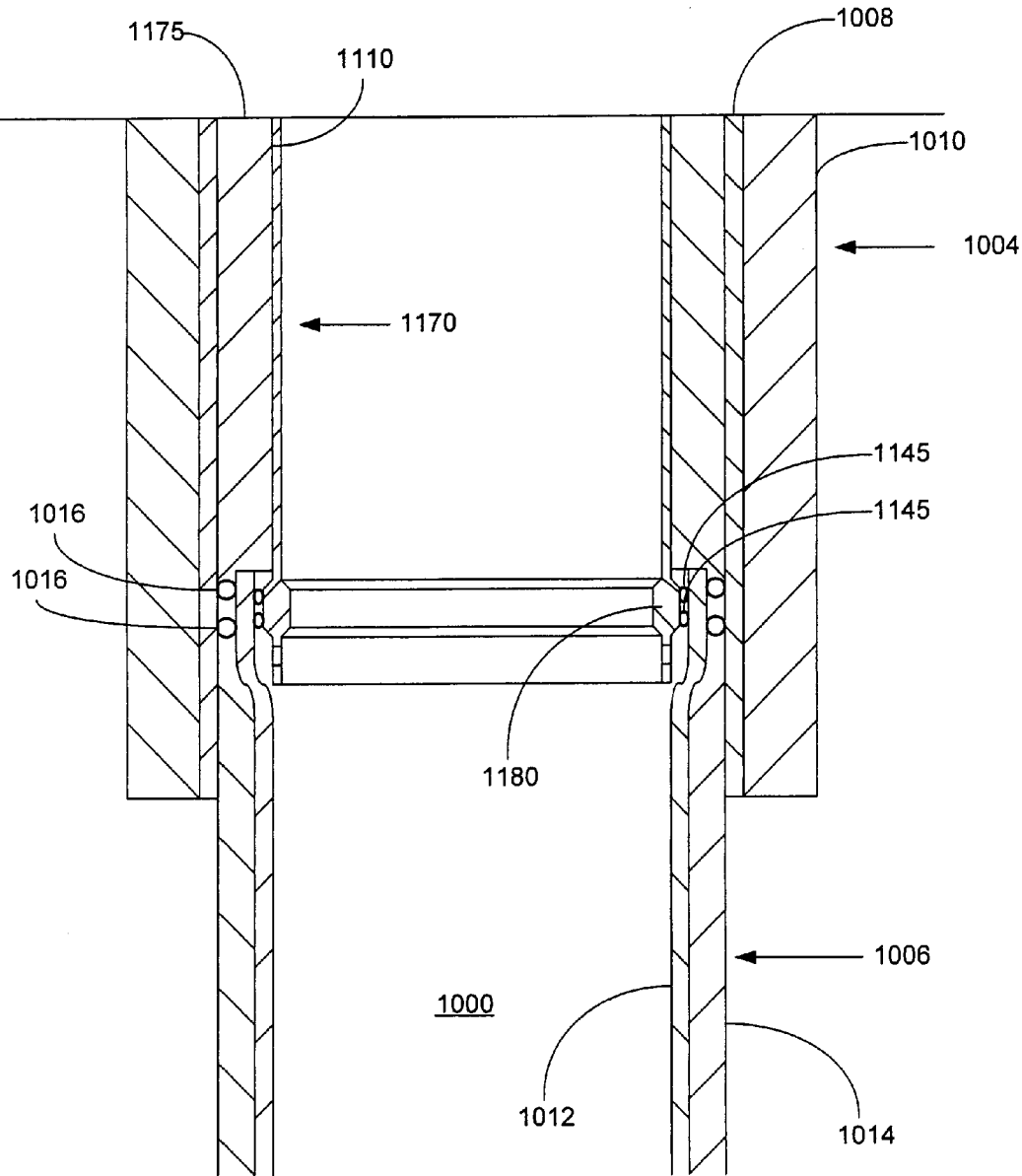


FIGURE 10g

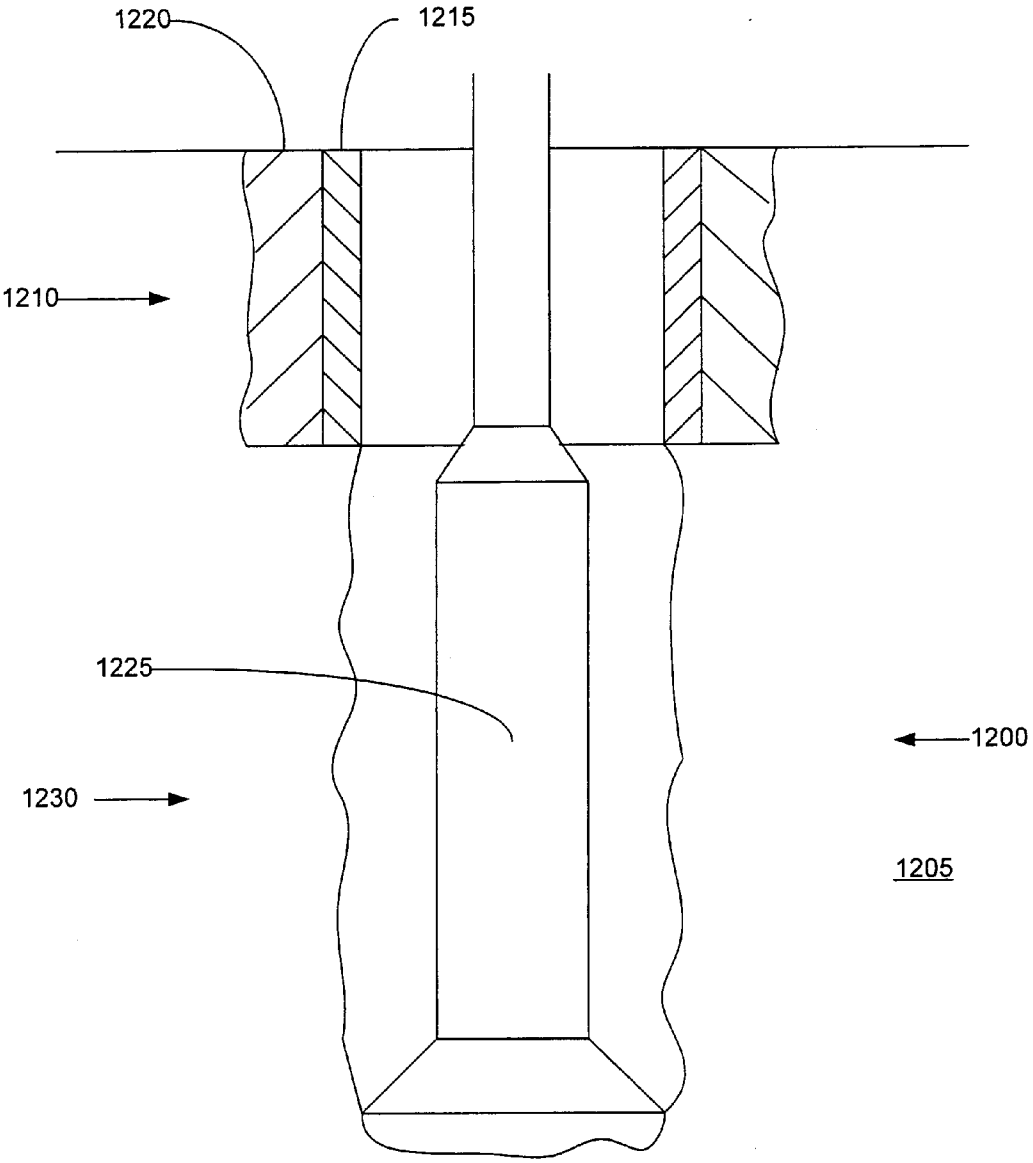


FIGURE 11a

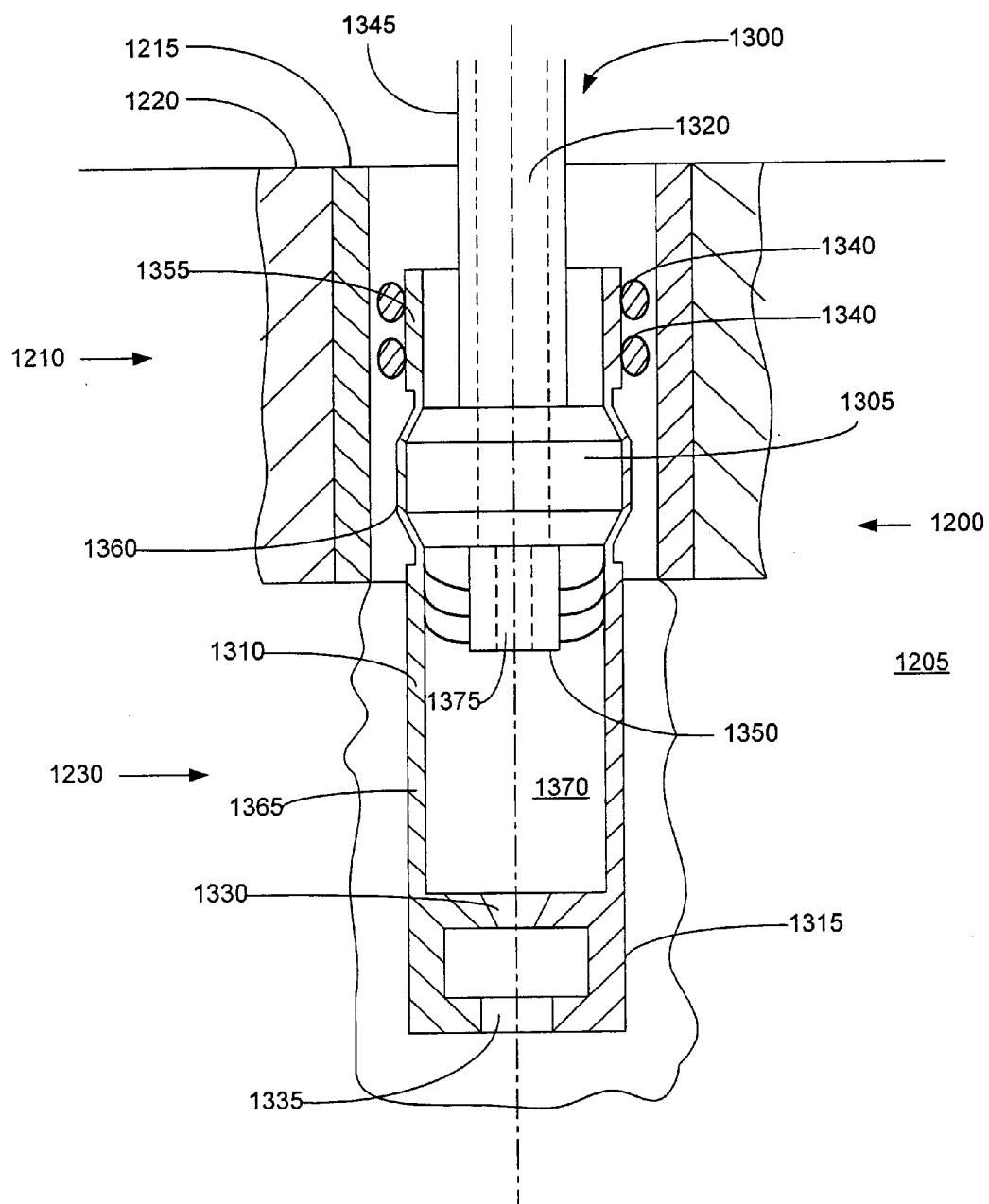


FIGURE 11b

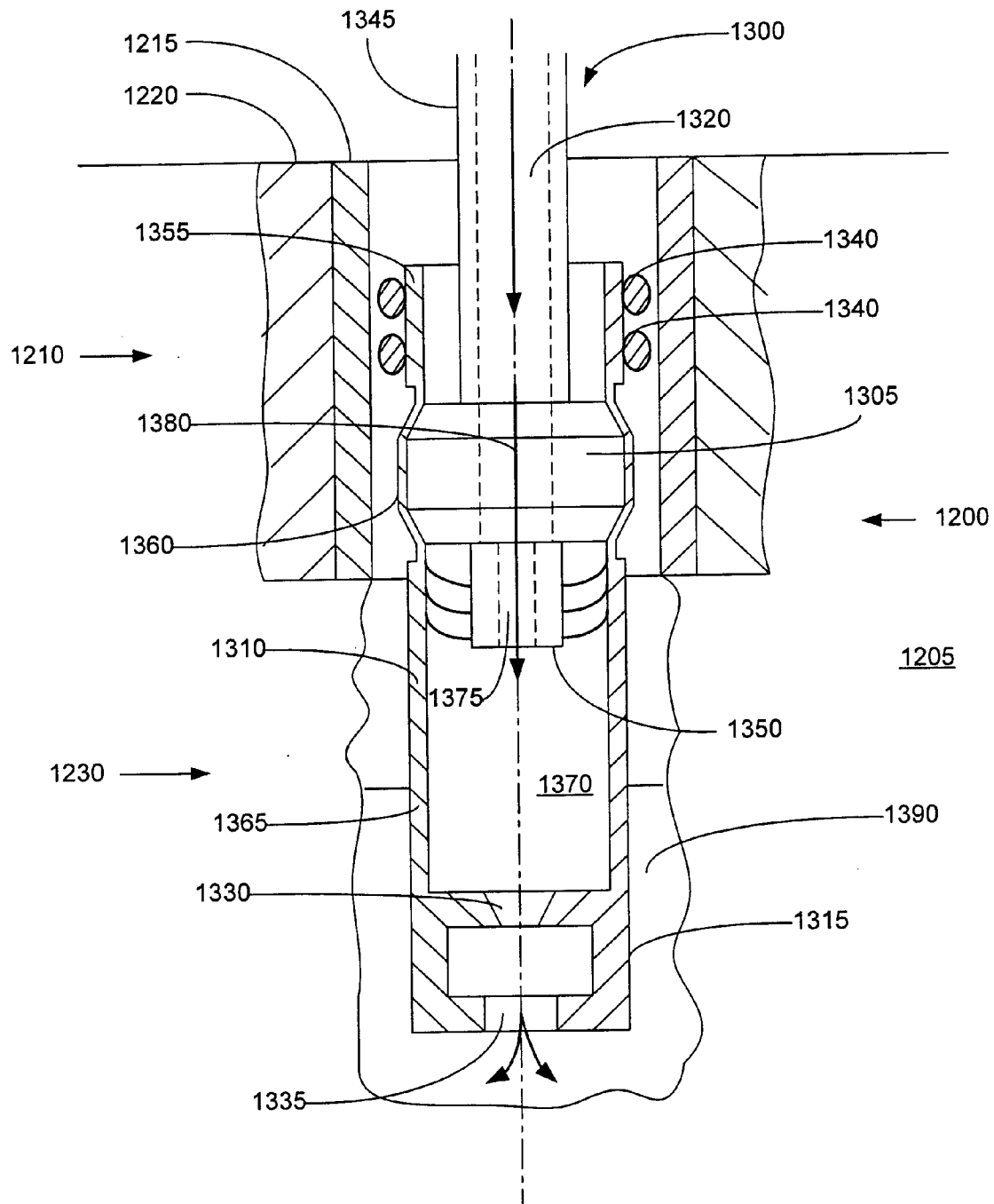


FIGURE 11c

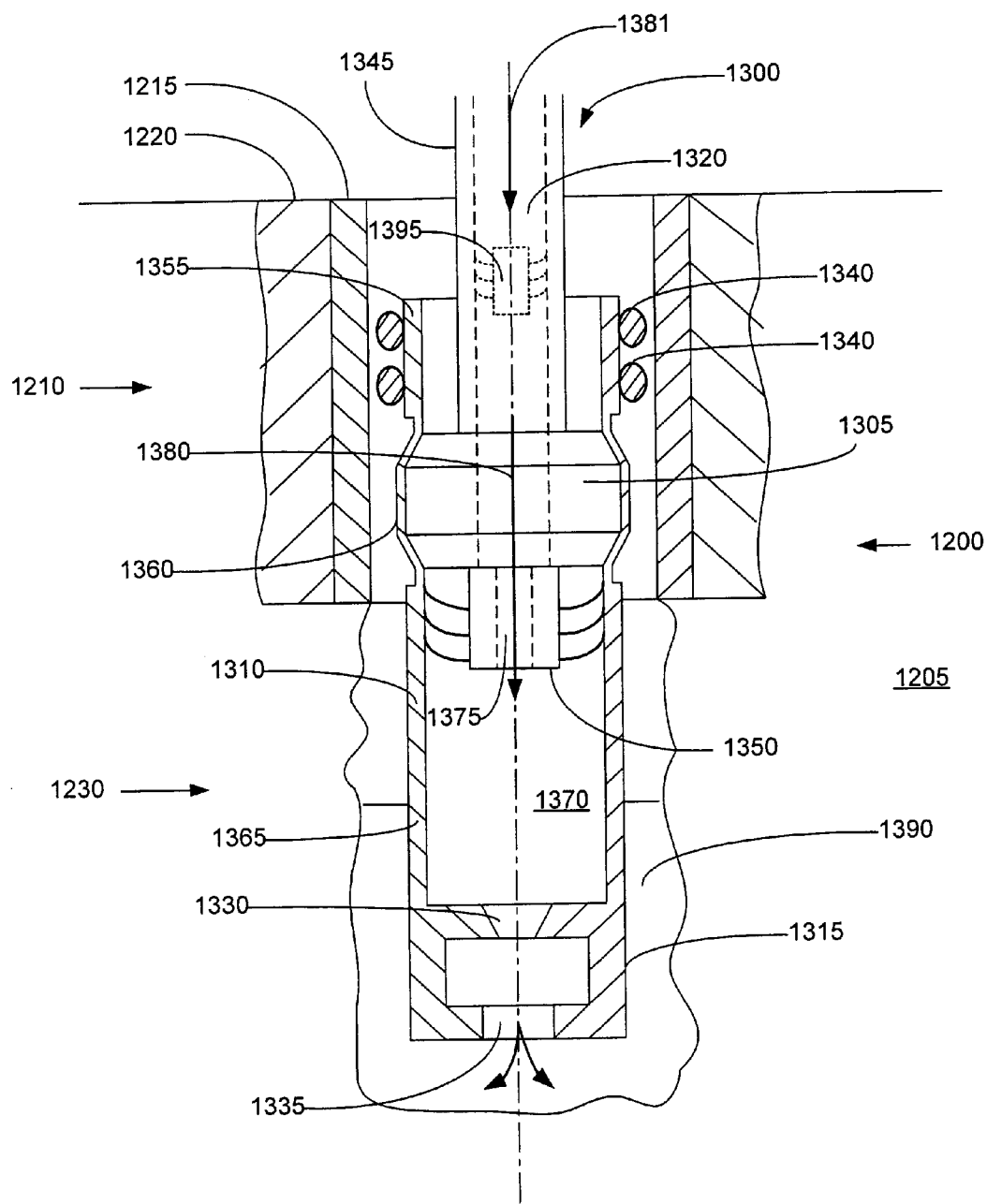


FIGURE 11d

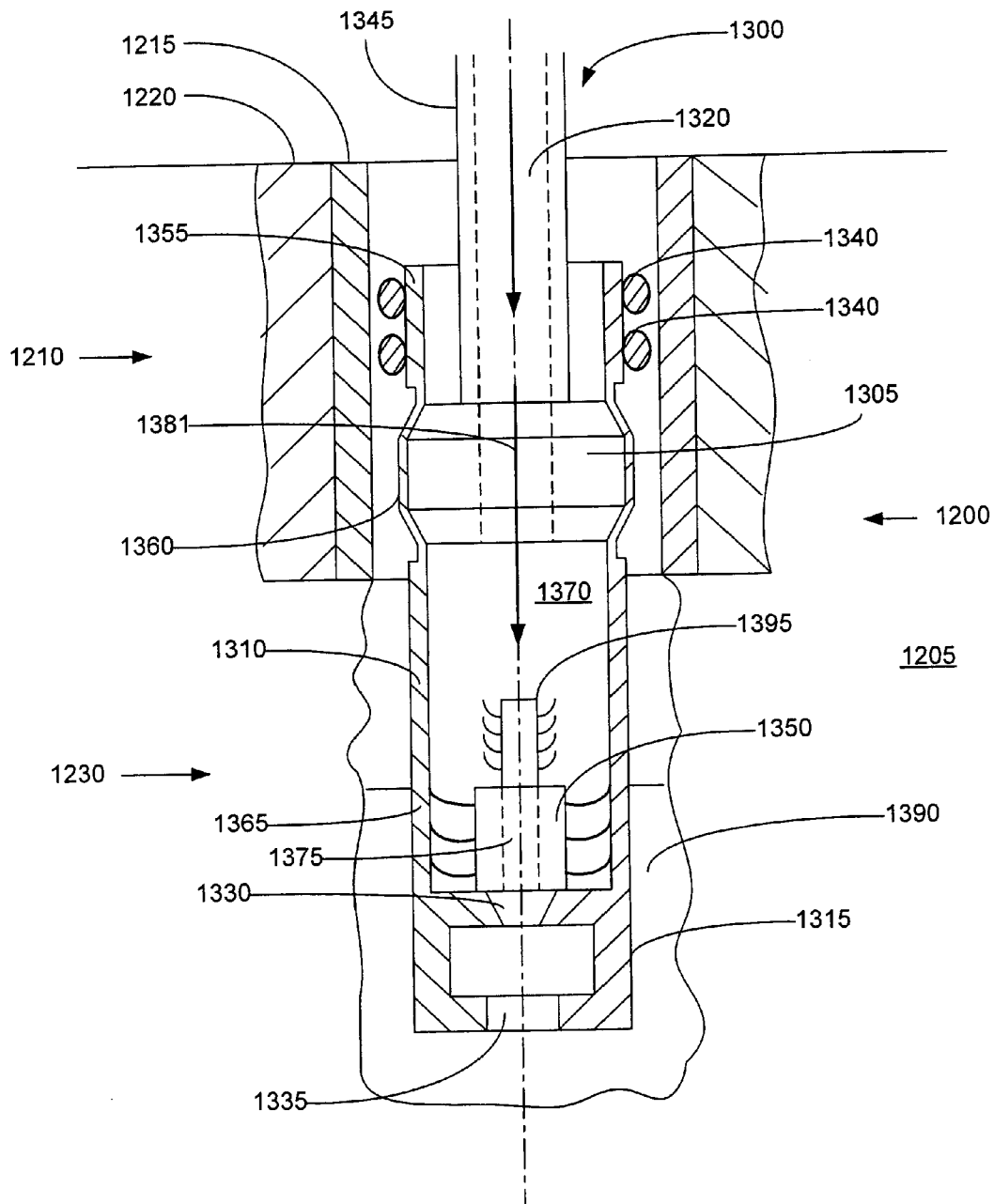


FIGURE 11e

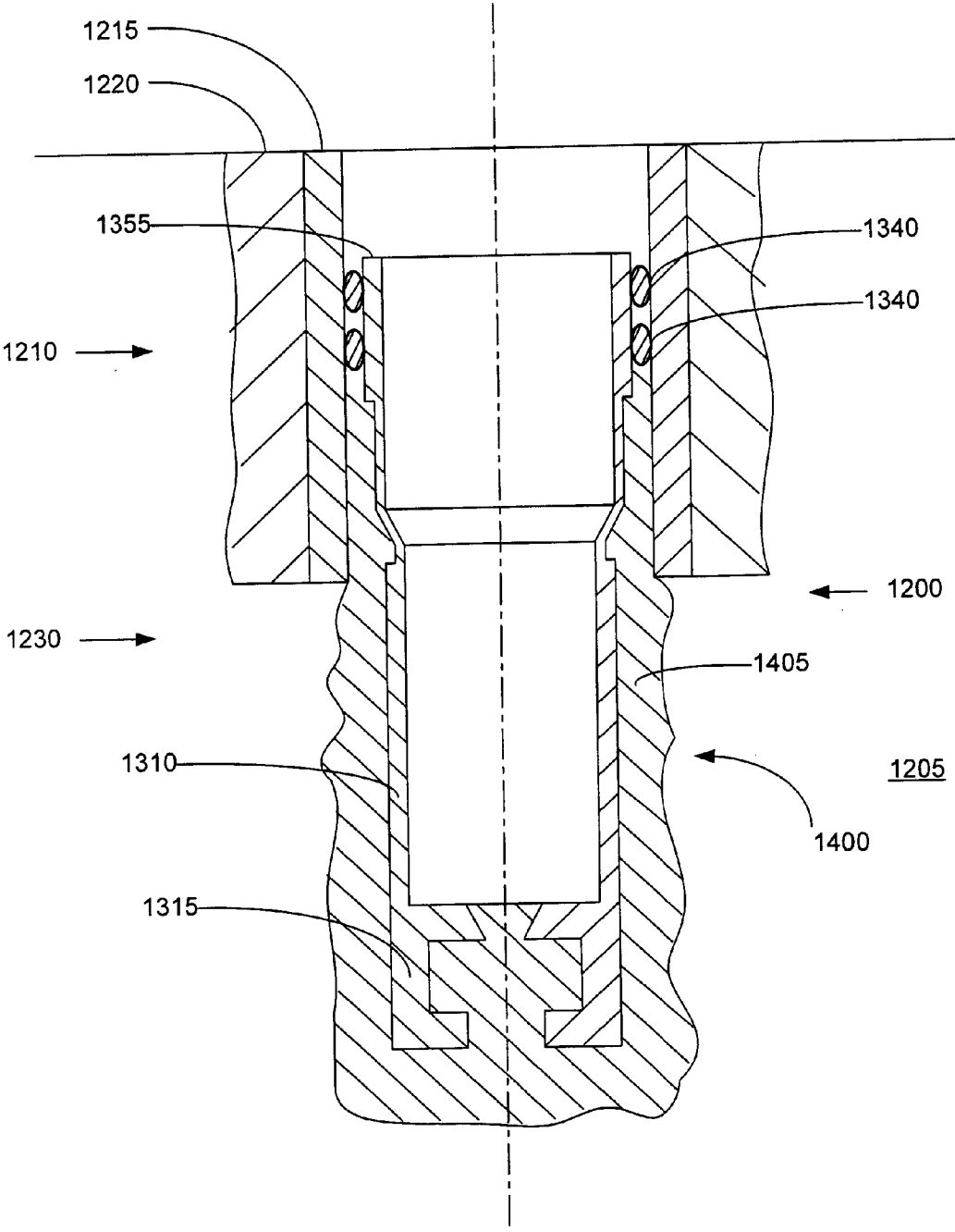


FIGURE 11f

PIPELINE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 10/199,524, attorney docket no. 25791.100, filed on Jul. 19, 2002 which was a continuation of U.S. patent application Ser. No. 09/454,139, attorney docket no. 25791.3.02, filed on Dec. 3, 1999, which issued as U.S. Pat. No. 6,497,289, which claimed the benefit of the filing date of U.S. Provisional Patent Application Ser. No. 60/111,293, attorney docket number 25791.3, filed on Dec. 7, 1998, the disclosures of which is incorporated herein by reference.

[0002] This application is related to the following co-pending applications: (1) U.S. Pat. No. 6,497,289, which was filed as U.S. patent application Ser. No. 09/454,139, attorney docket no. 25791.03.02, filed on Dec. 3, 1999, which claims priority from provisional application 60/111,293, filed on Dec. 7, 1998, (2) U.S. patent application Ser. No. 09/510,913, attorney docket no. 25791.7.02, filed on Feb. 23, 2000, which claims priority from provisional application 60/121,702, filed on Feb. 25, 1999, (3) U.S. patent application Ser. No. 09/502,350, attorney docket no. 25791.8.02, filed on Feb. 10, 2000, which claims priority from provisional application 60/119,611, filed on Feb. 11, 1999, (4) U.S. Pat. No. 6,328,113, which was filed as U.S. patent application Ser. No. 09/440,338, attorney docket number 25791.9.02, filed on Nov. 15, 1999, which claims priority from provisional application 60/108,558, filed on Nov. 16, 1998, (5) U.S. patent application Ser. No. 10/169,434, attorney docket no. 25791.10.04, filed on Jul. 1, 2002, which claims priority from provisional application 60/183,546, filed on Feb. 18 2000, (6) U.S. Pat. No. 6,640,903 which was filed as U.S. patent application Ser. No. 09/523,468, attorney docket no. 25791.11.02, filed on Mar. 10, 2000, which claims priority from provisional application 60/124,042, filed on Mar. 11, 1999, (7) U.S. Pat. No. 6,568,471, which was filed as patent application Ser. No. 09/512,895, attorney docket no. 25791.12.02, filed on Feb. 24, 2000, which claims priority from provisional application 60/121,841, filed on Feb. 26, 1999, (8) U.S. Pat. No. 6,575,240, which was filed as patent application Ser. No. 09/511,941, attorney docket no. 25791.16.02, filed on Feb. 24, 2000, which claims priority from provisional application 60/121,907, filed on Feb. 26, 1999, (9) U.S. Pat. No. 6,557,640, which was filed as patent application Ser. No. 09/588,946, attorney docket no. 25791.17.02, filed on Jun. 7, 2000, which claims priority from provisional application 60/137,998, filed on Jun. 7, 1999, (10) U.S. patent application Ser. No. 09/981,916, attorney docket no. 25791.18, filed on Oct. 18, 2001 as a continuation-in-part application of U.S. Pat. No. 6,328,113, which was filed as U.S. patent application Pat. No. 09/440,338, attorney docket number 25791.9.02, filed on Nov. 15, 1999, which claims priority from provisional application 60/108,558, filed on Nov. 16, 1998, (11) U.S. Pat. No. 6,604,763, which was filed as application Ser. No. 09/559,122, attorney docket no. 25791.23.02, filed on Apr. 26, 2000, which claims priority from provisional application 60/131,106, filed on Apr. 26, 1999, (12) U.S. patent application Ser. No. 10/030,593, attorney docket no. 25791.25.08, filed on Jan. 8, 2002, which claims priority from provisional application 60/146,203, filed on Jul. 29, 1999, (13) U.S. provisional patent

application Ser. No. 60/143,039, attorney docket no. 25791.26, filed on Jul. 9, 1999, (14) U.S. patent application Ser. No. 10/111,982, attorney docket no. 25791.27.08, filed on Apr. 30, 2002, which claims priority from provisional patent application Ser. No. 60/162,671, attorney docket no. 25791.27, filed on Nov. 1, 1999, (15) U.S. provisional patent application Ser. No. **60/154,047**, attorney docket no. 25791.29, filed on Sep. 16, 1999, (16) U.S. provisional patent application Ser. No. 60/438,828, attorney docket no. 25791.31, filed on Jan. 9, 2003, (17) U.S. patent number 6,564,875, which was filed as application Ser. No. 09/679,907, attorney docket no. 25791.34.02, on Oct. 5, 2000, which claims priority from provisional patent application Ser. No. 60/159,082, attorney docket no. 25791.34, filed on Oct. 12, 1999, (18) U.S. patent application Ser. No. 10/089,419, filed on Mar. 27, 2002, attorney docket no. 25791.36.03, which claims priority from provisional patent application Ser. No. 60/159,039, attorney docket no. 25791.36, filed on Oct. 12, 1999, (19) U.S. patent application Ser. No. 09/679,906, filed on Oct. 5, 2000, attorney docket no. 25791.37.02, which claims priority from provisional patent application Ser. No. 60/159,033, attorney docket no. 25791.37, filed on Oct. 12, 1999, (20) U.S. patent application Ser. No. 10/303,992, filed on Nov. 22, 2002, attorney docket no. 25791.38.07, which claims priority from provisional patent application Ser. No. 60/212,359, attorney docket no. 25791.38, filed on Jun. 19, 2000, (21) U.S. provisional patent application Ser. No. 60/165,228, attorney docket no. 25791.39, filed on Nov. 12, 1999, (22) U.S. provisional patent application Ser. No. 60/455,051, attorney docket no. 25791.40, filed on Mar. 14, 2003, (23) PCT application US02/2477, filed on Jun. 26, 2002, attorney docket no. 25791.44.02, which claims priority from U.S. provisional patent application Ser. No. 60/303,711, attorney docket no. 25791.44, filed on Jul. 6, 2001, (24) U.S. patent application Ser. No. 10/311,412, filed on Dec. 12, 2002, attorney docket no. 25791.45.07, which claims priority from provisional patent application Ser. No. 60/221,443, attorney docket no. 25791.45, filed on Jul. 28, 2000, (25) U.S. patent application Ser. No. 10/_____, filed on Dec. 18, 2002, attorney docket no. 25791.46.07, which claims priority from provisional patent application Ser. No. 60/221,645, attorney docket no. 25791.46, filed on Jul. 28, 2000, (26) U.S. patent application Ser. No. 10/322,947, filed on Jan. 22, 2003, attorney docket no. 25791.47.03, which claims priority from provisional patent application Ser. No. 60/233,638, attorney docket no. 25791.47, filed on Sep. 18, 2000, (27) U.S. patent application Ser. No. 10/406,648, filed on Mar. 31, 2003, attorney docket no. 25791.48.06, which claims priority from provisional patent application Ser. No. 60/237,334, attorney docket no. 25791.48, filed on Oct. 2, 2000, (28) PCT application US02/04353, filed on Feb. 14, 2002, attorney docket no. 25791.50.02, which claims priority from U.S. provisional patent application Ser. No. 60/270,007, attorney docket no. 25791.50, filed on Feb. 20, 2001, (29) U.S. patent application Ser. No. 10/465,835, filed on Jun. 13, 2003, attorney docket no. 25791.51.06, which claims priority from provisional patent application Ser. No. 60/262,434, attorney docket no. 25791.51, filed on Jan. 17, 2001, (30) U.S. patent application Ser. No. 10/465,831, filed on Jun. 13, 2003, attorney docket no. 25791.52.06, which claims priority from U.S. provisional patent application Ser. No. 60/259,486, attorney docket no. 25791.52, filed on Jan. 3, 2001, (31) U.S. provisional patent application Ser. No. 60/452,303, filed on

Mar. 5, 2003, attorney docket no. 25791.53, (32) U.S. Pat. No. 6,470,966, which was filed as patent application Ser. No. 09/850,093, filed on May 7, 2001, attorney docket no. 25791.55, as a divisional application of U.S. Pat. No. 6,497,289, which was filed as U.S. patent application Ser. No. 09/454,139, attorney docket no. 25791.03.02, filed on Dec. 3, 1999, which claims priority from provisional application 60/111,293, filed on Dec. 7, 1998, (33) U.S. Pat. No. 6,561,227, which was filed as patent application Ser. No. 09/852,026, filed on May 9, 2001, attorney docket no. 25791.56, as a divisional application of U.S. Pat. No. 6,497,289, which was filed as U.S. patent application Ser. No. 09/454,139, attorney docket no. 25791.03.02, filed on Dec. 3, 1999, which claims priority from provisional application 60/111,293, filed on Dec. 7, 1998, (34) U.S. patent application Ser. No. 09/852,027, filed on May 9, 2001, attorney docket no. 25791.57, as a divisional application of U.S. Pat. No. 6,497,289, which was filed as U.S. patent application Ser. No. 09/454,139, attorney docket no. 25791.03.02, filed on Dec. 3, 1999, which claims priority from provisional application 60/111,293, filed on Dec. 7, 1998, (35) PCT Application US02/25608, attorney docket no. 25791.58.02, filed on Aug. 13, 2002, which claims priority from provisional application 60/318,021, filed on Sep. 7, 2001, attorney docket no. 25791.58, (36) PCT Application US02/24399, attorney docket no. 25791.59.02, filed on Aug. 1, 2002, which claims priority from U.S. provisional patent application Ser. No. 60/313,453, attorney docket no. 25791.59, filed on Aug. 20, 2001, (37) PCT Application US02/29856, attorney docket no. 25791.60.02, filed on Sep. 19, 2002, which claims priority from U.S. provisional patent application Ser. No. 60/326,886, attorney docket no. 25791.60, filed on Oct. 3, 2001, (38) PCT Application US02/20256, attorney docket no. 25791.61.02, filed on Jun. 26, 2002, which claims priority from U.S. provisional patent application Ser. No. 60/303,740, attorney docket no. 25791.61, filed on Jul. 6, 2001, (39) U.S. patent application Ser. No. 09/962,469, filed on Sep. 25, 2001, attorney docket no. 25791.62, which is a divisional of U.S. patent application Ser. No. 09/523,468, attorney docket no. 25791.11.02, filed on Mar. 10, 2000, (now U.S. Pat. No. 6,640,903 which issued Nov. 4, 2003), which claims priority from provisional application 60/124,042, filed on Mar. 11, 1999, (40) U.S. patent application Ser. No. 09/962,470, filed on Sep. 25, 2001, attorney docket no. 25791.63, which is a divisional of U.S. patent application Ser. No. 09/523,468, attorney docket no. 25791.11.02, filed on Mar. 10, 2000, (now U.S. Patent No. 6,640,903 which issued Nov. 4, 2003), which claims priority from provisional application 60/124,042, filed on Mar. 11, 1999, (41) U.S. patent application Ser. No. 09/962,471, filed on Sep. 25, 2001, attorney docket no. 25791.64, which is a divisional of U.S. patent application Ser. No. 09/523,468, attorney docket no. 25791.11.02, filed on Mar. 10, 2000, (now U.S. Pat. No. 6,640,903 which issued Nov. 4, 2003), which claims priority from provisional application 60/124,042, filed on Mar. 11, 1999, (42) U.S. patent application Ser. No. 09/962,467, filed on Sep. 25, 2001, attorney docket no. 25791.65, which is a divisional of U.S. patent application Ser. No. 09/523,468, attorney docket no. 25791.11.02, filed on Mar. 10, 2000, (now U.S. Pat. No. 6,640,903 which issued Nov. 4, 2003), which claims priority from provisional application 60/124,042, filed on Mar. 11, 1999, (43) U.S. patent application Ser. No. 09/962,468, filed on Sep. 25, 2001, attorney docket no. 25791.66, which is a

divisional of U.S. patent application Ser. No. 09/523,468, attorney docket no. 25791.11.02, filed on Mar. 10, 2000, (now U.S. Pat. No. 6,640,903 which issued Nov. 4, 2003), which claims priority from provisional application 60/124,042, filed on Mar. 11, 1999, (44) PCT application US02/25727, filed on Aug. 14, 2002, attorney docket no. 25791.67.03, which claims priority from U.S. provisional patent application Ser. No. 60/317,985, attorney docket no. 25791.67, filed on Sep. 6, 2001, and U.S. provisional patent application Ser. No. 60/318,386, attorney docket no. 25791.67.02, filed on Sep. 10, 2001, (45) PCT application US02/39425, filed on Dec. 10, 2002, attorney docket no. 25791.68.02, which claims priority from U.S. provisional patent application Ser. No. 60/343,674, attorney docket no. 25791.68, filed on Dec. 27, 2001, (46) U.S. utility patent application Ser. No. 09/969,922, attorney docket no. 25791.69, filed on Oct. 3, 2001, (now U.S. Pat. No. 6,634,431 which issued Oct. 21, 2003), which is a continuation-in-part application of U.S. Pat. No. 6,328,113, which was filed as U.S. patent application Ser. No. 09/440,338, attorney docket number 25791.9.02, filed on Nov. 15, 1999, which claims priority from provisional application 60/108,558, filed on Nov. 16, 1998, (47) U.S. utility patent application Ser. No. 10/516,467, attorney docket no. 25791.70, filed on Dec. 10, 2001, which is a continuation application of U.S. utility patent application Ser. No. 09/969,922, attorney docket no. 25791.69, filed on Oct. 3, 2001, (now U.S. Pat. No. 6,634,431 which issued Oct. 21, 2003), which is a continuation-in-part application of U.S. Pat. No. 6,328,113, which was filed as U.S. patent application Ser. No. 09/440,338, attorney docket number 25791.9.02, filed on Nov. 15, 1999, which claims priority from provisional application 60/108,558, filed on Nov. 16, 1998, (48) PCT application US 03/00609, filed on Jan. 9, 2003, attorney docket no. 25791.71.02, which claims priority from U.S. provisional patent application Ser. No. 60/357,372, attorney docket no. 25791.71, filed on Feb. 15, 2002, (49) U.S. patent application Ser. No. 10/074,703, attorney docket no. 25791.74, filed on Feb. 12, 2002, which is a divisional of U.S. Pat. No. 6,568,471, which was filed as patent application Ser. No. 09/512,895, attorney docket no. 25791.12.02, filed on Feb. 24, 2000, which claims priority from provisional application 60/121,841, filed on Feb. 26, 1999, (50) U.S. patent application Ser. No. 10/074,244, attorney docket no. 25791.75, filed on Feb. 12, 2002, which is a divisional of U.S. Pat. No. 6,568,471, which was filed as patent application Ser. No. 09/512,895, attorney docket no. 25791.12.02, filed on Feb. 24, 2000, which claims priority from provisional application 60/121,841, filed on Feb. 26, 1999, (51) U.S. patent application Ser. No. 10/076,660, attorney docket no. 25791.76, filed on Feb. 15, 2002, which is a divisional of U.S. Pat. No. 6,568,471, which was filed as patent application Ser. No. 09/512,895, attorney docket no. 25791.12.02, filed on Feb. 24, 2000, which claims priority from provisional application 60/121,841, filed on Feb. 26, 1999, (52) U.S. patent application Ser. No. 10/076,661, attorney docket no. 25791.77, filed on Feb. 15, 2002, which is a divisional of U.S. Pat. No. 6,568,471, which was filed as patent application Ser. No. 09/512,895, attorney docket no. 25791.12.02, filed on Feb. 24, 2000, which claims priority from provisional application 60/121,841, filed on Feb. 26, 1999, (53) U.S. patent application Ser. No. 10/076,659, attorney docket no. 25791.78, filed on Feb. 15, 2002, which is a divisional of U.S. Pat. No. 6,568,471, which was filed as patent application Ser. No.

09/512,895, attorney docket no. 25791.12.02, filed on Feb. 24, 2000, which claims priority from provisional application 60/121,841, filed on Feb. 26, 1999, (54) U.S. patent application Ser. No. 10/078,928, attorney docket no. 25791.79, filed on Feb. 20, 2002, which is a divisional of U.S. Pat. No. 6,568,471, which was filed as patent application Ser. No. 09/512,895, attorney docket no. 25791.12.02, filed on Feb. 24, 2000, which claims priority from provisional application 60/121,841, filed on Feb. 26, 1999, (55) U.S. patent application Ser. No. 10/078,922, attorney docket no. 25791.80, filed on Feb. 20, 2002, which is a divisional of U.S. Pat. No. 6,568,471, which was filed as patent application Ser. No. 09/512,895, attorney docket no. 25791.12.02, filed on Feb. 24, 2000, which claims priority from provisional application 60/121,841, filed on Feb. 26, 1999, (56) U.S. patent application Ser. No. 10/078,921, attorney docket no. 25791.81, filed on Feb. 20, 2002, which is a divisional of U.S. Pat. No. 6,568,471, which was filed as patent application Ser. No. 09/512,895, attorney docket no. 25791.12.02, filed on Feb. 24, 2000, which claims priority from provisional application 60/121,841, filed on Feb. 26, 1999, (57) U.S. patent application Ser. No. 10/261,928, attorney docket no. 25791.82, filed on Oct. 1, 2002, which is a divisional of U.S. Pat. No. 6,557,640, which was filed as patent application Ser. No. 09/588,946, attorney docket no. 25791.17.02, filed on Jun. 7, 2000, which claims priority from provisional application 60/137,998, filed on Jun. 7, 1999, (58) U.S. patent application Ser. No. 10/079,276, attorney docket no. 25791.83, filed on Feb. 20, 2002, which is a divisional of U.S. Pat. No. 6,568,471, which was filed as patent application Ser. No. 09/512,895, attorney docket no. 25791.12.02, filed on Feb. 24, 2000, which claims priority from provisional application 60/121,841, filed on Feb. 26, 1999, (59) U.S. patent application Ser. No. 10/262,009, attorney docket no. 25791.84, filed on Oct. 1, 2002, which is a divisional of U.S. Pat. No. 6,557,640, which was filed as patent application Ser. No. 09/588,946, attorney docket no. 25791.17.02, filed on Jun. 7, 2000, which claims priority from provisional application 60/137,998, filed on Jun. 7, 1999, (60) U.S. patent application Ser. No. 10/092,481, attorney docket no. 25791.85, filed on Mar. 7, 2002, which is a divisional of U.S. Pat. No. 6,568,471, which was filed as patent application Ser. No. 09/512,895, attorney docket no. 25791.12.02, filed on Feb. 24, 2000, which claims priority from provisional application 60/121,841, filed on Feb. 26, 1999, (61) U.S. patent application Ser. No. 10/261,926, attorney docket no. 25791.86, filed on Oct. 1, 2002, which is a divisional of U.S. Pat. No. 6,557,640, which was filed as patent application Ser. No. 09/588,946, attorney docket no. 25791.17.02, filed on Jun. 7, 2000, which claims priority from provisional application 60/137,998, filed on Jun. 7, 1999, (62) PCT application US 02/36157, filed on Nov. 12, 2002, attorney docket no. 25791.87.02, which claims priority from U.S. provisional patent application Ser. No. 60/338,996, attorney docket no. 25791.87, filed on Nov. 12, 2001, (63) PCT application US 02/36267, filed on Nov. 12, 2002, attorney docket no. 25791.88.02, which claims priority from U.S. provisional patent application Ser. No. 60/339,013, attorney docket no. 25791.88, filed on Nov. 12, 2001, (64) PCT application US 03/11765, filed on Apr. 16, 2003, attorney docket no. 25791.89.02, which claims priority from U.S. provisional patent application Ser. No. 60/383,917, attorney docket no. 25791.89, filed on May 29, 2002, (65) PCT application US 03/15020, filed on Jun. 12, 2003, attorney docket no.

25791.90.02, which claims priority from U.S. provisional patent application Ser. No. 60/391,703, attorney docket no. 25791.90, filed on Jun. 26, 2002, (66) PCT application US 02/39418, filed on Dec. 10, 2002, attorney docket no. 25791.92.02, which claims priority from U.S. provisional patent application Ser. No. 60/346,309, attorney docket no. 25791.92, filed on Jan. 7, 2002, (67) PCT application US 03/06544, filed on Mar. 4, 2003, attorney docket no. 25791.93.02, which claims priority from U.S. provisional patent application Ser. No. 60/372,048, attorney docket no. 25791.93, filed on Apr. 12, 2002, (68) U.S. patent application Ser. No. 10/331,718, attorney docket no. 25791.94, filed on Dec. 30, 2002, which is a divisional U.S. patent application Ser. No. 09/679,906, filed on Oct. 5, 2000, attorney docket no. 25791.37.02, which claims priority from provisional patent application Ser. No. 60/159,033, attorney docket no. 25791.37, filed on Oct. 12, 1999, (69) PCT application US 03/04837, filed on Feb. 29, 2003, attorney docket no. 25791.95.02, which claims priority from U.S. provisional patent application Ser. No. 60/363,829, attorney docket no. 25791.95, filed on Mar. 13, 2002, (70) U.S. patent application Ser. No. 10/261,927, attorney docket no. 25791.97, filed on Oct. 1, 2002, which is a divisional of U.S. Pat. No. 6,557,640, which was filed as patent application Ser. No. 09/588,946, attorney docket no. 25791.17.02, filed on Jun. 7, 2000, which claims priority from provisional application 60/137,998, filed on Jun. 7, 1999, (71) U.S. patent application Ser. No. 10/262,008, attorney docket no. 25791.98, filed on Oct. 1, 2002, which is a divisional of U.S. Pat. No. 6,557,640, which was filed as patent application Ser. No. 09/588,946, attorney docket no. 25791.17.02, filed on Jun. 7, 2000, which claims priority from provisional application 60/137,998, filed on Jun. 7, 1999, (72) U.S. patent application Ser. No. 10/261,925, attorney docket no. 25791.99, filed on Oct. 1, 2002, which is a divisional of U.S. Pat. No. 6,557,640, which was filed as patent application Ser. No. 09/588,946, attorney docket no. 25791.17.02, filed on Jun. 7, 2000, which claims priority from provisional application 60/137,998, filed on Jun. 7, 1999, (73) U.S. patent application Ser. No. 10/199,524, attorney docket no. 25791.100, filed on Jul. 19, 2002, which is a continuation of U.S. Pat. No. 6,497,289, which was filed as U.S. patent application Ser. No. 09/454,139, attorney docket no. 25791.03.02, filed on Dec. 3, 1999, which claims priority from provisional application 60/111,293, filed on Dec. 7, 1998, (74) PCT application US 03/10144, filed on Mar. 28, 2003, attorney docket no. 25791.101.02, which claims priority from U.S. provisional patent application Ser. No. 60/372,632, attorney docket no. 25791.101, filed on Apr. 15, 2002, (75) U.S. provisional patent application Ser. No. 60/412,542, attorney docket no. 25791.102, filed on Sep. 20, 2002, (76) PCT application US 03/14153, filed on May 6, 2003, attorney docket no. 25791.104.02, which claims priority from U.S. provisional patent application Ser. No. 60/380,147, attorney docket no. 25791.104, filed on May 6, 2002, (77) PCT application US 03/19993, filed on Jun. 24, 2003, attorney docket no. 25791.106.02, which claims priority from U.S. provisional patent application Ser. No. 60/397,284, attorney docket no. 25791.106, filed on Jul. 19, 2002, (78) PCT application US 03/13787, filed on May 5, 2003, attorney docket no. 25791.107.02, which claims priority from U.S. provisional patent application Ser. No. 60/387,486, attorney docket no. 25791.107, filed on Jun. 10, 2002, (79) PCT application US 03/18530, filed on Jun. 11,

2003, attorney docket no. 25791.108.02, which claims priority from U.S. provisional patent application Ser. No. 60/387,961, attorney docket no. 25791.108, filed on Jun. 12, 2002, (80) PCT application US 03/20694, filed on Jul. 1, 2003, attorney docket no. 25791.110.02, which claims priority from U.S. provisional patent application Ser. No. 60/398,061, attorney docket no. 25791.110, filed on Jul. 24, 2002, (81) PCT application US 03/20870, filed on Jul. 2, 2003, attorney docket no. 25791.111.02, which claims priority from U.S. provisional patent application Ser. No. 60/399,240, attorney docket no. 25791.111, filed on Jul. 29, 2002, (82) U.S. provisional patent application Ser. No. 60/412,487, attorney docket no. 25791.112, filed on Sep. 20, 2002, (83) U.S. provisional patent application Ser. No. 60/412,488, attorney docket no. 25791.114, filed on Sep. 20, 2002, (84) U.S. patent application Ser. No. 10/280,356, attorney docket no. 25791.115, filed on Oct. 25, 2002, which is a continuation of U.S. Pat. No. 6,470,966, which was filed as patent application Ser. No. 09/850,093, filed on May 7, 2001, attorney docket no. 25791.55, as a divisional application of U.S. Pat. No. 6,497,289, which was filed as U.S. patent application Ser. No. 09/454,139, attorney docket no. 25791.03.02, filed on Dec. 3, 1999, which claims priority from provisional application 60/111,293, filed on Dec. 7, 1998, (85) U.S. provisional patent application Ser. No. 60/412,177, attorney docket no. 25791.117, filed on Sep. 20, 2002, (86) U.S. provisional patent application Ser. No. 60/412,653, attorney docket no. 25791.118, filed on Sep. 20, 2002, (87) U.S. provisional patent application Ser. No. 60/405,610, attorney docket no. 25791.119, filed on Aug. 23, 2002, (88) U.S. provisional patent application Ser. No. 60/405,394, attorney docket no. 25791.120, filed on Aug. 23, 2002, (89) U.S. provisional patent application Ser. No. 60/412,544, attorney docket no. 25791.121, filed on Sep. 20, 2002, (90) PCT application US 03/24779, filed on Aug. 8, 2003, attorney docket no. 25791.125.02, which claims priority from U.S. provisional patent application Ser. No. 60/407,442, attorney docket no. 25791.125, filed on Aug. 30, 2002, (91) U.S. provisional patent application Ser. No. 60/423,363, attorney docket no. 25791.126, filed on Dec. 10, 2002, (92) U.S. provisional patent application Ser. No. 60/412,196, attorney docket no. 25791.127, filed on Sep. 20, 2002, (93) U.S. provisional patent application Ser. No. 60/412,187, attorney docket no. 25791.128, filed on Sep. 20, 2002, (94) U.S. provisional patent application Ser. No. 60/412,371, attorney docket no. 25791.129, filed on Sep. 20, 2002, (95) U.S. patent application Ser. No. 10/382,325, attorney docket no. 25791.145, filed on Mar. 5, 2003, which is a continuation of U.S. Pat. No. 6,557,640, which was filed as patent application Ser. No. 09/588,946, attorney docket no. 25791.17.02, filed on Jun. 7, 2000, which claims priority from provisional application 60/137,998, filed on Jun. 7, 1999, (96) U.S. patent application Ser. No. 10/624,842, attorney docket no. 25791.151, filed on Jul. 22, 2003, which is a divisional of U.S. patent application Ser. No. 09/502,350, attorney docket no. 25791.8.02, filed on Feb. 10, 2000, which claims priority from provisional application 60/119,611, filed on Feb. 11, 1999, (97) U.S. provisional patent application Ser. No. 60/431,184, attorney docket no. 25791.157, filed on Dec. 5, 2002, (98) U.S. provisional patent application Ser. No. **60/448,526**, attorney docket no. 25791.185, filed on Feb. 18, 2003, (99) U.S. provisional patent application Ser. No. 60/461,539, attorney docket no. 25791.186, filed on Apr. 9, 2003, (100) U.S. provisional

patent application Ser. No. 60/462,750, attorney docket no. 25791.193, filed on Apr. 14, 2003, (101) U.S. provisional patent application Ser. No. 60/436,106, attorney docket no. 25791.200, filed on Dec. 23, 2002, (102) U.S. provisional patent application Ser. No. 60/442,942, attorney docket no. 25791.213, filed on Jan. 27, 2003, (103) U.S. provisional patent application Ser. No. 60/442,938, attorney docket no. 25791.225, filed on Jan. 27, 2003, (104) U.S. provisional patent application Ser. No. 60/418,687, attorney docket no. 25791.228, filed on Apr. 18, 2003, (105) U.S. provisional patent application Ser. No. 60/454,896, attorney docket no. 25791.236, filed on Mar. 14, 2003, (106) U.S. provisional patent application Ser. No. 60/450,504, attorney docket no. 25791.238, filed on Feb. 26, 2003, (107) U.S. provisional patent application Ser. No. 60/451,152, attorney docket no. 25791.239, filed on Mar. 9, 2003, (108) U.S. provisional patent application Ser. No. 60/455,124, attorney docket no. 25791.241, filed on Mar. 17, 2003, (109) U.S. provisional patent application Ser. No. 60/453,678, attorney docket no. 25791.253, filed on Mar. 11, 2003, (110) U.S. patent application Ser. No. 10/421,682, attorney docket no. 25791.256, filed on Apr. 23, 2003, which is a continuation of U.S. patent application Ser. No. 09/523,468, attorney docket no. 25791.11.02, filed on Mar. 10, 2000, (now U.S. Pat. No. 6,640,903 which issued Nov. 4, 2003), which claims priority from provisional application 60/124,042, filed on Mar. 11, 1999, (111) U.S. provisional patent application Ser. No. 60/457,965, attorney docket no. 25791.260, filed on Mar. 27, 2003, (112) U.S. provisional patent application Ser. No. 60/455,718, attorney docket no. 25791.262, filed on Mar. 18, 2003, (113) U.S. Pat. No. 6,550,821, which was filed as patent application Ser. No. 09/811,734, filed on Mar. 19, 2001, (114) U.S. patent application Ser. No. 10/436,467, attorney docket no. 25791.268, filed on May 12, 2003, which is a continuation of U.S. Pat. No. 6,604,763, which was filed as application Ser. No. 09/559,122, attorney docket no. 25791.23.02, filed on Apr. 26, 2000, which claims priority from provisional application 60/131,106, filed on Apr. 26, 1999, (115) U.S. provisional patent application Ser. No. 60/459,776, attorney docket no. 25791.270, filed on Apr. 2, 2003, (116) U.S. provisional patent application Ser. No. 60/461,094, attorney docket no. 25791.272, filed on Apr. 8, 2003, (117) U.S. provisional patent application Ser. No. 60/461,038, attorney docket no. 25791.273, filed on Apr. 7, 2003, (118) U.S. provisional patent application Ser. No. 60/463,586, attorney docket no. 25791.277, filed on Apr. 17, 2003, (119) U.S. provisional patent application Ser. No. 60/472,240, attorney docket no. 25791.286, filed on May 20, 2003, (120) U.S. patent application Ser. No. 10/619,285, attorney docket no. 25791.292, filed on Jul. 14, 2003, which is a continuation-in-part of U.S. utility patent application Ser. No. 09/969,922, attorney docket no. 25791.69, filed on Oct. 3, 2001, (now U.S. Pat. No. 6,634,431 which issued Oct. 21, 2003), which is a continuation-in-part application of U.S. Pat. No. 6,328,113, which was filed as U.S. Patent Application Ser. No. 09/440,338, attorney docket number 25791.9.02, filed on Nov. 15, 1999, which claims priority from provisional application 60/108,558, filed on Nov. 16, 1998, (121) U.S. utility patent application Ser. No. 10/418,688, attorney docket no. 25791.257, which was filed on Apr. 18, 2003, as a division of U.S. utility patent application Ser. No. 09/523,468, attorney docket no. 25791.11.02, filed on Mar. 10, 2000, (now U.S. Patent 6,640,903 which issued Nov. 4, 2003), which claims priority

from provisional application 60/124,042, filed on Mar. 11, 1999; (122) PCT patent application Ser. No. PCT/US2004/06246, attorney docket no. 25791.238.02, filed on Feb. 26, 2004; (123) PCT patent application Ser. No. PCT/US2004/08170, attorney docket number 25791.40.02, filed on Mar. 15, 2004; (124) PCT patent application Ser. No. PCT/US2004/08171, attorney docket number 25791.236.02, filed on Mar. 15, 2004; (125) PCT patent application Ser. No. PCT/US2004/08073, attorney docket number 25791.262.02, filed on Mar. 18, 2004; (126) PCT patent application Ser. No. PCT/US2004/07711, attorney docket number 25791.253.02, filed on Mar. 11, 2004; (127) PCT patent application Ser. No. PCT/US2004/029025, attorney docket number 25791.260.02, filed on Mar. 26, 2004; (128) PCT patent application Ser. No. PCT/US2004/010317, attorney docket number 25791.270.02, filed on Apr. 2, 2004; (129) PCT patent application Ser. No. PCT/US2004/010712, attorney docket number 25791.272.02, filed on Apr. 6, 2004; (130) PCT patent application Ser. No. PCT/US2004/010762, attorney docket number 25791.273.02, filed on Apr. 6, 2004; (131) PCT patent application Ser. No. PCT/US2004/011973, attorney docket number 25791.277.02, filed on Apr. 15, 2004; (132) U.S. provisional patent application Ser. No. 60/495,056, attorney docket number 25791.301, filed on Aug. 14, 2003; (133) U.S. provisional patent application Ser. No. 60/600,679, attorney docket number 25791.194, filed on Aug. 11, 2004; (134) PCT patent application Ser. No. PCT/US2005/027318, attorney docket number 25791.329.02, filed on Jul. 29, 2005; (135) PCT patent application Ser. No. PCT/US2005/028936, attorney docket number 25791.338.02, filed on Aug. 12, 2005; (136) PCT patent application Ser. No. PCT/US2005/028669, attorney docket number 25791.194.02, filed on Aug. 11, 2005; (137) PCT patent application Ser. No. PCT/US2005/028453, attorney docket number 25791.371, filed on Aug. 11, 2005; (138) PCT patent application Ser. No. PCT/US2005/028641, attorney docket number 25791.372, filed on Aug. 11, 2005; (139) PCT patent application Ser. No. PCT/US2005/028819, attorney docket number 25791.373, filed on Aug. 11, 2005; (140) PCT patent application Ser. No. PCT/US2005/028446, attorney docket number 25791.374, filed on Aug. 11, 2005; (141) PCT patent application Ser. No. PCT/US2005/028642, attorney docket number 25791.375, filed on Aug. 11, 2005; (142) PCT patent application Ser. No. PCT/US2005/028451, attorney docket number 25791.376, filed on Aug. 11, 2005, and (143). PCT patent application Ser. No. PCT/US2005/028473, attorney docket number 25791.377, filed on Aug. 11, 2005, (144) U.S. utility patent application Ser. No. 10/546,082, attorney docket number 25791.378, filed on Aug. 16, 2005, (145) U.S. utility patent application Ser. No. 10/546076, attorney docket number 25791.379, filed on Aug. 16, 2005, (146) U.S. utility patent application Ser. No. 10/545936, attorney docket number 25791.380, filed on Aug. 16, 2005, (147) U.S. utility patent application Ser. No. 10/546,079, attorney docket number 25791.381, filed on Aug. 16, 2005 (148) U.S. utility patent application Ser. No. 10/545,941, attorney docket number 25791.382, filed on Aug. 16, 2005, (149) U.S. utility patent application Ser. No. 546078, attorney docket number 25791.383, filed on Aug. 16, 2005, filed on Aug. 11, 2005., (150) U.S. utility patent application Ser. No. 10/545,941, attorney docket number 25791.185.05, filed on Aug. 16, 2005, (151) U.S. utility patent application Ser. No. 11/249,967, attorney docket number 25791.384, filed on Oct. 13, 2005, (152) U.S.

provisional patent application Ser. No. 60/734,302, attorney docket number 25791.24, filed on Nov. 7, 2005, (153) U.S. provisional patent application Ser. No. 60/725,181, attorney docket number 25791.184, filed on Oct. 11, 2005, (154) PCT patent application Ser. No. PCT/US2005/023391, attorney docket number 25791.299.02 filed Jun. 29, 2005 which claims priority from U.S. provisional patent application Ser. No. 60/585370, attorney docket number 25791.299, filed on Jul. 2, 2004, (155) U.S. provisional patent application Ser. No. 60/721,579, attorney docket number 25791.327, filed on Sep. 28, 2005, (156) U.S. provisional patent application Ser. No. 60/717,391, attorney docket number 25791.214, filed on Sep. 15, 2005, (157) U.S. provisional patent application Ser. No. 60/702,935, attorney docket number 25791.133, filed on Jul. 27, 2005, (158) U.S. provisional patent application Ser. No. 60/663,913, attorney docket number 25791.32, filed on Mar. 21, 2005, (159) U.S. provisional patent application Ser. No. 60/652,564, attorney docket number 25791.348, filed on Feb. 14, 2005, (160) U.S. provisional patent application Ser. No. 60/645,840, attorney docket number 25791.324, filed on Jan. 21, 2005, (161) PCT patent application Ser. No. PCT/US2005/043122, attorney docket number 25791.326.02, filed on Nov. 29, 2005 which claims priority from U.S. provisional patent application Ser. No. 60/631,703, attorney docket number 25791.326, filed on Nov. 30, 2004, (162) U.S. provisional patent application Ser. No. 60/752787, attorney docket number 25791.339, filed on Dec. 22, 2005, (163) U.S. National Stage application Ser. No. 10/548,934, attorney docket no. 25791.253.05, filed on Sep. 12, 2005; (164) U.S. National Stage application Ser. No. 10/549,410, attorney docket no. 25791.262.05, filed on Sep. 13, 2005; (165) U.S. Provisional Patent Application No. 60/717,391, attorney docket no. 25791.214 filed on Sep. 15, 2005; (166) U.S. National Stage application Ser. No. 10/550,906, attorney docket no. 25791.260.06, filed on Sep. 27, 2005; (167) U.S. National Stage application Ser. No. 10/551,880, attorney docket no. 25791.270.06, filed on Sep. 30, 2005; (168) U.S. National Stage application Ser. No. 10/552,253, attorney docket no. **25791.273.06**, filed on Oct. 4, 2005; (169) U.S. National Stage application Ser. No. 10/552,790, attorney docket no. 25791.272.06, filed on Oct. 11, 2005; (170) U.S. Provisional Patent Application No. 60/725,181, attorney docket no. 25791.184 filed on Oct. 11, 2005; (171) U.S. National Stage application Ser. No. 10/553,094, attorney docket no. 25791.193.03, filed on Oct. 13, 2005; (172) U.S. National Stage application Ser. No. 10/553,566, attorney docket no. 25791.277.06, filed on Oct. 17, 2005; (173) PCT Patent Application No. PCT/US2006/002449, attorney docket no. 25791.324.02 filed on Jan. 20, 2006, and (174) PCT Patent Application No. PCT/US2006/004809, attorney docket no. 25791.348.02 filed on Feb. 9, 2006; (175) U.S. Utility Patent application Ser. No. 11/356,899, attorney docket no. 25791.386, filed on Feb. 17, 2006, (176) U.S. National Stage application Ser. No. 10/568,200, attorney docket no. 25791.301.06, filed on Feb. 13, 2006, (177) U.S. National Stage application Ser. No. 10/568,719, attorney docket no. 25791.137.04, filed on Feb. 16, 2006, filed on Feb. 16, 2006, (178) U.S. National Stage application Ser. No. 10/569,323, attorney docket no. 25791.215.06, filed on Feb. 17, 2006, (179) U.S. National State patent application Ser. No. 10/571,041, attorney docket no. 25791.305.05, filed on 313106; (180) U.S. National State patent application Ser. No. 10/571,017, attorney docket no. 25791.306.04, filed on Mar. 3106; (181) U.S. National State patent application Ser.

No. 10/571,086, attorney docket no. 25791.307.04, filed on Feb. 16, 2006; and (182) U.S. National State patent application Ser. No. 10/571,085, attorney docket no. 25791.308.07, filed on Mar. 6, 2006, (183) U.S. utility patent application Ser. No. 10/938,788, attorney docket number 25791.330, filed on Sep. 10, 2004, (184) U.S. utility patent application Ser. No. 10/938,225, attorney docket number 25791.331, filed on Sep. 10, 2004, (185) U.S. utility patent application Ser. No. 10/952,288, attorney docket number 25791.332, filed on Sep. 28, 2004, (186) U.S. utility patent application Ser. No. 10/952,416, attorney docket number 25791.333, filed on Sep. 28, 2004, (187) U.S. utility patent application Ser. No. 10/950,749, attorney docket number 25791.334, filed on Sep. 27, 2004, (188) U.S. utility patent application Ser. No. 10/950,869, attorney docket number 25791.335, filed on Sep. 27, 2004; (189) U.S. provisional patent application Ser. No. 60/761,324, attorney docket number 25791.340, filed on Jan. 23, 2006, (190) U.S. provisional patent application Ser. No. 60/754,556, attorney docket number 25791.342, filed on Dec. 28, 2005, (191) U.S. utility patent application Ser. No. 11/380,051, attorney docket number 25791.388, filed on Apr. 25, 2006, (192) U.S. utility patent application Ser. No. 11/380,055, attorney docket number 25791.389, filed on Apr. 25, 2006, and (193) U.S. utility patent application Ser. No. _____, attorney docket no. 25791.404, filed on _____

BACKGROUND OF THE INVENTION

[0003] This invention relates generally to pipelines, and in particular to pipelines that are formed using expandable tubing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. 1 is a fragmentary cross-sectional view illustrating the drilling of a new section of a well borehole.

[0005] FIG. 2 is a fragmentary cross-sectional view illustrating the placement of an embodiment of an apparatus for creating a casing within the new section of the well borehole.

[0006] FIG. 3 is a fragmentary cross-sectional view illustrating the injection of a first quantity of a hardenable fluidic sealing material into the new section of the well borehole.

[0007] FIG. 3a is another fragmentary cross-sectional view illustrating the injection of a first quantity of a hardenable fluidic sealing material into the new section of the well borehole.

[0008] FIG. 4 is a fragmentary cross-sectional view illustrating the injection of a second quantity of a hardenable fluidic sealing material into the new section of the well borehole.

[0009] FIG. 5 is a fragmentary cross-sectional view illustrating the drilling out of a portion of the cured hardenable fluidic sealing material from the new section of the well borehole.

[0010] FIG. 6 is a cross-sectional view of an embodiment of the overlapping joint between adjacent tubular members.

[0011] FIG. 7 is a fragmentary cross-sectional view of a preferred embodiment of the apparatus for creating a casing within a well borehole.

[0012] FIG. 8 is a fragmentary cross-sectional illustration of the placement of an expanded tubular member within another tubular member.

[0013] FIG. 9 is a cross-sectional illustration of a preferred embodiment of an apparatus for forming a casing including a drillable mandrel and shoe.

[0014] FIG. 9a is another cross-sectional illustration of the apparatus of FIG. 9.

[0015] FIG. 9b is another cross-sectional illustration of the apparatus of FIG. 9.

[0016] FIG. 9c is another cross-sectional illustration of the apparatus of FIG. 9.

[0017] FIG. 10a is a cross-sectional illustration of a wellbore including a pair of adjacent overlapping casings.

[0018] FIG. 10b is a cross-sectional illustration of an apparatus and method for creating a tie-back liner using an expandable tubular member.

[0019] FIG. 10c is a cross-sectional illustration of the pumping of a fluidic sealing material into the annular region between the tubular member and the existing casing.

[0020] FIG. 10d is a cross-sectional illustration of the pressurizing of the interior of the tubular member below the mandrel.

[0021] FIG. 10e is a cross-sectional illustration of the extrusion of the tubular member off of the mandrel.

[0022] FIG. 10f is a cross-sectional illustration of the tie-back liner before drilling out the shoe and packer.

[0023] FIG. 10g is a cross-sectional illustration of the completed tie-back liner created using an expandable tubular member.

[0024] FIG. 11a is a fragmentary cross-sectional view illustrating the drilling of a new section of a well borehole.

[0025] FIG. 11b is a fragmentary cross-sectional view illustrating the placement of an embodiment of an apparatus for hanging a tubular liner within the new section of the well borehole.

[0026] FIG. 11c is a fragmentary cross-sectional view illustrating the injection of a first quantity of a hardenable fluidic sealing material into the new section of the well borehole.

[0027] FIG. 11d is a fragmentary cross-sectional view illustrating the introduction of a wiper dart into the new section of the well borehole.

[0028] FIG. 11e is a fragmentary cross-sectional view illustrating the injection of a second quantity of a hardenable fluidic sealing material into the new section of the well borehole.

[0029] FIG. 11f is a fragmentary cross-sectional view illustrating the completion of the tubular liner.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

[0030] An apparatus and method for forming a wellbore casing within a subterranean formation is provided. The apparatus and method permits a wellbore casing to be

formed in a subterranean formation by placing a tubular member and a mandrel in a new section of a wellbore, and then extruding the tubular member off of the mandrel by pressurizing an interior portion of the tubular member. The apparatus and method further permits adjacent tubular members in the wellbore to be joined using an overlapping joint that prevents fluid and or gas passage. The apparatus and method further permits a new tubular member to be supported by an existing tubular member by expanding the new tubular member into engagement with the existing tubular member. The apparatus and method further minimizes the reduction in the hole size of the wellbore casing necessitated by the addition of new sections of wellbore casing.

[0031] An apparatus and method for forming a tie-back liner using an expandable tubular member is also provided. The apparatus and method permits a tie-back liner to be created by extruding a tubular member off of a mandrel by pressurizing and interior portion of the tubular member. In this manner, a tie-back liner is produced. The apparatus and method further permits adjacent tubular members in the wellbore to be joined using an overlapping joint that prevents fluid and/or gas passage. The apparatus and method further permits a new tubular member to be supported by an existing tubular member by expanding the new tubular member into engagement with the existing tubular member.

[0032] An apparatus and method for expanding a tubular member is also provided that includes an expandable tubular member, mandrel and a shoe. In a preferred embodiment, the interior portions of the apparatus is composed of materials that permit the interior portions to be removed using a conventional drilling apparatus. In this manner, in the event of a malfunction in a downhole region, the apparatus may be easily removed.

[0033] An apparatus and method for hanging an expandable tubular liner in a wellbore is also provided. The apparatus and method permit a tubular liner to be attached to an existing section of casing. The apparatus and method further have application to the joining of tubular members in general.

[0034] Referring initially to FIGS. 1-5, an embodiment of an apparatus and method for forming a wellbore casing within a subterranean formation will now be described. As illustrated in FIG. 1, a wellbore 100 is positioned in a subterranean formation 105. The wellbore 100 includes an existing cased section 110 having a tubular casing 115 and an annular outer layer of cement 120.

[0035] In order to extend the wellbore 100 into the subterranean formation 105, a drill string 125 is used in a well known manner to drill out material from the subterranean formation 105 to form a new section 130.

[0036] As illustrated in FIG. 2, an apparatus 200 for forming a wellbore casing in a subterranean formation is then positioned in the new section 130 of the wellbore 100. The apparatus 200 preferably includes an expandable mandrel or pig 205, a tubular member 210, a shoe 215, a lower cup seal 220, an upper cup seal 225, a fluid passage 230, a fluid passage 235, a fluid passage 240, seals 245, and a support member 250.

[0037] The expandable mandrel 205 is coupled to and supported by the support member 250. The expandable mandrel 205 is preferably adapted to controllably expand in

a radial direction. The expandable mandrel 205 may comprise any number of conventional commercially available expandable mandrels modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the expandable mandrel 205 comprises a hydraulic expansion tool as disclosed in U.S. Pat. No. 5,348,095, the contents of which are incorporated herein by reference, modified in accordance with the teachings of the present disclosure.

[0038] The tubular member 210 is supported by the expandable mandrel 205. The tubular member 210 is expanded in the radial direction and extruded off of the expandable mandrel 205. The tubular member 210 may be fabricated from any number of conventional commercially available materials such as, for example, Oilfield Country Tubular Goods (OCTG), 13 chromium steel tubing/casing, or plastic tubing/casing. In a preferred embodiment, the tubular member 210 is fabricated from OCTG in order to maximize strength after expansion. The inner and outer diameters of the tubular member 210 may range, for example, from approximately 0.75 to 47 inches and 1.05 to 48 inches, respectively. In a preferred embodiment, the inner and outer diameters of the tubular member 210 range from about 3 to 15.5 inches and 3.5 to 16 inches, respectively in order to optimally provide minimal telescoping effect in the most commonly drilled wellbore sizes. The tubular member 210 preferably comprises a solid member.

[0039] In a preferred embodiment, the end portion 260 of the tubular member 210 is slotted, perforated, or otherwise modified to catch or slow down the mandrel 205 when it completes the extrusion of tubular member 210. In a preferred embodiment, the length of the tubular member 210 is limited to minimize the possibility of buckling. For typical tubular member 210 materials, the length of the tubular member 210 is preferably limited to between about 40 to 20,000 feet in length.

[0040] The shoe 215 is coupled to the expandable mandrel 205 and the tubular member 210. The shoe 215 includes fluid passage 240. The shoe 215 may comprise any number of conventional commercially available shoes such as, for example, Super Seal II float shoe, Super Seal II Down-Jet float shoe or a guide shoe with a sealing sleeve for a latch down plug modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the shoe 215 comprises an aluminum down-jet guide shoe with a sealing sleeve for a latch-down plug available from Halliburton Energy Services in Dallas, Tex., modified in accordance with the teachings of the present disclosure, in order to optimally guide the tubular member 210 in the wellbore, optimally provide an adequate seal between the interior and exterior diameters of the overlapping joint between the tubular members, and to optimally allow the complete drill out of the shoe and plug after the completion of the cementing and expansion operations.

[0041] In a preferred embodiment, the shoe 215 includes one or more through and side outlet ports in fluidic communication with the fluid passage 240. In this manner, the shoe 215 optimally injects hardenable fluidic sealing material into the region outside the shoe 215 and tubular member 210. In a preferred embodiment, the shoe 215 includes the fluid passage 240 having an inlet geometry that can receive a dart and/or a ball sealing member. In this manner, the fluid

passage **240** can be optimally sealed off by introducing a plug, dart and/or ball sealing elements into the fluid passage **230**.

[0042] The lower cup seal **220** is coupled to and supported by the support member **250**. The lower cup seal **220** prevents foreign materials from entering the interior region of the tubular member **210** adjacent to the expandable mandrel **205**. The lower cup seal **220** may comprise any number of conventional commercially available cup seals such as, for example, TP cups, or Selective Injection Packer (SIP) cups modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the lower cup seal **220** comprises a SIP cup seal, available from Halliburton Energy Services in Dallas, Tex. in order to optimally block foreign material and contain a body of lubricant.

[0043] The upper cup seal **225** is coupled to and supported by the support member **250**. The upper cup seal **225** prevents foreign materials from entering the interior region of the tubular member **210**. The upper cup seal **225** may comprise any number of conventional commercially available cup seals such as, for example, TP cups or SIP cups modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the upper cup seal **225** comprises a SIP cup, available from Halliburton Energy Services in Dallas, Tex. in order to optimally block the entry of foreign materials and contain a body of lubricant.

[0044] The fluid passage **230** permits fluidic materials to be transported to and from the interior region of the tubular member **210** below the expandable mandrel **205**. The fluid passage **230** is coupled to and positioned within the support member **250** and the expandable mandrel **205**. The fluid passage **230** preferably extends from a position adjacent to the surface to the bottom of the expandable mandrel **205**. The fluid passage **230** is preferably positioned along a centerline of the apparatus **200**.

[0045] The fluid passage **230** is preferably selected, in the casing running mode of operation, to transport materials such as drilling mud or formation fluids at flow rates and pressures ranging from about 0 to 3,000 gallons/minute and 0 to 9,000 psi in order to minimize drag on the tubular member being run and to minimize surge pressures exerted on the wellbore which could cause a loss of wellbore fluids and lead to hole collapse.

[0046] The fluid passage **235** permits fluidic materials to be released from the fluid passage **230**. In this manner, during placement of the apparatus **200** within the new section **130** of the wellbore **100**, fluidic materials **255** forced up the fluid passage **230** can be released into the wellbore **100** above the tubular member **210** thereby minimizing surge pressures on the wellbore section **130**. The fluid passage **235** is coupled to and positioned within the support member **250**. The fluid passage is further fluidically coupled to the fluid passage **230**.

[0047] The fluid passage **235** preferably includes a control valve for controllably opening and closing the fluid passage **235**. In a preferred embodiment, the control valve is pressure activated in order to controllably minimize surge pressures. The fluid passage **235** is preferably positioned substantially orthogonal to the centerline of the apparatus **200**.

[0048] The fluid passage **235** is preferably selected to convey fluidic materials at flow rates and pressures ranging

from about 0 to 3,000 gallons/minute and 0 to 9,000 psi in order to reduce the drag on the apparatus **200** during insertion into the new section **130** of the wellbore **100** and to minimize surge pressures on the new wellbore section **130**.

[0049] The fluid passage **240** permits fluidic materials to be transported to and from the region exterior to the tubular member **210** and shoe **215**. The fluid passage **240** is coupled to and positioned within the shoe **215** in fluidic communication with the interior region of the tubular member **210** below the expandable mandrel **205**. The fluid passage **240** preferably has a cross-sectional shape that permits a plug, or other similar device, to be placed in fluid passage **240** to thereby block further passage of fluidic materials. In this manner, the interior region of the tubular member **210** below the expandable mandrel **205** can be fluidically isolated from the region exterior to the tubular member **210**. This permits the interior region of the tubular member **210** below the expandable mandrel **205** to be pressurized. The fluid passage **240** is preferably positioned substantially along the centerline of the apparatus **200**.

[0050] The fluid passage **240** is preferably selected to convey materials such as cement, drilling mud or epoxies at flow rates and pressures ranging from about 0 to 3,000 gallons/minute and 0 to 9,000 psi in order to optimally fill the annular region between the tubular member **210** and the new section **130** of the wellbore **100** with fluidic materials. In a preferred embodiment, the fluid passage **240** includes an inlet geometry that can receive a dart and/or a ball sealing member. In this manner, the fluid passage **240** can be sealed off by introducing a plug, dart and/or ball sealing elements into the fluid passage **230**.

[0051] The seals **245** are coupled to and supported by an end portion **260** of the tubular member **210**. The seals **245** are further positioned on an outer surface **265** of the end portion **260** of the tubular member **210**. The seals **245** permit the overlapping joint between the end portion **270** of the casing **115** and the portion **260** of the tubular member **210** to be fluidically sealed. The seals **245** may comprise any number of conventional commercially available seals such as, for example, lead, rubber, Teflon, or epoxy seals modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the seals **245** are molded from Stratalock epoxy available from Halliburton Energy Services in Dallas, Tex. in order to optimally provide a load bearing interference fit between the end **260** of the tubular member **210** and the end **270** of the existing casing **115**.

[0052] In a preferred embodiment, the seals **245** are selected to optimally provide a sufficient frictional force to support the expanded tubular member **210** from the existing casing **115**. In a preferred embodiment, the frictional force optimally provided by the seals **245** ranges from about 1,000 to 1,000,000 lbf in order to optimally support the expanded tubular member **210**.

[0053] The support member **250** is coupled to the expandable mandrel **205**, tubular member **210**, shoe **215**, and seals **220** and **225**. The support member **250** preferably comprises an annular member having sufficient strength to carry the apparatus **200** into the new section **130** of the wellbore **100**. In a preferred embodiment, the support member **250** further includes one or more conventional centralizers (not illustrated) to help stabilize the apparatus **200**.

[0054] In a preferred embodiment, a quantity of lubricant 275 is provided in the annular region above the expandable mandrel 205 within the interior of the tubular member 210. In this manner, the extrusion of the tubular member 210 off of the expandable mandrel 205 is facilitated. The lubricant 275 may comprise any number of conventional commercially available lubricants such as, for example, Lubriplate, chlorine based lubricants, oil based lubricants or Climax 1500 Antisieze (3100). In a preferred embodiment, the lubricant 275 comprises Climax 1500 Antisieze (3100) available from Climax Lubricants and Equipment Co. in Houston, Tex. in order to optimally provide optimum lubrication to facilitate the expansion process.

[0055] In a preferred embodiment, the support member 250 is thoroughly cleaned prior to assembly to the remaining portions of the apparatus 200. In this manner, the introduction of foreign material into the apparatus 200 is minimized. This minimizes the possibility of foreign material clogging the various flow passages and valves of the apparatus 200.

[0056] In a preferred embodiment, before or after positioning the apparatus 200 within the new section 130 of the wellbore 100, a couple of wellbore volumes are circulated in order to ensure that no foreign materials are located within the well bore 100 that might clog up the various flow passages and valves of the apparatus 200 and to ensure that no foreign material interferes with the expansion process.

[0057] As illustrated in FIG. 3, the fluid passage 235 is then closed and a hardenable fluidic sealing material 305 is then pumped from a surface location into the fluid passage 230. The material 305 then passes from the fluid passage 230 into the interior region 310 of the tubular member 210 below the expandable mandrel 205. The material 305 then passes from the interior region 310 into the fluid passage 240. The material 305 then exits the apparatus 200 and fills the annular region 315 between the exterior of the tubular member 210 and the interior wall of the new section 130 of the wellbore 100. Continued pumping of the material 305 causes the material 305 to fill up at least a portion of the annular region 315.

[0058] The material 305 is preferably pumped into the annular region 315 at pressures and flow rates ranging, for example, from about 0 to 5000 psi and 0 to 1,500 gallons/min, respectively. The optimum flow rate and operating pressures vary as a function of the casing and wellbore sizes, wellbore section length, available pumping equipment, and fluid properties of the fluidic material being pumped. The optimum flow rate and operating pressure are preferably determined using conventional empirical methods.

[0059] The hardenable fluidic sealing material 305 may comprise any number of conventional commercially available hardenable fluidic sealing materials such as, for example, slag mix, cement or epoxy. In a preferred embodiment, the hardenable fluidic sealing material 305 comprises a blended cement prepared specifically for the particular well section being drilled from Halliburton Energy Services in Dallas, Tex. in order to provide optimal support for tubular member 210 while also maintaining optimum flow characteristics so as to minimize difficulties during the displacement of cement in the annular region 315. The optimum blend of the blended cement is preferably determined using conventional empirical methods.

[0060] The annular region 315 preferably is filled with the material 305 in sufficient quantities to ensure that, upon

radial expansion of the tubular member 210, the annular region 315 of the new section 130 of the wellbore 100 will be filled with material 305.

[0061] In a particularly preferred embodiment, as illustrated in FIG. 3a, the wall thickness and/or the outer diameter of the tubular member 210 is reduced in the region adjacent to the mandrel 205 in order optimally permit placement of the apparatus 200 in positions in the wellbore with tight clearances. Furthermore, in this manner, the initiation of the radial expansion of the tubular member 210 during the extrusion process is optimally facilitated.

[0062] As illustrated in FIG. 4, once the annular region 315 has been adequately filled with material 305, a plug 405, or other similar device, is introduced into the fluid passage 240 thereby fluidically isolating the interior region 310 from the annular region 315. In a preferred embodiment, a non-hardenable fluidic material 306 is then pumped into the interior region 310 causing the interior region to pressurize. In this manner, the interior of the expanded tubular member 210 will not contain significant amounts of cured material 305. This reduces and simplifies the cost of the entire process. Alternatively, the material 305 may be used during this phase of the process.

[0063] Once the interior region 310 becomes sufficiently pressurized, the tubular member 210 is extruded off of the expandable mandrel 205. During the extrusion process, the expandable mandrel 205 may be raised out of the expanded portion of the tubular member 210. In a preferred embodiment, during the extrusion process, the mandrel 205 is raised at approximately the same rate as the tubular member 210 is expanded in order to keep the tubular member 210 stationary relative to the new wellbore section 130. In an alternative preferred embodiment, the extrusion process is commenced with the tubular member 210 positioned above the bottom of the new wellbore section 130, keeping the mandrel 205 stationary, and allowing the tubular member 210 to extrude off of the mandrel 205 and fall down the new wellbore section 130 under the force of gravity.

[0064] The plug 405 is preferably placed into the fluid passage 240 by introducing the plug 405 into the fluid passage 230 at a surface location in a conventional manner. The plug 405 preferably acts to fluidically isolate the hardenable fluidic sealing material 305 from the non hardenable fluidic material 306.

[0065] The plug 405 may comprise any number of conventional commercially available devices from plugging a fluid passage such as, for example, Multiple Stage Cementer (MSC) latch-down plug, Omega latch-down plug or three-wiper latch-down plug modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the plug 405 comprises a MSC latch-down plug available from Halliburton Energy Services in Dallas, Tex.

[0066] After placement of the plug 405 in the fluid passage 240, a non hardenable fluidic material 306 is preferably pumped into the interior region 310 at pressures and flow rates ranging, for example, from approximately 400 to 10,000 psi and 30 to 4,000 gallons/min. In this manner, the amount of hardenable fluidic sealing material within the interior 310 of the tubular member 210 is minimized. In a preferred embodiment, after placement of the plug 405 in the fluid passage 240, the non hardenable material 306 is

preferably pumped into the interior region 310 at pressures and flow rates ranging from approximately 500 to 9,000 psi and 40 to 3,000 gallons/min in order to maximize the extrusion speed.

[0067] In a preferred embodiment, the apparatus 200 is adapted to minimize tensile, burst, and friction effects upon the tubular member 210 during the expansion process. These effects will be depend upon the geometry of the expansion mandrel 205, the material composition of the tubular member 210 and expansion mandrel 205, the inner diameter of the tubular member 210, the wall thickness of the tubular member 210, the type of lubricant, and the yield strength of the tubular member 210. In general, the thicker the wall thickness, the smaller the inner diameter, and the greater the yield strength of the tubular member 210, then the greater the operating pressures required to extrude the tubular member 210 off of the mandrel 205.

[0068] For typical tubular members 210, the extrusion of the tubular member 210 off of the expandable mandrel will begin when the pressure of the interior region 310 reaches, for example, approximately 500 to 9,000 psi.

[0069] During the extrusion process, the expandable mandrel 205 may be raised out of the expanded portion of the tubular member 210 at rates ranging, for example, from about 0 to 5 ft/sec. In a preferred embodiment, during the extrusion process, the expandable mandrel 205 is raised out of the expanded portion of the tubular member 210 at rates ranging from about 0 to 2 ft/sec in order to minimize the time required for the expansion process while also permitting easy control of the expansion process.

[0070] When the end portion 260 of the tubular member 210 is extruded off of the expandable mandrel 205, the outer surface 265 of the end portion 260 of the tubular member 210 will preferably contact the interior surface 410 of the end portion 270 of the casing 115 to form an fluid tight overlapping joint. The contact pressure of the overlapping joint may range, for example, from approximately 50 to 20,000 psi. In a preferred embodiment, the contact pressure of the overlapping joint ranges from approximately 400 to 10,000 psi in order to provide optimum pressure to activate the annular sealing members 245 and optimally provide resistance to axial motion to accommodate typical tensile and compressive loads.

[0071] The overlapping joint between the section 410 of the existing casing 115 and the section 265 of the expanded tubular member 210 preferably provides a gaseous and fluidic seal. In a particularly preferred embodiment, the sealing members 245 optimally provide a fluidic and gaseous seal in the overlapping joint.

[0072] In a preferred embodiment, the operating pressure and flow rate of the non hardenable fluidic material 306 is controllably ramped down when the expandable mandrel 205 reaches the end portion 260 of the tubular member 210. In this manner, the sudden release of pressure caused by the complete extrusion of the tubular member 210 off of the expandable mandrel 205 can be minimized. In a preferred embodiment, the operating pressure is reduced in a substantially linear fashion from 100% to about 10% during the end of the extrusion process beginning when the mandrel 205 is within about 5 feet from completion of the extrusion process.

[0073] Alternatively, or in combination, a shock absorber is provided in the support member 250 in order to absorb the shock caused by the sudden release of pressure. The shock absorber may comprise, for example, any conventional commercially available shock absorber adapted for use in wellbore operations.

[0074] Alternatively, or in combination, a mandrel catching structure is provided in the end portion 260 of the tubular member 210 in order to catch or at least decelerate the mandrel 205.

[0075] Once the extrusion process is completed, the expandable mandrel 205 is removed from the wellbore 100. In a preferred embodiment, either before or after the removal of the expandable mandrel 205, the integrity of the fluidic seal of the overlapping joint between the upper portion 260 of the tubular member 210 and the lower portion 270 of the casing 115 is tested using conventional methods.

[0076] If the fluidic seal of the overlapping joint between the upper portion 260 of the tubular member 210 and the lower portion 270 of the casing 115 is satisfactory, then any uncured portion of the material 305 within the expanded tubular member 210 is then removed in a conventional manner such as, for example, circulating the uncured material out of the interior of the expanded tubular member 210. The mandrel 205 is then pulled out of the wellbore section 130 and a drill bit or mill is used in combination with a conventional drilling assembly 505 to drill out any hardened material 305 within the tubular member 210. The material 305 within the annular region 315 is then allowed to cure.

[0077] As illustrated in FIG. 5, preferably any remaining cured material 305 within the interior of the expanded tubular member 210 is then removed in a conventional manner using a conventional drill string 505. The resulting new section of casing 510 includes the expanded tubular member 210 and an outer annular layer 515 of cured material 305. The bottom portion of the apparatus 200 comprising the shoe 215 and dart 405 may then be removed by drilling out the shoe 215 and dart 405 using conventional drilling methods.

[0078] In a preferred embodiment, as illustrated in FIG. 6, the upper portion 260 of the tubular member 210 includes one or more sealing members 605 and one or more pressure relief holes 610. In this manner, the overlapping joint between the lower portion 270 of the casing 115 and the upper portion 260 of the tubular member 210 is pressure-tight and the pressure on the interior and exterior surfaces of the tubular member 210 is equalized during the extrusion process.

[0079] In a preferred embodiment, the sealing members 605 are seated within recesses 615 formed in the outer surface 265 of the upper portion 260 of the tubular member 210. In an alternative preferred embodiment, the sealing members 605 are bonded or molded onto the outer surface 265 of the upper portion 260 of the tubular member 210. The pressure relief holes 610 are preferably positioned in the last few feet of the tubular member 210. The pressure relief holes reduce the operating pressures required to expand the upper portion 260 of the tubular member 210. This reduction in required operating pressure in turn reduces the velocity of the mandrel 205 upon the completion of the extrusion process. This reduction in velocity in turn minimizes the

mechanical shock to the entire apparatus 200 upon the completion of the extrusion process.

[0080] Referring now to FIG. 7, a particularly preferred embodiment of an apparatus 700 for forming a casing within a wellbore preferably includes an expandable mandrel or pig 705, an expandable mandrel or pig container 710, a tubular member 715, a float shoe 720, a lower cup seal 725, an upper cup seal 730, a fluid passage 735, a fluid passage 740, a support member 745, a body of lubricant 750, an overshot connection 755, another support member 760, and a stabilizer 765.

[0081] The expandable mandrel 705 is coupled to and supported by the support member 745. The expandable mandrel 705 is further coupled to the expandable mandrel container 710. The expandable mandrel 705 is preferably adapted to controllably expand in a radial direction. The expandable mandrel 705 may comprise any number of conventional commercially available expandable mandrels modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the expandable mandrel 705 comprises a hydraulic expansion tool substantially as disclosed in U.S. Pat. No. 5,348,095, the contents of which are incorporated herein by reference, modified in accordance with the teachings of the present disclosure.

[0082] The expandable mandrel container 710 is coupled to and supported by the support member 745. The expandable mandrel container 710 is further coupled to the expandable mandrel 705. The expandable mandrel container 710 may be constructed from any number of conventional commercially available materials such as, for example, Oilfield Country Tubular Goods, stainless steel, titanium or high strength steels. In a preferred embodiment, the expandable mandrel container 710 is fabricated from material having a greater strength than the material from which the tubular member 715 is fabricated. In this manner, the container 710 can be fabricated from a tubular material having a thinner wall thickness than the tubular member 210. This permits the container 710 to pass through tight clearances thereby facilitating its placement within the wellbore.

[0083] In a preferred embodiment, once the expansion process begins, and the thicker, lower strength material of the tubular member 715 is expanded, the outside diameter of the tubular member 715 is greater than the outside diameter of the container 710.

[0084] The tubular member 715 is coupled to and supported by the expandable mandrel 705. The tubular member 715 is preferably expanded in the radial direction and extruded off of the expandable mandrel 705 substantially as described above with reference to FIGS. 1-6. The tubular member 715 may be fabricated from any number of materials such as, for example, Oilfield Country Tubular Goods (OCTG), automotive grade steel or plastics. In a preferred embodiment, the tubular member 715 is fabricated from OCTG.

[0085] In a preferred embodiment, the tubular member 715 has a substantially annular cross-section. In a particularly preferred embodiment, the tubular member 715 has a substantially circular annular cross-section.

[0086] The tubular member 715 preferably includes an upper section 805, an intermediate section 810, and a lower section 815. The upper section 805 of the tubular member

715 preferably is defined by the region beginning in the vicinity of the mandrel container 710 and ending with the top section 820 of the tubular member 715. The intermediate section 810 of the tubular member 715 is preferably defined by the region beginning in the vicinity of the top of the mandrel container 710 and ending with the region in the vicinity of the mandrel 705. The lower section of the tubular member 715 is preferably defined by the region beginning in the vicinity of the mandrel 705 and ending at the bottom 825 of the tubular member 715.

[0087] In a preferred embodiment, the wall thickness of the upper section 805 of the tubular member 715 is greater than the wall thicknesses of the intermediate and lower sections 810 and 815 of the tubular member 715 in order to optimally facilitate the initiation of the extrusion process and optimally permit the apparatus 700 to be positioned in locations in the wellbore having tight clearances.

[0088] The outer diameter and wall thickness of the upper section 805 of the tubular member 715 may range, for example, from about 1.05 to 48 inches and $\frac{1}{8}$ to 2 inches, respectively. In a preferred embodiment, the outer diameter and wall thickness of the upper section 805 of the tubular member 715 range from about 3.5 to 16 inches and $\frac{3}{8}$ to 1.5 inches, respectively.

[0089] The outer diameter and wall thickness of the intermediate section 810 of the tubular member 715 may range, for example, from about 2.5 to 50 inches and $\frac{1}{16}$ to 1.5 inches, respectively. In a preferred embodiment, the outer diameter and wall thickness of the intermediate section 810 of the tubular member 715 range from about 3.5 to 19 inches and $\frac{1}{8}$ to 1.25 inches, respectively.

[0090] The outer diameter and wall thickness of the lower section 815 of the tubular member 715 may range, for example, from about 2.5 to 50 inches and $\frac{1}{16}$ to 1.25 inches, respectively. In a preferred embodiment, the outer diameter and wall thickness of the lower section 810 of the tubular member 715 range from about 3.5 to 19 inches and $\frac{1}{8}$ to 1.25 inches, respectively. In a particularly preferred embodiment, the wall thickness of the lower section 815 of the tubular member 715 is further increased to increase the strength of the shoe 720 when drillable materials such as, for example, aluminum are used.

[0091] The tubular member 715 preferably comprises a solid tubular member. In a preferred embodiment, the end portion 820 of the tubular member 715 is slotted, perforated, or otherwise modified to catch or slow down the mandrel 705 when it completes the extrusion of tubular member 715. In a preferred embodiment, the length of the tubular member 715 is limited to minimize the possibility of buckling. For typical tubular member 715 materials, the length of the tubular member 715 is preferably limited to between about 40 to 20,000 feet in length.

[0092] The shoe 720 is coupled to the expandable mandrel 705 and the tubular member 715. The shoe 720 includes the fluid passage 740. In a preferred embodiment, the shoe 720 further includes an inlet passage 830, and one or more jet ports 835. In a particularly preferred embodiment, the cross-sectional shape of the inlet passage 830 is adapted to receive a latch-down dart, or other similar elements, for blocking the inlet passage 830. The interior of the shoe 720 preferably includes a body of solid material 840 for increasing the

strength of the shoe 720. In a particularly preferred embodiment, the body of solid material 840 comprises aluminum.

[0093] The shoe 720 may comprise any number of conventional commercially available shoes such as, for example, Super Seal II Down-Jet float shoe, or guide shoe with a sealing sleeve for a latch down plug modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the shoe 720 comprises an aluminum down-jet guide shoe with a sealing sleeve for a latch-down plug available from Halliburton Energy Services in Dallas, Tex., modified in accordance with the teachings of the present disclosure, in order to optimize guiding the tubular member 715 in the wellbore, optimize the seal between the tubular member 715 and an existing wellbore casing, and to optimally facilitate the removal of the shoe 720 by drilling it out after completion of the extrusion process.

[0094] The lower cup seal 725 is coupled to and supported by the support member 745. The lower cup seal 725 prevents foreign materials from entering the interior region of the tubular member 715 above the expandable mandrel 705. The lower cup seal 725 may comprise any number of conventional commercially available cup seals such as, for example, TP cups or Selective Injection Packer (SIP) cups modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the lower cup seal 725 comprises a SIP cup, available from Halliburton Energy Services in Dallas, Tex. in order to optimally provide a debris barrier and hold a body of lubricant.

[0095] The upper cup seal 730 is coupled to and supported by the support member 760. The upper cup seal 730 prevents foreign materials from entering the interior region of the tubular member 715. The upper cup seal 730 may comprise any number of conventional commercially available cup seals such as, for example, TP cups or Selective Injection Packer (SIP) cup modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the upper cup seal 730 comprises a SIP cup available from Halliburton Energy Services in Dallas, Tex. in order to optimally provide a debris barrier and contain a body of lubricant.

[0096] The fluid passage 735 permits fluidic materials to be transported to and from the interior region of the tubular member 715 below the expandable mandrel 705. The fluid passage 735 is fluidically coupled to the fluid passage 740. The fluid passage 735 is preferably coupled to and positioned within the support member 760, the support member 745, the mandrel container 710, and the expandable mandrel 705. The fluid passage 735 preferably extends from a position adjacent to the surface to the bottom of the expandable mandrel 705. The fluid passage 735 is preferably positioned along a centerline of the apparatus 700. The fluid passage 735 is preferably selected to transport materials such as cement, drilling mud or epoxies at flow rates and pressures ranging from about 40 to 3,000 gallons/minute and 500 to 9,000 psi in order to provide sufficient operating pressures to extrude the tubular member 715 off of the expandable mandrel 705.

[0097] As described above with reference to FIGS. 1-6, during placement of the apparatus 700 within a new section of a wellbore, fluidic materials forced up the fluid passage 735 can be released into the wellbore above the tubular

member 715. In a preferred embodiment, the apparatus 700 further includes a pressure release passage that is coupled to and positioned within the support member 260. The pressure release passage is further fluidically coupled to the fluid passage 735. The pressure release passage preferably includes a control valve for controllably opening and closing the fluid passage. In a preferred embodiment, the control valve is pressure activated in order to controllably minimize surge pressures. The pressure release passage is preferably positioned substantially orthogonal to the centerline of the apparatus 700. The pressure release passage is preferably selected to convey materials such as cement, drilling mud or epoxies at flow rates and pressures ranging from about 0 to 500 gallons/minute and 0 to 1,000 psi in order to reduce the drag on the apparatus 700 during insertion into a new section of a wellbore and to minimize surge pressures on the new wellbore section.

[0098] The fluid passage 740 permits fluidic materials to be transported to and from the region exterior to the tubular member 715. The fluid passage 740 is preferably coupled to and positioned within the shoe 720 in fluidic communication with the interior region of the tubular member 715 below the expandable mandrel 705. The fluid passage 740 preferably has a cross-sectional shape that permits a plug, or other similar device, to be placed in the inlet 830 of the fluid passage 740 to thereby block further passage of fluidic materials. In this manner, the interior region of the tubular member 715 below the expandable mandrel 705 can be optimally fluidically isolated from the region exterior to the tubular member 715. This permits the interior region of the tubular member 715 below the expandable mandrel 205 to be pressurized.

[0099] The fluid passage 740 is preferably positioned substantially along the centerline of the apparatus 700. The fluid passage 740 is preferably selected to convey materials such as cement, drilling mud or epoxies at flow rates and pressures ranging from about 0 to 3,000 gallons/minute and 0 to 9,000 psi in order to optimally fill an annular region between the tubular member 715 and a new section of a wellbore with fluidic materials. In a preferred embodiment, the fluid passage 740 includes an inlet passage 830 having a geometry that can receive a dart and/or a ball sealing member. In this manner, the fluid passage 240 can be sealed off by introducing a plug, dart and/or ball sealing elements into the fluid passage 230.

[0100] In a preferred embodiment, the apparatus 700 further includes one or more seals 845 coupled to and supported by the end portion 820 of the tubular member 715. The seals 845 are further positioned on an outer surface of the end portion 820 of the tubular member 715. The seals 845 permit the overlapping joint between an end portion of preexisting casing and the end portion 820 of the tubular member 715 to be fluidically sealed. The seals 845 may comprise any number of conventional commercially available seals such as, for example, lead, rubber, Teflon, or epoxy seals modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the seals 845 comprise seals molded from StrataLock epoxy available from Halliburton Energy Services in Dallas, Tex. in order to optimally provide a hydraulic seal and a load bearing interference fit in the overlapping joint between the tubular member 715 and an existing casing with optimal load bearing capacity to support the tubular member 715.

[0101] In a preferred embodiment, the seals **845** are selected to provide a sufficient frictional force to support the expanded tubular member **715** from the existing casing. In a preferred embodiment, the frictional force provided by the seals **845** ranges from about 1,000 to 1,000,000 lbf in order to optimally support the expanded tubular member **715**.

[0102] The support member **745** is preferably coupled to the expandable mandrel **705** and the overshot connection **755**. The support member **745** preferably comprises an annular member having sufficient strength to carry the apparatus **700** into a new section of a wellbore. The support member **745** may comprise any number of conventional commercially available support members such as, for example, steel drill pipe, coiled tubing or other high strength tubular modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the support member **745** comprises conventional drill pipe available from various steel mills in the United States.

[0103] In a preferred embodiment, a body of lubricant **750** is provided in the annular region above the expandable mandrel container **710** within the interior of the tubular member **715**. In this manner, the extrusion of the tubular member **715** off of the expandable mandrel **705** is facilitated. The lubricant **750** may comprise any number of conventional commercially available lubricants such as, for example, Lubriplate, chlorine based lubricants, oil based lubricants, or Climax 1500 Antisize (3100). In a preferred embodiment, the lubricant **750** comprises Climax 1500 Antisize (3100) available from Halliburton Energy Services in Houston, Tex. in order to optimally provide lubrication to facilitate the extrusion process.

[0104] The overshot connection **755** is coupled to the support member **745** and the support member **760**. The overshot connection **755** preferably permits the support member **745** to be removably coupled to the support member **760**. The overshot connection **755** may comprise any number of conventional commercially available overshot connections such as, for example, Innerstring Sealing Adapter, Innerstring Flat-Face Sealing Adapter or EZ Drill Setting Tool Stinger. In a preferred embodiment, the overshot connection **755** comprises an Innerstring Adapter with an Upper Guide available from Halliburton Energy Services in Dallas, Tex.

[0105] The support member **760** is preferably coupled to the overshot connection **755** and a surface support structure (not illustrated). The support member **760** preferably comprises an annular member having sufficient strength to carry the apparatus **700** into a new section of a wellbore. The support member **760** may comprise any number of conventional commercially available support members such as, for example, steel drill pipe, coiled tubing or other high strength tubulars modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the support member **760** comprises a conventional drill pipe available from steel mills in the United States.

[0106] The stabilizer **765** is preferably coupled to the support member **760**. The stabilizer **765** also preferably stabilizes the components of the apparatus **700** within the tubular member **715**. The stabilizer **765** preferably comprises a spherical member having an outside diameter that is about **80** to **99%** of the interior diameter of the tubular member **715** in order to optimally minimize buckling of the

tubular member **715**. The stabilizer **765** may comprise any number of conventional commercially available stabilizers such as, for example, EZ Drill Star Guides, packer shoes or drag blocks modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the stabilizer **765** comprises a sealing adapter upper guide available from Halliburton Energy Services in Dallas, Tex.

[0107] In a preferred embodiment, the support members **745** and **760** are thoroughly cleaned prior to assembly to the remaining portions of the apparatus **700**. In this manner, the introduction of foreign material into the apparatus **700** is minimized. This minimizes the possibility of foreign material clogging the various flow passages and valves of the apparatus **700**.

[0108] In a preferred embodiment, before or after positioning the apparatus **700** within a new section of a wellbore, a couple of wellbore volumes are circulated through the various flow passages of the apparatus **700** in order to ensure that no foreign materials are located within the wellbore that might clog up the various flow passages and valves of the apparatus **700** and to ensure that no foreign material interferes with the expansion mandrel **705** during the expansion process.

[0109] In a preferred embodiment, the apparatus **700** is operated substantially as described above with reference to FIGS. **1-7** to form a new section of casing within a wellbore.

[0110] As illustrated in FIG. **8**, in an alternative preferred embodiment, the method and apparatus described herein is used to repair an existing wellbore casing **805** by forming a tubular liner **810** inside of the existing wellbore casing **805**. In a preferred embodiment, an outer annular lining of cement is not provided in the repaired section. In the alternative preferred embodiment, any number of fluidic materials can be used to expand the tubular liner **810** into intimate contact with the damaged section of the wellbore casing such as, for example, cement, epoxy, slag mix, or drilling mud. In the alternative preferred embodiment, sealing members **815** are preferably provided at both ends of the tubular member in order to optimally provide a fluidic seal. In an alternative preferred embodiment, the tubular liner **810** is formed within a horizontally positioned pipeline section, such as those used to transport hydrocarbons or water, with the tubular liner **810** placed in an overlapping relationship with the adjacent pipeline section. In this manner, underground pipelines can be repaired without having to dig out and replace the damaged sections.

[0111] In another alternative preferred embodiment, the method and apparatus described herein is used to directly line a wellbore with a tubular liner **810**. In a preferred embodiment, an outer annular lining of cement is not provided between the tubular liner **810** and the wellbore. In the alternative preferred embodiment, any number of fluidic materials can be used to expand the tubular liner **810** into intimate contact with the wellbore such as, for example, cement, epoxy, slag mix, or drilling mud.

[0112] Referring now to FIGS. **9, 9a, 9b** and **9c**, a preferred embodiment of an apparatus **900** for forming a wellbore casing includes an expandable tubular member **902**, a support member **904**, an expandable mandrel or pig **906**, and a shoe **908**. In a preferred embodiment, the design and construction of the mandrel **906** and shoe **908** permits

easy removal of those elements by drilling them out. In this manner, the assembly **900** can be easily removed from a wellbore using a conventional drilling apparatus and corresponding drilling methods.

[0113] The expandable tubular member **902** preferably includes an upper portion **910**, an intermediate portion **912** and a lower portion **914**. During operation of the apparatus **900**, the tubular member **902** is preferably extruded off of the mandrel **906** by pressurizing an interior region **966** of the tubular member **902**. The tubular member **902** preferably has a substantially annular cross-section.

[0114] In a particularly preferred embodiment, an expandable tubular member **915** is coupled to the upper portion **910** of the expandable tubular member **902**. During operation of the apparatus **900**, the tubular member **915** is preferably extruded off of the mandrel **906** by pressurizing the interior region **966** of the tubular member **902**. The tubular member **915** preferably has a substantially annular cross-section. In a preferred embodiment, the wall thickness of the tubular member **915** is greater than the wall thickness of the tubular member **902**.

[0115] The tubular member **915** may be fabricated from any number of conventional commercially available materials such as, for example, oilfield tubulars, low alloy steels, titanium or stainless steels. In a preferred embodiment, the tubular member **915** is fabricated from oilfield tubulars in order to optimally provide approximately the same mechanical properties as the tubular member **902**. In a particularly preferred embodiment, the tubular member **915** has a plastic yield point ranging from about 40,000 to 135,000 psi in order to optimally provide approximately the same yield properties as the tubular member **902**. The tubular member **915** may comprise a plurality of tubular members coupled end to end.

[0116] In a preferred embodiment, the upper end portion of the tubular member **915** includes one or more sealing members for optimally providing a fluidic and/or gaseous seal with an existing section of wellbore casing.

[0117] In a preferred embodiment, the combined length of the tubular members **902** and **915** are limited to minimize the possibility of buckling. For typical tubular member materials, the combined length of the tubular members **902** and **915** are limited to between about 40 to 20,000 feet in length.

[0118] The lower portion **914** of the tubular member **902** is preferably coupled to the shoe **908** by a threaded connection **968**. The intermediate portion **912** of the tubular member **902** preferably is placed in intimate sliding contact with the mandrel **906**.

[0119] The tubular member **902** may be fabricated from any number of conventional commercially available materials such as, for example, oilfield tubulars, low alloy steels, titanium or stainless steels. In a preferred embodiment, the tubular member **902** is fabricated from oilfield tubulars in order to optimally provide approximately the same mechanical properties as the tubular member **915**. In a particularly preferred embodiment, the tubular member **902** has a plastic yield point ranging from about 40,000 to 135,000 psi in order to optimally provide approximately the same yield properties as the tubular member **915**.

[0120] The wall thickness of the upper, intermediate, and lower portions, **910**, **912** and **914** of the tubular member **902**

may range, for example, from about $\frac{1}{16}$ to 1.5 inches. In a preferred embodiment, the wall thickness of the upper, intermediate, and lower portions, **910**, **912** and **914** of the tubular member **902** range from about $\frac{1}{8}$ to 1.25 in order to optimally provide wall thickness that are about the same as the tubular member **915**. In a preferred embodiment, the wall thickness of the lower portion **914** is less than or equal to the wall thickness of the upper portion **910** in order to optimally provide a geometry that will fit into tight clearances downhole.

[0121] The outer diameter of the upper, intermediate, and lower portions, **910**, **912** and **914** of the tubular member **902** may range, for example, from about 1.05 to 48 inches. In a preferred embodiment, the outer diameter of the upper, intermediate, and lower portions, **910**, **912** and **914** of the tubular member **902** range from about $3\frac{1}{2}$ to 19 inches in order to optimally provide the ability to expand the most commonly used oilfield tubulars.

[0122] The length of the tubular member **902** is preferably limited to between about 2 to 5 feet in order to optimally provide enough length to contain the mandrel **906** and a body of lubricant.

[0123] The tubular member **902** may comprise any number of conventional commercially available tubular members modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the tubular member **902** comprises Oilfield Country Tubular Goods available from various U.S. steel mills. The tubular member **915** may comprise any number of conventional commercially available tubular members modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the tubular member **915** comprises Oilfield Country Tubular Goods available from various U.S. steel mills.

[0124] The various elements of the tubular member **902** may be coupled using any number of conventional process such as, for example, threaded connections, welding or machined from one piece. In a preferred embodiment, the various elements of the tubular member **902** are coupled using welding. The tubular member **902** may comprise a plurality of tubular elements that are coupled end to end. The various elements of the tubular member **915** may be coupled using any number of conventional process such as, for example, threaded connections, welding or machined from one piece. In a preferred embodiment, the various elements of the tubular member **915** are coupled using welding. The tubular member **915** may comprise a plurality of tubular elements that are coupled end to end. The tubular members **902** and **915** may be coupled using any number of conventional process such as, for example, threaded connections, welding or machined from one piece.

[0125] The support member **904** preferably includes an innerstring adapter **916**, a fluid passage **918**, an upper guide **920**, and a coupling **922**. During operation of the apparatus **900**, the support member **904** preferably supports the apparatus **900** during movement of the apparatus **900** within a wellbore. The support member **904** preferably has a substantially annular cross-section.

[0126] The support member **904** may be fabricated from any number of conventional commercially available materials such as, for example, oilfield tubulars, low alloy steel,

coiled tubing or stainless steel. In a preferred embodiment, the support member **904** is fabricated from low alloy steel in order to optimally provide high yield strength.

[0127] The innerstring adaptor **916** preferably is coupled to and supported by a conventional drill string support from a surface location. The innerstring adaptor **916** may be coupled to a conventional drill string support **971** by a threaded connection **970**.

[0128] The fluid passage **918** is preferably used to convey fluids and other materials to and from the apparatus **900**. In a preferred embodiment, the fluid passage **918** is fluidically coupled to the fluid passage **952**. In a preferred embodiment, the fluid passage **918** is used to convey hardenable fluidic sealing materials to and from the apparatus **900**. In a particularly preferred embodiment, the fluid passage **918** may include one or more pressure relief passages (not illustrated) to release fluid pressure during positioning of the apparatus **900** within a wellbore. In a preferred embodiment, the fluid passage **918** is positioned along a longitudinal centerline of the apparatus **900**. In a preferred embodiment, the fluid passage **918** is selected to permit the conveyance of hardenable fluidic materials at operating pressures ranging from about 0 to 9,000 psi.

[0129] The upper guide **920** is coupled to an upper portion of the support member **904**. The upper guide **920** preferably is adapted to center the support member **904** within the tubular member **915**. The upper guide **920** may comprise any number of conventional guide members modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the upper guide **920** comprises an innerstring adapter available from Halliburton Energy Services in Dallas, Tex. order to optimally guide the apparatus **900** within the tubular member **915**.

[0130] The coupling **922** couples the support member **904** to the mandrel **906**. The coupling **922** preferably comprises a conventional threaded connection.

[0131] The various elements of the support member **904** may be coupled using any number of conventional processes such as, for example, welding, threaded connections or machined from one piece. In a preferred embodiment, the various elements of the support member **904** are coupled using threaded connections.

[0132] The mandrel **906** preferably includes a retainer **924**, a rubber cup **926**, an expansion cone **928**, a lower cone retainer **930**, a body of cement **932**, a lower guide **934**, an extension sleeve **936**, a spacer **938**, a housing **940**, a sealing sleeve **942**, an upper cone retainer **944**, a lubricator mandrel **946**, a lubricator sleeve **948**, a guide **950**, and a fluid passage **952**.

[0133] The retainer **924** is coupled to the lubricator mandrel **946**, lubricator sleeve **948**, and the rubber cup **926**. The retainer **924** couples the rubber cup **926** to the lubricator sleeve **948**. The retainer **924** preferably has a substantially annular cross-section. The retainer **924** may comprise any number of conventional commercially available retainers such as, for example, slotted spring pins or roll pin.

[0134] The rubber cup **926** is coupled to the retainer **924**, the lubricator mandrel **946**, and the lubricator sleeve **948**. The rubber cup **926** prevents the entry of foreign materials into the interior region **972** of the tubular member **902** below

the rubber cup **926**. The rubber cup **926** may comprise any number of conventional commercially available rubber cups such as, for example, TP cups or Selective Injection Packer (SIP) cup. In a preferred embodiment, the rubber cup **926** comprises a SIP cup available from Halliburton Energy Services in Dallas, Tex. in order to optimally block foreign materials.

[0135] In a particularly preferred embodiment, a body of lubricant is further provided in the interior region **972** of the tubular member **902** in order to lubricate the interface between the exterior surface of the mandrel **902** and the interior surface of the tubular members **902** and **915**. The lubricant may comprise any number of conventional commercially available lubricants such as, for example, Lubriplate, chlorine based lubricants, oil based lubricants or Climax 1500 Antiseize (3100). In a preferred embodiment, the lubricant comprises Climax 1500 Antiseize (3100) available from Climax Lubricants and Equipment Co. in Houston, Tex. in order to optimally provide lubrication to facilitate the extrusion process.

[0136] The expansion cone **928** is coupled to the lower cone retainer **930**, the body of cement **932**, the lower guide **934**, the extension sleeve **936**, the housing **940**, and the upper cone retainer **944**. In a preferred embodiment, during operation of the apparatus **900**, the tubular members **902** and **915** are extruded off of the outer surface of the expansion cone **928**. In a preferred embodiment, axial movement of the expansion cone **928** is prevented by the lower cone retainer **930**, housing **940** and the upper cone retainer **944**. Inner radial movement of the expansion cone **928** is prevented by the body of cement **932**, the housing **940**, and the upper cone retainer **944**.

[0137] The expansion cone **928** preferably has a substantially annular cross section. The outside diameter of the expansion cone **928** is preferably tapered to provide a cone shape. The wall thickness of the expansion cone **928** may range, for example, from about 0.125 to 3 inches. In a preferred embodiment, the wall thickness of the expansion cone **928** ranges from about 0.25 to 0.75 inches in order to optimally provide adequate compressive strength with minimal material. The maximum and minimum outside diameters of the expansion cone **928** may range, for example, from about 1 to 47 inches. In a preferred embodiment, the maximum and minimum outside diameters of the expansion cone **928** range from about 3.5 to 19 in order to optimally provide expansion of generally available oilfield tubulars

[0138] The expansion cone **928** may be fabricated from any number of conventional commercially available materials such as, for example, ceramic, tool steel, titanium or low alloy steel. In a preferred embodiment, the expansion cone **928** is fabricated from tool steel in order to optimally provide high strength and abrasion resistance. The surface hardness of the outer surface of the expansion cone **928** may range, for example, from about 50 Rockwell C to 70 Rockwell C. In a preferred embodiment, the surface hardness of the outer surface of the expansion cone **928** ranges from about 58 Rockwell C to 62 Rockwell C in order to optimally provide high yield strength. In a preferred embodiment, the expansion cone **928** is heat treated to optimally provide a hard outer surface and a resilient interior body in order to optimally provide abrasion resistance and fracture toughness.

[0139] The lower cone retainer 930 is coupled to the expansion cone 928 and the housing 940. In a preferred embodiment, axial movement of the expansion cone 928 is prevented by the lower cone retainer 930. Preferably, the lower cone retainer 930 has a substantially annular cross-section.

[0140] The lower cone retainer 930 may be fabricated from any number of conventional commercially available materials such as, for example, ceramic, tool steel, titanium or low alloy steel. In a preferred embodiment, the lower cone retainer 930 is fabricated from tool steel in order to optimally provide high strength and abrasion resistance. The surface hardness of the outer surface of the lower cone retainer 930 may range, for example, from about 50 Rockwell C to 70 Rockwell C. In a preferred embodiment, the surface hardness of the outer surface of the lower cone retainer 930 ranges from about 58 Rockwell C to 62 Rockwell C in order to optimally provide high yield strength. In a preferred embodiment, the lower cone retainer 930 is heat treated to optimally provide a hard outer surface and a resilient interior body in order to optimally provide abrasion resistance and fracture toughness.

[0141] In a preferred embodiment, the lower cone retainer 930 and the expansion cone 928 are formed as an integral one-piece element in order to reduce the number of components and increase the overall strength of the apparatus. The outer surface of the lower cone retainer 930 preferably mates with the inner surfaces of the tubular members 902 and 915.

[0142] The body of cement 932 is positioned within the interior of the mandrel 906. The body of cement 932 provides an inner bearing structure for the mandrel 906. The body of cement 932 further may be easily drilled out using a conventional drill device. In this manner, the mandrel 906 may be easily removed using a conventional drilling device.

[0143] The body of cement 932 may comprise any number of conventional commercially available cement compounds. Alternatively, aluminum, cast iron or some other drillable metallic, composite, or aggregate material may be substituted for cement. The body of cement 932 preferably has a substantially annular cross-section.

[0144] The lower guide 934 is coupled to the extension sleeve 936 and housing 940. During operation of the apparatus 900, the lower guide 934 preferably helps guide the movement of the mandrel 906 within the tubular member 902. The lower guide 934 preferably has a substantially annular cross-section.

[0145] The lower guide 934 may be fabricated from any number of conventional commercially available materials such as, for example, oilfield tubulars, low alloy steel or stainless steel. In a preferred embodiment, the lower guide 934 is fabricated from low alloy steel in order to optimally provide high yield strength. The outer surface of the lower guide 934 preferably mates with the inner surface of the tubular member 902 to provide a sliding fit.

[0146] The extension sleeve 936 is coupled to the lower guide 934 and the housing 940. During operation of the apparatus 900, the extension sleeve 936 preferably helps guide the movement of the mandrel 906 within the tubular member 902. The extension sleeve 936 preferably has a substantially annular cross-section.

[0147] The extension sleeve 936 may be fabricated from any number of conventional commercially available materials such as, for example, oilfield tubulars, low alloy steel or stainless steel. In a preferred embodiment, the extension sleeve 936 is fabricated from low alloy steel in order to optimally provide high yield strength. The outer surface of the extension sleeve 936 preferably mates with the inner surface of the tubular member 902 to provide a sliding fit. In a preferred embodiment, the extension sleeve 936 and the lower guide 934 are formed as an integral one-piece element in order to minimize the number of components and increase the strength of the apparatus.

[0148] The spacer 938 is coupled to the sealing sleeve 942. The spacer 938 preferably includes the fluid passage 952 and is adapted to mate with the extension tube 960 of the shoe 908. In this manner, a plug or dart can be conveyed from the surface through the fluid passages 918 and 952 into the fluid passage 962. Preferably, the spacer 938 has a substantially annular cross-section.

[0149] The spacer 938 may be fabricated from any number of conventional commercially available materials such as, for example, steel, aluminum or cast iron. In a preferred embodiment, the spacer 938 is fabricated from aluminum in order to optimally provide drillability. The end of the spacer 938 preferably mates with the end of the extension tube 960. In a preferred embodiment, the spacer 938 and the sealing sleeve 942 are formed as an integral one-piece element in order to reduce the number of components and increase the strength of the apparatus.

[0150] The housing 940 is coupled to the lower guide 934, extension sleeve 936, expansion cone 928, body of cement 932, and lower cone retainer 930. During operation of the apparatus 900, the housing 940 preferably prevents inner radial motion of the expansion cone 928. Preferably, the housing 940 has a substantially annular cross-section.

[0151] The housing 940 may be fabricated from any number of conventional commercially available materials such as, for example, oilfield tubulars, low alloy steel or stainless steel. In a preferred embodiment, the housing 940 is fabricated from low alloy steel in order to optimally provide high yield strength. In a preferred embodiment, the lower guide 934, extension sleeve 936 and housing 940 are formed as an integral one-piece element in order to minimize the number of components and increase the strength of the apparatus.

[0152] In a particularly preferred embodiment, the interior surface of the housing 940 includes one or more protrusions to facilitate the connection between the housing 940 and the body of cement 932.

[0153] The sealing sleeve 942 is coupled to the support member 904, the body of cement 932, the spacer 938, and the upper cone retainer 944. During operation of the apparatus, the sealing sleeve 942 preferably provides support for the mandrel 906. The sealing sleeve 942 is preferably coupled to the support member 904 using the coupling 922. Preferably, the sealing sleeve 942 has a substantially annular cross-section.

[0154] The sealing sleeve 942 may be fabricated from any number of conventional commercially available materials such as, for example, steel, aluminum or cast iron. In a

preferred embodiment, the sealing sleeve 942 is fabricated from aluminum in order to optimally provide drillability of the sealing sleeve 942.

[0155] In a particularly preferred embodiment, the outer surface of the sealing sleeve 942 includes one or more protrusions to facilitate the connection between the sealing sleeve 942 and the body of cement 932.

[0156] In a particularly preferred embodiment, the spacer 938 and the sealing sleeve 942 are integrally formed as a one-piece element in order to minimize the number of components.

[0157] The upper cone retainer 944 is coupled to the expansion cone 928, the sealing sleeve 942, and the body of cement 932. During operation of the apparatus 900, the upper cone retainer 944 preferably prevents axial motion of the expansion cone 928. Preferably, the upper cone retainer 944 has a substantially annular cross-section.

[0158] The upper cone retainer 944 may be fabricated from any number of conventional commercially available materials such as, for example, steel, aluminum or cast iron. In a preferred embodiment, the upper cone retainer 944 is fabricated from aluminum in order to optimally provide drillability of the upper cone retainer 944.

[0159] In a particularly preferred embodiment, the upper cone retainer 944 has a cross-sectional shape designed to provide increased rigidity. In a particularly preferred embodiment, the upper cone retainer 944 has a cross-sectional shape that is substantially I-shaped to provide increased rigidity and minimize the amount of material that would have to be drilled out.

[0160] The lubricator mandrel 946 is coupled to the retainer 924, the rubber cup 926, the upper cone retainer 944, the lubricator sleeve 948, and the guide 950. During operation of the apparatus 900, the lubricator mandrel 946 preferably contains the body of lubricant in the annular region 972 for lubricating the interface between the mandrel 906 and the tubular member 902. Preferably, the lubricator mandrel 946 has a substantially annular cross-section.

[0161] The lubricator mandrel 946 may be fabricated from any number of conventional commercially available materials such as, for example, steel, aluminum or cast iron. In a preferred embodiment, the lubricator mandrel 946 is fabricated from aluminum in order to optimally provide drillability of the lubricator mandrel 946.

[0162] The lubricator sleeve 948 is coupled to the lubricator mandrel 946, the retainer 924, the rubber cup 926, the upper cone retainer 944, the lubricator sleeve 948, and the guide 950. During operation of the apparatus 900, the lubricator sleeve 948 preferably supports the rubber cup 926. Preferably, the lubricator sleeve 948 has a substantially annular cross-section.

[0163] The lubricator sleeve 948 may be fabricated from any number of conventional commercially available materials such as, for example, steel, aluminum or cast iron. In a preferred embodiment, the lubricator sleeve 948 is fabricated from aluminum in order to optimally provide drillability of the lubricator sleeve 948.

[0164] As illustrated in FIG. 9c, the lubricator sleeve 948 is supported by the lubricator mandrel 946. The lubricator

sleeve 948 in turn supports the rubber cup 926. The retainer 924 couples the rubber cup 926 to the lubricator sleeve 948. In a preferred embodiment, seals 949a and 949b are provided between the lubricator mandrel 946, lubricator sleeve 948, and rubber cup 926 in order to optimally seal off the interior region 972 of the tubular member 902.

[0165] The guide 950 is coupled to the lubricator mandrel 946, the retainer 924, and the lubricator sleeve 948. During operation of the apparatus 900, the guide 950 preferably guides the apparatus on the support member 904. Preferably, the guide 950 has a substantially annular cross-section. The guide 950 may be fabricated from any number of conventional commercially available materials such as, for example, steel, aluminum or cast iron. In a preferred embodiment, the guide 950 is fabricated from aluminum in order to optimally provide drillability of the guide 950.

[0166] The fluid passage 952 is coupled to the mandrel 906. During operation of the apparatus, the fluid passage 952 preferably conveys hardenable fluidic materials. In a preferred embodiment, the fluid passage 952 is positioned about the centerline of the apparatus 900. In a particularly preferred embodiment, the fluid passage 952 is adapted to convey hardenable fluidic materials at pressures and flow rate ranging from about 0 to 9,000 psi and 0 to 3,000 gallons/min in order to optimally provide pressures and flow rates to displace and circulate fluids during the installation of the apparatus 900.

[0167] The various elements of the mandrel 906 may be coupled using any number of conventional process such as, for example, threaded connections, welded connections or cementing. In a preferred embodiment, the various elements of the mandrel 906 are coupled using threaded connections and cementing.

[0168] The shoe 908 preferably includes a housing 954, a body of cement 956, a sealing sleeve 958, an extension tube 960, a fluid passage 962, and one or more outlet jets 964.

[0169] The housing 954 is coupled to the body of cement 956 and the lower portion 914 of the tubular member 902. During operation of the apparatus 900, the housing 954 preferably couples the lower portion of the tubular member 902 to the shoe 908 to facilitate the extrusion and positioning of the tubular member 902. Preferably, the housing 954 has a substantially annular cross-section.

[0170] The housing 954 may be fabricated from any number of conventional commercially available materials such as, for example, steel or aluminum. In a preferred embodiment, the housing 954 is fabricated from aluminum in order to optimally provide drillability of the housing 954.

[0171] In a particularly preferred embodiment, the interior surface of the housing 954 includes one or more protrusions to facilitate the connection between the body of cement 956 and the housing 954.

[0172] The body of cement 956 is coupled to the housing 954, and the sealing sleeve 958. In a preferred embodiment, the composition of the body of cement 956 is selected to permit the body of cement to be easily drilled out using conventional drilling machines and processes.

[0173] The composition of the body of cement 956 may include any number of conventional cement compositions.

In an alternative embodiment, a drillable material such as, for example, aluminum or iron may be substituted for the body of cement **956**.

[0174] The sealing sleeve **958** is coupled to the body of cement **956**, the extension tube **960**, the fluid passage **962**, and one or more outlet jets **964**. During operation of the apparatus **900**, the sealing sleeve **958** preferably is adapted to convey a hardenable fluidic material from the fluid passage **952** into the fluid passage **962** and then into the outlet jets **964** in order to inject the hardenable fluidic material into an annular region external to the tubular member **902**. In a preferred embodiment, during operation of the apparatus **900**, the sealing sleeve **958** further includes an inlet geometry that permits a conventional plug or dart **974** to become lodged in the inlet of the sealing sleeve **958**. In this manner, the fluid passage **962** may be blocked thereby fluidically isolating the interior region **966** of the tubular member **902**.

[0175] In a preferred embodiment, the sealing sleeve **958** has a substantially annular cross-section. The sealing sleeve **958** may be fabricated from any number of conventional commercially available materials such as, for example, steel, aluminum or cast iron. In a preferred embodiment, the sealing sleeve **958** is fabricated from aluminum in order to optimally provide drillability of the sealing sleeve **958**.

[0176] The extension tube **960** is coupled to the sealing sleeve **958**, the fluid passage **962**, and one or more outlet jets **964**. During operation of the apparatus **900**, the extension tube **960** preferably is adapted to convey a hardenable fluidic material from the fluid passage **952** into the fluid passage **962** and then into the outlet jets **964** in order to inject the hardenable fluidic material into an annular region external to the tubular member **902**. In a preferred embodiment, during operation of the apparatus **900**, the sealing sleeve **960** further includes an inlet geometry that permits a conventional plug or dart **974** to become lodged in the inlet of the sealing sleeve **958**. In this manner, the fluid passage **962** is blocked thereby fluidically isolating the interior region **966** of the tubular member **902**. In a preferred embodiment, one end of the extension tube **960** mates with one end of the spacer **938** in order to optimally facilitate the transfer of material between the two.

[0177] In a preferred embodiment, the extension tube **960** has a substantially annular cross-section. The extension tube **960** may be fabricated from any number of conventional commercially available materials such as, for example, steel, aluminum or cast iron. In a preferred embodiment, the extension tube **960** is fabricated from aluminum in order to optimally provide drillability of the extension tube **960**.

[0178] The fluid passage **962** is coupled to the sealing sleeve **958**, the extension tube **960**, and one or more outlet jets **964**. During operation of the apparatus **900**, the fluid passage **962** is preferably conveys hardenable fluidic materials. In a preferred embodiment, the fluid passage **962** is positioned about the centerline of the apparatus **900**. In a particularly preferred embodiment, the fluid passage **962** is adapted to convey hardenable fluidic materials at pressures and flow rate ranging from about 0 to 9,000 psi and 0 to 3,000 gallons/min in order to optimally provide fluids at operationally efficient rates.

[0179] The outlet jets **964** are coupled to the sealing sleeve **958**, the extension tube **960**, and the fluid passage **962**.

During operation of the apparatus **900**, the outlet jets **964** preferably convey hardenable fluidic material from the fluid passage **962** to the region exterior of the apparatus **900**. In a preferred embodiment, the shoe **908** includes a plurality of outlet jets **964**.

[0180] In a preferred embodiment, the outlet jets **964** comprise passages drilled in the housing **954** and the body of cement **956** in order to simplify the construction of the apparatus **900**.

[0181] The various elements of the shoe **908** may be coupled using any number of conventional process such as, for example, threaded connections, cement or machined from one piece of material. In a preferred embodiment, the various elements of the shoe **908** are coupled using cement.

[0182] In a preferred embodiment, the assembly **900** is operated substantially as described above with reference to FIGS. 1-8 to create a new section of casing in a wellbore or to repair a wellbore casing or pipeline.

[0183] In particular, in order to extend a wellbore into a subterranean formation, a drill string is used in a well known manner to drill out material from the subterranean formation to form a new section.

[0184] The apparatus **900** for forming a wellbore casing in a subterranean formation is then positioned in the new section of the wellbore. In a particularly preferred embodiment, the apparatus **900** includes the tubular member **915**. In a preferred embodiment, a hardenable fluidic sealing hardenable fluidic sealing material is then pumped from a surface location into the fluid passage **918**. The hardenable fluidic sealing material then passes from the fluid passage **918** into the interior region **966** of the tubular member **902** below the mandrel **906**. The hardenable fluidic sealing material then passes from the interior region **966** into the fluid passage **962**. The hardenable fluidic sealing material then exits the apparatus **900** via the outlet jets **964** and fills an annular region between the exterior of the tubular member **902** and the interior wall of the new section of the wellbore. Continued pumping of the hardenable fluidic sealing material causes the material to fill up at least a portion of the annular region.

[0185] The hardenable fluidic sealing material is preferably pumped into the annular region at pressures and flow rates ranging, for example, from about 0 to 5,000 psi and 0 to 1,500 gallons/min, respectively. In a preferred embodiment, the hardenable fluidic sealing material is pumped into the annular region at pressures and flow rates that are designed for the specific wellbore section in order to optimize the displacement of the hardenable fluidic sealing material while not creating high enough circulating pressures such that circulation might be lost and that could cause the wellbore to collapse. The optimum pressures and flow rates are preferably determined using conventional empirical methods.

[0186] The hardenable fluidic sealing material may comprise any number of conventional commercially available hardenable fluidic sealing materials such as, for example, slag mix, cement or epoxy. In a preferred embodiment, the hardenable fluidic sealing material comprises blended cements designed specifically for the well section being lined available from Halliburton Energy Services in Dallas, Tex. in order to optimally provide support for the new

tubular member while also maintaining optimal flow characteristics so as to minimize operational difficulties during the displacement of the cement in the annular region. The optimum composition of the blended cements is preferably determined using conventional empirical methods.

[0187] The annular region preferably is filled with the hardenable fluidic sealing material in sufficient quantities to ensure that, upon radial expansion of the tubular member 902, the annular region of the new section of the wellbore will be filled with hardenable material.

[0188] Once the annular region has been adequately filled with hardenable fluidic sealing material, a plug or dart 974, or other similar device, preferably is introduced into the fluid passage 962 thereby fluidically isolating the interior region 966 of the tubular member 902 from the external annular region. In a preferred embodiment, a non hardenable fluidic material is then pumped into the interior region 966 causing the interior region 966 to pressurize. In a particularly preferred embodiment, the plug or dart 974, or other similar device, preferably is introduced into the fluid passage 962 by introducing the plug or dart 974, or other similar device into the non hardenable fluidic material. In this manner, the amount of cured material within the interior of the tubular members 902 and 915 is minimized.

[0189] Once the interior region 966 becomes sufficiently pressurized, the tubular members 902 and 915 are extruded off of the mandrel 906. The mandrel 906 may be fixed or it may be expandable. During the extrusion process, the mandrel 906 is raised out of the expanded portions of the tubular members 902 and 915 using the support member 904. During this extrusion process, the shoe 908 is preferably substantially stationary.

[0190] The plug or dart 974 is preferably placed into the fluid passage 962 by introducing the plug or dart 974 into the fluid passage 918 at a surface location in a conventional manner. The plug or dart 974 may comprise any number of conventional commercially available devices for plugging a fluid passage such as, for example, Multiple Stage Cementer (MSC) latch-down plug, Omega latch-down plug or three-wiper latch down plug modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the plug or dart 974 comprises a MSC latch-down plug available from Halliburton Energy Services in Dallas, Tex.

[0191] After placement of the plug or dart 974 in the fluid passage 962, the non hardenable fluidic material is preferably pumped into the interior region 966 at pressures and flow rates ranging from approximately 500 to 9,000 psi and 40 to 3,000 gallons/min in order to optimally extrude the tubular members 902 and 915 off of the mandrel 906.

[0192] For typical tubular members 902 and 915, the extrusion of the tubular members 902 and 915 off of the expandable mandrel will begin when the pressure of the interior region 966 reaches approximately 500 to 9,000 psi. In a preferred embodiment, the extrusion of the tubular members 902 and 915 off of the mandrel 906 begins when the pressure of the interior region 966 reaches approximately 1,200 to 8,500 psi with a flow rate of about 40 to 1250 gallons/minute.

[0193] During the extrusion process, the mandrel 906 may be raised out of the expanded portions of the tubular

members 902 and 915 at rates ranging, for example, from about 0 to 5 ft/sec. In a preferred embodiment, during the extrusion process, the mandrel 906 is raised out of the expanded portions of the tubular members 902 and 915 at rates ranging from about 0 to 2 ft/sec in order to optimally provide pulling speed fast enough to permit efficient operation and permit full expansion of the tubular members 902 and 915 prior to curing of the hardenable fluidic sealing material; but not so fast that timely adjustment of operating parameters during operation is prevented.

[0194] When the upper end portion of the tubular member 915 is extruded off of the mandrel 906, the outer surface of the upper end portion of the tubular member 915 will preferably contact the interior surface of the lower end portion of the existing casing to form a fluid tight overlapping joint. The contact pressure of the overlapping joint may range, for example, from approximately 50 to 20,000 psi. In a preferred embodiment, the contact pressure of the overlapping joint between the upper end of the tubular member 915 and the existing section of wellbore casing ranges from approximately 400 to 10,000 psi in order to optimally provide contact pressure to activate the sealing members and provide optimal resistance such that the tubular member 915 and existing wellbore casing will carry typical tensile and compressive loads.

[0195] In a preferred embodiment, the operating pressure and flow rate of the non hardenable fluidic material will be controllably ramped down when the mandrel 906 reaches the upper end portion of the tubular member 915. In this manner, the sudden release of pressure caused by the complete extrusion of the tubular member 915 off of the expandable mandrel 906 can be minimized. In a preferred embodiment, the operating pressure is reduced in a substantially linear fashion from 100% to about 10% during the end of the extrusion process beginning when the mandrel 906 has completed approximately all but about the last 5 feet of the extrusion process.

[0196] In an alternative preferred embodiment, the operating pressure and/or flow rate of the hardenable fluidic sealing material and/or the non hardenable fluidic material are controlled during all phases of the operation of the apparatus 900 to minimize shock.

[0197] Alternatively, or in combination, a shock absorber is provided in the support member 904 in order to absorb the shock caused by the sudden release of pressure.

[0198] Alternatively, or in combination, a mandrel catching structure is provided above the support member 904 in order to catch or at least decelerate the mandrel 906.

[0199] Once the extrusion process is completed, the mandrel 906 is removed from the wellbore. In a preferred embodiment, either before or after the removal of the mandrel 906, the integrity of the fluidic seal of the overlapping joint between the upper portion of the tubular member 915 and the lower portion of the existing casing is tested using conventional methods. If the fluidic seal of the overlapping joint between the upper portion of the tubular member 915 and the lower portion of the existing casing is satisfactory, then the uncured portion of any of the hardenable fluidic sealing material within the expanded tubular member 915 is then removed in a conventional manner. The hardenable fluidic sealing material within the annular region

between the expanded tubular member **915** and the existing casing and new section of wellbore is then allowed to cure.

[0200] Preferably any remaining cured hardenable fluidic sealing material within the interior of the expanded tubular members **902** and **915** is then removed in a conventional manner using a conventional drill string. The resulting new section of casing preferably includes the expanded tubular members **902** and **915** and an outer annular layer of cured hardenable fluidic sealing material. The bottom portion of the apparatus **900** comprising the shoe **908** may then be removed by drilling out the shoe **908** using conventional drilling methods.

[0201] In an alternative embodiment, during the extrusion process, it may be necessary to remove the entire apparatus **900** from the interior of the wellbore due to a malfunction. In this circumstance, a conventional drill string is used to drill out the interior sections of the apparatus **900** in order to facilitate the removal of the remaining sections. In a preferred embodiment, the interior elements of the apparatus **900** are fabricated from materials such as, for example, cement and aluminum, that permit a conventional drill string to be employed to drill out the interior components.

[0202] In particular, in a preferred embodiment, the composition of the interior sections of the mandrel **906** and shoe **908**, including one or more of the body of cement **932**, the spacer **938**, the sealing sleeve **942**, the upper cone retainer **944**, the lubricator mandrel **946**, the lubricator sleeve **948**, the guide **950**, the housing **954**, the body of cement **956**, the sealing sleeve **958**, and the extension tube **960**, are selected to permit at least some of these components to be drilled out using conventional drilling methods and apparatus. In this manner, in the event of a malfunction downhole, the apparatus **900** may be easily removed from the wellbore.

[0203] Referring now to FIGS. **10a**, **10b**, **10c**, **10d**, **10e**, **10f**, and **10g** a method and apparatus for creating a tie-back liner in a wellbore will now be described. As illustrated in FIG. **10a**, a wellbore **1000** positioned in a subterranean formation **1002** includes a first casing **1004** and a second casing **1006**.

[0204] The first casing **1004** preferably includes a tubular liner **1008** and a cement annulus **1010**. The second casing **1006** preferably includes a tubular liner **1012** and a cement annulus **1014**. In a preferred embodiment, the second casing **1006** is formed by expanding a tubular member substantially as described above with reference to FIGS. **1-9c** or below with reference to FIGS. **11a-11f**.

[0205] In a particularly preferred embodiment, an upper portion of the tubular liner **1012** overlaps with a lower portion of the tubular liner **1008**. In a particularly preferred embodiment, an outer surface of the upper portion of the tubular liner **1012** includes one or more sealing members **1016** for providing a fluidic seal between the tubular liners **1008** and **1012**.

[0206] Referring to FIG. **10b**, in order to create a tie-back liner that extends from the overlap between the first and second casings, **1004** and **1006**, an apparatus **1100** is preferably provided that includes an expandable mandrel or pig **1105**, a tubular member **1110**, a shoe **1115**, one or more cup seals **1120**, a fluid passage **1130**, a fluid passage **1135**, one or more fluid passages **1140**, seals **1145**, and a support member **1150**.

[0207] The expandable mandrel or pig **1105** is coupled to and supported by the support member **1150**. The expandable mandrel **1105** is preferably adapted to controllably expand in a radial direction. The expandable mandrel **1105** may comprise any number of conventional commercially available expandable mandrels modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the expandable mandrel **1105** comprises a hydraulic expansion tool substantially as disclosed in U.S. Pat. No. 5,348,095, the disclosure of which is incorporated herein by reference, modified in accordance with the teachings of the present disclosure.

[0208] The tubular member **1110** is coupled to and supported by the expandable mandrel **1105**. The tubular member **1105** is expanded in the radial direction and extruded off of the expandable mandrel **1105**. The tubular member **1110** may be fabricated from any number of materials such as, for example, Oilfield Country Tubular Goods, 13 chromium tubing or plastic piping. In a preferred embodiment, the tubular member **1110** is fabricated from Oilfield Country Tubular Goods.

[0209] The inner and outer diameters of the tubular member **1110** may range, for example, from approximately 0.75 to 47 inches and 1.05 to 48 inches, respectively. In a preferred embodiment, the inner and outer diameters of the tubular member **1110** range from about 3 to 15.5 inches and 3.5 to 16 inches, respectively in order to optimally provide coverage for typical oilfield casing sizes. The tubular member **1110** preferably comprises a solid member.

[0210] In a preferred embodiment, the upper end portion of the tubular member **1110** is slotted, perforated, or otherwise modified to catch or slow down the mandrel **1105** when it completes the extrusion of tubular member **1110**. In a preferred embodiment, the length of the tubular member **1110** is limited to minimize the possibility of buckling. For typical tubular member **1110** materials, the length of the tubular member **1110** is preferably limited to between about 40 to 20,000 feet in length.

[0211] The shoe **1115** is coupled to the expandable mandrel **1105** and the tubular member **1110**. The shoe **1115** includes the fluid passage **1135**. The shoe **1115** may comprise any number of conventional commercially available shoes such as, for example, Super Seal II float shoe, Super Seal II Down-Jet float shoe or a guide shoe with a sealing sleeve for a latch down plug modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the shoe **1115** comprises an aluminum down-jet guide shoe with a sealing sleeve for a latch-down plug with side ports radiating off of the exit flow port available from Halliburton Energy Services in Dallas, Tex., modified in accordance with the teachings of the present disclosure, in order to optimally guide the tubular member **1100** to the overlap between the tubular member **1100** and the casing **1012**, optimally fluidically isolate the interior of the tubular member **1100** after the latch down plug has seated, and optimally permit drilling out of the shoe **1115** after completion of the expansion and cementing operations.

[0212] In a preferred embodiment, the shoe **1115** includes one or more side outlet ports **1140** in fluidic communication with the fluid passage **1135**. In this manner, the shoe **1115** injects hardenable fluidic sealing material into the region outside the shoe **1115** and tubular member **1110**. In a

preferred embodiment, the shoe **1115** includes one or more of the fluid passages **1140** each having an inlet geometry that can receive a dart and/or a ball sealing member. In this manner, the fluid passages **1140** can be sealed off by introducing a plug, dart and/or ball sealing elements into the fluid passage **1130**.

[0213] The cup seal **1120** is coupled to and supported by the support member **1150**. The cup seal **1120** prevents foreign materials from entering the interior region of the tubular member **1110** adjacent to the expandable mandrel **1105**. The cup seal **1120** may comprise any number of conventional commercially available cup seals such as, for example, TP cups or Selective Injection Packer (SIP) cups modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the cup seal **1120** comprises a SIP cup, available from Halliburton Energy Services in Dallas, Tex. in order to optimally provide a barrier to debris and contain a body of lubricant.

[0214] The fluid passage **1130** permits fluidic materials to be transported to and from the interior region of the tubular member **1110** below the expandable mandrel **1105**. The fluid passage **1130** is coupled to and positioned within the support member **1150** and the expandable mandrel **1105**. The fluid passage **1130** preferably extends from a position adjacent to the surface to the bottom of the expandable mandrel **1105**. The fluid passage **1130** is preferably positioned along a centerline of the apparatus **1100**. The fluid passage **1130** is preferably selected to transport materials such as cement, drilling mud or epoxies at flow rates and pressures ranging from about 0 to 3,000 gallons/minute and 0 to 9,000 psi in order to optimally provide sufficient operating pressures to circulate fluids at operationally efficient rates.

[0215] The fluid passage **1135** permits fluidic materials to be transmitted from fluid passage **1130** to the interior of the tubular member **1110** below the mandrel **1105**.

[0216] The fluid passages **1140** permits fluidic materials to be transported to and from the region exterior to the tubular member **1110** and shoe **1115**. The fluid passages **1140** are coupled to and positioned within the shoe **1115** in fluidic communication with the interior region of the tubular member **1110** below the expandable mandrel **1105**. The fluid passages **1140** preferably have a cross-sectional shape that permits a plug, or other similar device, to be placed in the fluid passages **1140** to thereby block further passage of fluidic materials. In this manner, the interior region of the tubular member **1110** below the expandable mandrel **1105** can be fluidically isolated from the region exterior to the tubular member **1105**. This permits the interior region of the tubular member **1110** below the expandable mandrel **1105** to be pressurized.

[0217] The fluid passages **1140** are preferably positioned along the periphery of the shoe **1115**. The fluid passages **1140** are preferably selected to convey materials such as cement, drilling mud or epoxies at flow rates and pressures ranging from about 0 to 3,000 gallons/minute and 0 to 9,000 psi in order to optimally fill the annular region between the tubular member **1110** and the tubular liner **1008** with fluidic materials. In a preferred embodiment, the fluid passages **1140** include an inlet geometry that can receive a dart and/or a ball sealing member. In this manner, the fluid passages **1140** can be sealed off by introducing a plug, dart and/or ball

sealing elements into the fluid passage **1130**. In a preferred embodiment, the apparatus **1100** includes a plurality of fluid passage **1140**.

[0218] In an alternative embodiment, the base of the shoe **1115** includes a single inlet passage coupled to the fluid passages **1140** that is adapted to receive a plug, or other similar device, to permit the interior region of the tubular member **1110** to be fluidically isolated from the exterior of the tubular member **1110**.

[0219] The seals **1145** are coupled to and supported by a lower end portion of the tubular member **1110**. The seals **1145** are further positioned on an outer surface of the lower end portion of the tubular member **1110**. The seals **1145** permit the overlapping joint between the upper end portion of the casing **1012** and the lower end portion of the tubular member **1110** to be fluidically sealed.

[0220] The seals **1145** may comprise any number of conventional commercially available seals such as, for example, lead, rubber, Teflon or epoxy seals modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the seals **1145** comprise seals molded from Stratalock epoxy available from Halliburton Energy Services in Dallas, Tex. in order to optimally provide a hydraulic seal in the overlapping joint and optimally provide load carrying capacity to withstand the range of typical tensile and compressive loads.

[0221] In a preferred embodiment, the seals **1145** are selected to optimally provide a sufficient frictional force to support the expanded tubular member **1110** from the tubular liner **1008**. In a preferred embodiment, the frictional force provided by the seals **1145** ranges from about 1,000 to 1,000,000 lbf in tension and compression in order to optimally support the expanded tubular member **1110**.

[0222] The support member **1150** is coupled to the expandable mandrel **1105**, tubular member **1110**, shoe **1115**, and seal **1120**. The support member **1150** preferably comprises an annular member having sufficient strength to carry the apparatus **1100** into the wellbore **1000**. In a preferred embodiment, the support member **1150** further includes one or more conventional centralizers (not illustrated) to help stabilize the tubular member **1110**.

[0223] In a preferred embodiment, a quantity of lubricant **1150** is provided in the annular region above the expandable mandrel **1105** within the interior of the tubular member **1110**. In this manner, the extrusion of the tubular member **1110** off of the expandable mandrel **1105** is facilitated. The lubricant **1150** may comprise any number of conventional commercially available lubricants such as, for example, Lubriplate, chlorine based lubricants or Climax 1500 Anti-seize (3100). In a preferred embodiment, the lubricant **1150** comprises Climax 1500 Antiseize (3100) available from Climax Lubricants and Equipment Co. in Houston, Tex. in order to optimally provide lubrication for the extrusion process.

[0224] In a preferred embodiment, the support member **1150** is thoroughly cleaned prior to assembly to the remaining portions of the apparatus **1100**. In this manner, the introduction of foreign material into the apparatus **1100** is minimized. This minimizes the possibility of foreign material clogging the various flow passages and valves of the

apparatus **1100** and to ensure that no foreign material interferes with the expansion mandrel **1105** during the extrusion process.

[0225] In a particularly preferred embodiment, the apparatus **1100** includes a packer **1155** coupled to the bottom section of the shoe **1115** for fluidically isolating the region of the wellbore **1000** below the apparatus **1100**. In this manner, fluidic materials are prevented from entering the region of the wellbore **1000** below the apparatus **1100**. The packer **1155** may comprise any number of conventional commercially available packers such as, for example, EZ Drill Packer, EZ SV Packer or a drillable cement retainer. In a preferred embodiment, the packer **1155** comprises an EZ Drill Packer available from Halliburton Energy Services in Dallas, Tex. In an alternative embodiment, a high gel strength pill may be set below the tie-back in place of the packer **1155**. In another alternative embodiment, the packer **1155** may be omitted.

[0226] In a preferred embodiment, before or after positioning the apparatus **1100** within the wellbore **1100**, a couple of wellbore volumes are circulated in order to ensure that no foreign materials are located within the wellbore **1000** that might clog up the various flow passages and valves of the apparatus **1100** and to ensure that no foreign material interferes with the operation of the expansion mandrel **1105**.

[0227] As illustrated in FIG. 10c, a hardenable fluidic sealing material **1160** is then pumped from a surface location into the fluid passage **1130**. The material **1160** then passes from the fluid passage **1130** into the interior region of the tubular member **1110** below the expandable mandrel **1105**. The material **1160** then passes from the interior region of the tubular member **1110** into the fluid passages **1140**. The material **1160** then exits the apparatus **1100** and fills the annular region between the exterior of the tubular member **1110** and the interior wall of the tubular liner **1008**. Continued pumping of the material **1160** causes the material **1160** to fill up at least a portion of the annular region.

[0228] The material **1160** may be pumped into the annular region at pressures and flow rates ranging, for example, from about 0 to 5,000 psi and 0 to 1,500 gallons/min, respectively. In a preferred embodiment, the material **1160** is pumped into the annular region at pressures and flow rates specifically designed for the casing sizes being run, the annular spaces being filled, the pumping equipment available, and the properties of the fluid being pumped. The optimum flow rates and pressures are preferably calculated using conventional empirical methods.

[0229] The hardenable fluidic sealing material **1160** may comprise any number of conventional commercially available hardenable fluidic sealing materials such as, for example, slag mix, cement or epoxy. In a preferred embodiment, the hardenable fluidic sealing material **1160** comprises blended cements specifically designed for well section being tied-back, available from Halliburton Energy Services in Dallas, Tex. in order to optimally provide proper support for the tubular member **1110** while maintaining optimum flow characteristics so as to minimize operational difficulties during the displacement of cement in the annular region. The optimum blend of the blended cements are preferably determined using conventional empirical methods.

[0230] The annular region may be filled with the material **1160** in sufficient quantities to ensure that, upon radial

expansion of the tubular member **1110**, the annular region will be filled with material **1160**.

[0231] As illustrated in FIG. 10d, once the annular region has been adequately filled with material **1160**, one or more plugs **1165**, or other similar devices, preferably are introduced into the fluid passages **1140** thereby fluidically isolating the interior region of the tubular member **1110** from the annular region external to the tubular member **1110**. In a preferred embodiment, a non hardenable fluidic material **1161** is then pumped into the interior region of the tubular member **1110** below the mandrel **1105** causing the interior region to pressurize. In a particularly preferred embodiment, the one or more plugs **1165**, or other similar devices, are introduced into the fluid passage **1140** with the introduction of the non hardenable fluidic material. In this manner, the amount of hardenable fluidic material within the interior of the tubular member **1110** is minimized.

[0232] As illustrated in FIG. 10e, once the interior region becomes sufficiently pressurized, the tubular member **1110** is extruded off of the expandable mandrel **1105**. During the extrusion process, the expandable mandrel **1105** is raised out of the expanded portion of the tubular member **1110**.

[0233] The plugs **1165** are preferably placed into the fluid passages **1140** by introducing the plugs **1165** into the fluid passage **1130** at a surface location in a conventional manner. The plugs **1165** may comprise any number of conventional commercially available devices from plugging a fluid passage such as, for example, brass balls, plugs, rubber balls, or darts modified in accordance with the teachings of the present disclosure.

[0234] In a preferred embodiment, the plugs **1165** comprise low density rubber balls. In an alternative embodiment, for a shoe **1105** having a common central inlet passage, the plugs **1165** comprise a single latch down dart.

[0235] After placement of the plugs **1165** in the fluid passages **1140**, the non hardenable fluidic material **1161** is preferably pumped into the interior region of the tubular member **1110** below the mandrel **1105** at pressures and flow rates ranging from approximately 500 to 9,000 psi and 40 to 3,000 gallons/min.

[0236] In a preferred embodiment, after placement of the plugs **1165** in the fluid passages **1140**, the non hardenable fluidic material **1161** is preferably pumped into the interior region of the tubular member **1110** below the mandrel **1105** at pressures and flow rates ranging from approximately 1200 to 8500 psi and 40 to 1250 gallons/min in order to optimally provide extrusion of typical tubulars.

[0237] For typical tubular members **1110**, the extrusion of the tubular member **1110** off of the expandable mandrel **1105** will begin when the pressure of the interior region of the tubular member **1110** below the mandrel **1105** reaches, for example, approximately 1200 to 8500 psi. In a preferred embodiment, the extrusion of the tubular member **1110** off of the expandable mandrel **1105** begins when the pressure of the interior region of the tubular member **1110** below the mandrel **1105** reaches approximately 1200 to 8500 psi.

[0238] During the extrusion process, the expandable mandrel **1105** may be raised out of the expanded portion of the tubular member **1110** at rates ranging, for example, from about 0 to 5 ft/sec. In a preferred embodiment, during the

extrusion process, the expandable mandrel **1105** is raised out of the expanded portion of the tubular member **1110** at rates ranging from about 0 to 2 ft/sec in order to optimally provide permit adjustment of operational parameters, and optimally ensure that the extrusion process will be completed before the material **1160** cures.

[0239] In a preferred embodiment, at least a portion **1180** of the tubular member **1110** has an internal diameter less than the outside diameter of the mandrel **1105**. In this manner, when the mandrel **1105** expands the section **1180** of the tubular member **1110**, at least a portion of the expanded section **1180** effects a seal with at least the wellbore casing **1012**. In a particularly preferred embodiment, the seal is effected by compressing the seals **1016** between the expanded section **1180** and the wellbore casing **1012**. In a preferred embodiment, the contact pressure of the joint between the expanded section **1180** of the tubular member **1110** and the casing **1012** ranges from about 500 to 10,000 psi in order to optimally provide pressure to activate the sealing members **1145** and provide optimal resistance to ensure that the joint will withstand typical extremes of tensile and compressive loads.

[0240] In an alternative preferred embodiment, substantially all of the entire length of the tubular member **1110** has an internal diameter less than the outside diameter of the mandrel **1105**. In this manner, extrusion of the tubular member **1110** by the mandrel **1105** results in contact between substantially all of the expanded tubular member **1110** and the existing casing **1008**. In a preferred embodiment, the contact pressure of the joint between the expanded tubular member **1110** and the casings **1008** and **1012** ranges from about 500 to 10,000 psi in order to optimally provide pressure to activate the sealing members **1145** and provide optimal resistance to ensure that the joint will withstand typical extremes of tensile and compressive loads.

[0241] In a preferred embodiment, the operating pressure and flow rate of the material **1161** is controllably ramped down when the expandable mandrel **1105** reaches the upper end portion of the tubular member **1110**. In this manner, the sudden release of pressure caused by the complete extrusion of the tubular member **1110** off of the expandable mandrel **1105** can be minimized. In a preferred embodiment, the operating pressure of the fluidic material **1161** is reduced in a substantially linear fashion from 100% to about 10% during the end of the extrusion process beginning when the mandrel **1105** has completed approximately all but about 5 feet of the extrusion process.

[0242] Alternatively, or in combination, a shock absorber is provided in the support member **1150** in order to absorb the shock caused by the sudden release of pressure.

[0243] Alternatively, or in combination, a mandrel catching structure is provided in the upper end portion of the tubular member **1110** in order to catch or at least decelerate the mandrel **1105**.

[0244] Referring to FIG. **10f**, once the extrusion process is completed, the expandable mandrel **1105** is removed from the wellbore **1000**. In a preferred embodiment, either before or after the removal of the expandable mandrel **1105**, the integrity of the fluidic seal of the joint between the upper portion of the tubular member **1110** and the upper portion of the tubular liner **1108** is tested using conventional methods.

If the fluidic seal of the joint between the upper portion of the tubular member **1110** and the upper portion of the tubular liner **1108** is satisfactory, then the uncured portion of the material **1160** within the expanded tubular member **1110** is then removed in a conventional manner. The material **1160** within the annular region between the tubular member **1110** and the tubular liner **1108** is then allowed to cure.

[0245] As illustrated in FIG. **10f**, preferably any remaining cured material **1160** within the interior of the expanded tubular member **1110** is then removed in a conventional manner using a conventional drill string. The resulting tie-back liner of casing **1170** includes the expanded tubular member **1110** and an outer annular layer **1175** of cured material **1160**.

[0246] As illustrated in FIG. **10g**, the remaining bottom portion of the apparatus **1100** comprising the shoe **1115** and packer **1155** is then preferably removed by drilling out the shoe **1115** and packer **1155** using conventional drilling methods.

[0247] In a particularly preferred embodiment, the apparatus **1100** incorporates the apparatus **900**.

[0248] Referring now to FIGS. **11a-11f**, an embodiment of an apparatus and method for hanging a tubular liner off of an existing wellbore casing will now be described. As illustrated in FIG. **11a**, a wellbore **1200** is positioned in a subterranean formation **1205**. The wellbore **1200** includes an existing cased section **1210** having a tubular casing **1215** and an annular outer layer of cement **1220**.

[0249] In order to extend the wellbore **1200** into the subterranean formation **1205**, a drill string **1225** is used in a well known manner to drill out material from the subterranean formation **1205** to form a new section **1230**.

[0250] As illustrated in FIG. **11b**, an apparatus **1300** for forming a wellbore casing in a subterranean formation is then positioned in the new section **1230** of the wellbore **100**. The apparatus **1300** preferably includes an expandable mandrel or pig **1305**, a tubular member **1310**, a shoe **1315**, a fluid passage **1320**, a fluid passage **1330**, a fluid passage **1335**, seals **1340**, a support member **1345**, and a wiper plug **1350**.

[0251] The expandable mandrel **1305** is coupled to and supported by the support member **1345**. The expandable mandrel **1305** is preferably adapted to controllably expand in a radial direction. The expandable mandrel **1305** may comprise any number of conventional commercially available expandable mandrels modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the expandable mandrel **1305** comprises a hydraulic expansion tool substantially as disclosed in U.S. Pat. No. 5,348,095, the disclosure of which is incorporated herein by reference, modified in accordance with the teachings of the present disclosure.

[0252] The tubular member **1310** is coupled to and supported by the expandable mandrel **1305**. The tubular member **1310** is preferably expanded in the radial direction and extruded off of the expandable mandrel **1305**. The tubular member **1310** may be fabricated from any number of materials such as, for example, Oilfield Country Tubular Goods (OCTG), 13 chromium steel tubing/casing or plastic casing. In a preferred embodiment, the tubular member **1310** is fabricated from OCTG. The inner and outer diameters of

the tubular member **1310** may range, for example, from approximately 0.75 to 47 inches and 1.05 to 48 inches, respectively. In a preferred embodiment, the inner and outer diameters of the tubular member **1310** range from about 3 to 15.5 inches and 3.5 to 16 inches, respectively in order to optimally provide minimal telescoping effect in the most commonly encountered wellbore sizes.

[0253] In a preferred embodiment, the tubular member **1310** includes an upper portion **1355**, an intermediate portion **1360**, and a lower portion **1365**. In a preferred embodiment, the wall thickness and outer diameter of the upper portion **1355** of the tubular member **1310** range from about $\frac{3}{8}$ to $1\frac{1}{2}$ inches and $3\frac{1}{2}$ to 16 inches, respectively. In a preferred embodiment, the wall thickness and outer diameter of the intermediate portion **1360** of the tubular member **1310** range from about 0.625 to 0.75 inches and 3 to 19 inches, respectively. In a preferred embodiment, the wall thickness and outer diameter of the lower portion **1365** of the tubular member **1310** range from about $\frac{3}{8}$ to 1.5 inches and 3.5 to 16 inches, respectively.

[0254] In a particularly preferred embodiment, the wall thickness of the intermediate section **1360** of the tubular member **1310** is less than or equal to the wall thickness of the upper and lower sections, **1355** and **1365**, of the tubular member **1310** in order to optimally facilitate the initiation of the extrusion process and optimally permit the placement of the apparatus in areas of the wellbore having tight clearances.

[0255] The tubular member **1310** preferably comprises a solid member. In a preferred embodiment, the upper end portion **1355** of the tubular member **1310** is slotted, perforated, or otherwise modified to catch or slow down the mandrel **1305** when it completes the extrusion of tubular member **1310**. In a preferred embodiment, the length of the tubular member **1310** is limited to minimize the possibility of buckling. For typical tubular member **1310** materials, the length of the tubular member **1310** is preferably limited to between about 40 to 20,000 feet in length.

[0256] The shoe **1315** is coupled to the tubular member **1310**. The shoe **1315** preferably includes fluid passages **1330** and **1335**. The shoe **1315** may comprise any number of conventional commercially available shoes such as, for example, Super Seal II float shoe, Super Seal II Down-Jet float shoe or guide shoe with a sealing sleeve for a latch-down plug modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the shoe **1315** comprises an aluminum downjet guide shoe with a sealing sleeve for a latch-down plug available from Halliburton Energy Services in Dallas, Tex., modified in accordance with the teachings of the present disclosure, in order to optimally guide the tubular member **1310** into the wellbore **1200**, optimally fluidically isolate the interior of the tubular member **1310**, and optimally permit the complete drill out of the shoe **1315** upon the completion of the extrusion and cementing operations.

[0257] In a preferred embodiment, the shoe **1315** further includes one or more side outlet ports in fluidic communication with the fluid passage **1330**. In this manner, the shoe **1315** preferably injects hardenable fluidic sealing material into the region outside the shoe **1315** and tubular member **1310**. In a preferred embodiment, the shoe **1315** includes the fluid passage **1330** having an inlet geometry that can receive

a fluidic sealing member. In this manner, the fluid passage **1330** can be sealed off by introducing a plug, dart and/or ball sealing elements into the fluid passage **1330**.

[0258] The fluid passage **1320** permits fluidic materials to be transported to and from the interior region of the tubular member **1310** below the expandable mandrel **1305**. The fluid passage **1320** is coupled to and positioned within the support member **1345** and the expandable mandrel **1305**. The fluid passage **1320** preferably extends from a position adjacent to the surface to the bottom of the expandable mandrel **1305**. The fluid passage **1320** is preferably positioned along a centerline of the apparatus **1300**. The fluid passage **1320** is preferably selected to transport materials such as cement, drilling mud, or epoxies at flow rates and pressures ranging from about 0 to 3,000 gallons/minute and 0 to 9,000 psi in order to optimally provide sufficient operating pressures to circulate fluids at operationally efficient rates.

[0259] The fluid passage **1330** permits fluidic materials to be transported to and from the region exterior to the tubular member **1310** and shoe **1315**. The fluid passage **1330** is coupled to and positioned within the shoe **1315** in fluidic communication with the interior region **1370** of the tubular member **1310** below the expandable mandrel **1305**. The fluid passage **1330** preferably has a cross-sectional shape that permits a plug, or other similar device, to be placed in fluid passage **1330** to thereby block further passage of fluidic materials. In this manner, the interior region **1370** of the tubular member **1310** below the expandable mandrel **1305** can be fluidically isolated from the region exterior to the tubular member **1310**. This permits the interior region **1370** of the tubular member **1310** below the expandable mandrel **1305** to be pressurized. The fluid passage **1330** is preferably positioned substantially along the centerline of the apparatus **1300**.

[0260] The fluid passage **1330** is preferably selected to convey materials such as cement, drilling mud or epoxies at flow rates and pressures ranging from about 0 to 3,000 gallons/minute and 0 to 9,000 psi in order to optimally fill the annular region between the tubular member **1310** and the new section **1230** of the wellbore **1200** with fluidic materials. In a preferred embodiment, the fluid passage **1330** includes an inlet geometry that can receive a dart and/or a ball sealing member. In this manner, the fluid passage **1330** can be sealed off by introducing a plug, dart and/or ball sealing elements into the fluid passage **1320**.

[0261] The fluid passage **1335** permits fluidic materials to be transported to and from the region exterior to the tubular member **1310** and shoe **1315**. The fluid passage **1335** is coupled to and positioned within the shoe **1315** in fluidic communication with the fluid passage **1330**. The fluid passage **1335** is preferably positioned substantially along the centerline of the apparatus **1300**. The fluid passage **1335** is preferably selected to convey materials such as cement, drilling mud or epoxies at flow rates and pressures ranging from about 0 to 3,000 gallons/minute and 0 to 9,000 psi in order to optimally fill the annular region between the tubular member **1310** and the new section **1230** of the wellbore **1200** with fluidic materials.

[0262] The seals **1340** are coupled to and supported by the upper end portion **1355** of the tubular member **1310**. The seals **1340** are further positioned on an outer surface of the upper end portion **1355** of the tubular member **1310**. The

seals **1340** permit the overlapping joint between the lower end portion of the casing **1215** and the upper portion **1355** of the tubular member **1310** to be fluidically sealed. The seals **1340** may comprise any number of conventional commercially available seals such as, for example, lead, rubber, Teflon, or epoxy seals modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the seals **1340** comprise seals molded from Stralalock epoxy available from Halliburton Energy Services in Dallas, Tex. in order to optimally provide a hydraulic seal in the annulus of the overlapping joint while also creating optimal load bearing capability to withstand typical tensile and compressive loads.

[0263] In a preferred embodiment, the seals **1340** are selected to optimally provide a sufficient frictional force to support the expanded tubular member **1310** from the existing casing **1215**. In a preferred embodiment, the frictional force provided by the seals **1340** ranges from about 1,000 to 1,000,000 lbf in order to optimally support the expanded tubular member **1310**.

[0264] The support member **1345** is coupled to the expandable mandrel **1305**, tubular member **1310**, shoe **1315**, and seals **1340**. The support member **1345** preferably comprises an annular member having sufficient strength to carry the apparatus **1300** into the new section **1230** of the wellbore **1200**. In a preferred embodiment, the support member **1345** further includes one or more conventional centralizers (not illustrated) to help stabilize the tubular member **1310**.

[0265] In a preferred embodiment, the support member **1345** is thoroughly cleaned prior to assembly to the remaining portions of the apparatus **1300**. In this manner, the introduction of foreign material into the apparatus **1300** is minimized. This minimizes the possibility of foreign material clogging the various flow passages and valves of the apparatus **1300** and to ensure that no foreign material interferes with the expansion process.

[0266] The wiper plug **1350** is coupled to the mandrel **1305** within the interior region **1370** of the tubular member **1310**. The wiper plug **1350** includes a fluid passage **1375** that is coupled to the fluid passage **1320**. The wiper plug **1350** may comprise one or more conventional commercially available wiper plugs such as, for example, Multiple Stage Cementer latch-down plugs, Omega latch-down plugs or three-wiper latch-down plug modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the wiper plug **1350** comprises a Multiple Stage Cementer latch-down plug available from Halliburton Energy Services in Dallas, Tex. modified in a conventional manner for releasable attachment to the expansion mandrel **1305**.

[0267] In a preferred embodiment, before or after positioning the apparatus **1300** within the new section **1230** of the wellbore **1200**, a couple of wellbore volumes are circulated in order to ensure that no foreign materials are located within the wellbore **1200** that might clog up the various flow passages and valves of the apparatus **1300** and to ensure that no foreign material interferes with the extrusion process.

[0268] As illustrated in FIG. **11c**, a hardenable fluidic sealing material **1380** is then pumped from a surface location into the fluid passage **1320**. The material **1380** then passes from the fluid passage **1320**, through the fluid passage

1375, and into the interior region **1370** of the tubular member **1310** below the expandable mandrel **1305**. The material **1380** then passes from the interior region **1370** into the fluid passage **1330**. The material **1380** then exits the apparatus **1300** via the fluid passage **1335** and fills the annular region **1390** between the exterior of the tubular member **1310** and the interior wall of the new section **1230** of the wellbore **1200**. Continued pumping of the material **1380** causes the material **1380** to fill up at least a portion of the annular region **1390**.

[0269] The material **1380** may be pumped into the annular region **1390** at pressures and flow rates ranging, for example, from about 0 to 5000 psi and 0 to 1,500 gallons/min, respectively. In a preferred embodiment, the material **1380** is pumped into the annular region **1390** at pressures and flow rates ranging from about 0 to 5000 psi and 0 to 1,500 gallons/min, respectively, in order to optimally fill the annular region between the tubular member **1310** and the new section **1230** of the wellbore **1200** with the hardenable fluidic sealing material **1380**.

[0270] The hardenable fluidic sealing material **1380** may comprise any number of conventional commercially available hardenable fluidic sealing materials such as, for example, slag mix, cement or epoxy. In a preferred embodiment, the hardenable fluidic sealing material **1380** comprises blended cements designed specifically for the well section being drilled and available from Halliburton Energy Services in order to optimally provide support for the tubular member **1310** during displacement of the material **1380** in the annular region **1390**. The optimum blend of the cement is preferably determined using conventional empirical methods.

[0271] The annular region **1390** preferably is filled with the material **1380** in sufficient quantities to ensure that, upon radial expansion of the tubular member **1310**, the annular region **1390** of the new section **1230** of the wellbore **1200** will be filled with material **1380**.

[0272] As illustrated in FIG. **11d**, once the annular region **1390** has been adequately filled with material **1380**, a wiper dart **1395**, or other similar device, is introduced into the fluid passage **1320**. The wiper dart **1395** is preferably pumped through the fluid passage **1320** by a non hardenable fluidic material **1381**. The wiper dart **1395** then preferably engages the wiper plug **1350**.

[0273] As illustrated in FIG. **11e**, in a preferred embodiment, engagement of the wiper dart **1395** with the wiper plug **1350** causes the wiper plug **1350** to decouple from the mandrel **1305**. The wiper dart **1395** and wiper plug **1350** then preferably will lodge in the fluid passage **1330**, thereby blocking fluid flow through the fluid passage **1330**, and fluidically isolating the interior region **1370** of the tubular member **1310** from the annular region **1390**. In a preferred embodiment, the non hardenable fluidic material **1381** is then pumped into the interior region **1370** causing the interior region **1370** to pressurize. Once the interior region **1370** becomes sufficiently pressurized, the tubular member **1310** is extruded off of the expandable mandrel **1305**. During the extrusion process, the expandable mandrel **1305** is raised out of the expanded portion of the tubular member **1310** by the support member **1345**.

[0274] The wiper dart **1395** is preferably placed into the fluid passage **1320** by introducing the wiper dart **1395** into

the fluid passage **1320** at a surface location in a conventional manner. The wiper dart **1395** may comprise any number of conventional commercially available devices from plugging a fluid passage such as, for example, Multiple Stage Cementer latch-down plugs, Omega latch-down plugs or three wiper latch-down plug/dart modified in accordance with the teachings of the present disclosure. In a preferred embodiment, the wiper dart **1395** comprises a three wiper latch-down plug modified to latch and seal in the Multiple Stage Cementer latch down plug **1350**. The three wiper latch-down plug is available from Halliburton Energy Services in Dallas, Tex.

[0275] After blocking the fluid passage **1330** using the wiper plug **1330** and wiper dart **1395**, the non hardenable fluidic material **1381** may be pumped into the interior region **1370** at pressures and flow rates ranging, for example, from approximately 0 to 5000 psi and 0 to 1,500 gallons/min in order to optimally extrude the tubular member **1310** off of the mandrel **1305**. In this manner, the amount of hardenable fluidic material within the interior of the tubular member **1310** is minimized.

[0276] In a preferred embodiment, after blocking the fluid passage **1330**, the non hardenable fluidic material **1381** is preferably pumped into the interior region **1370** at pressures and flow rates ranging from approximately 500 to 9,000 psi and 40 to 3,000 gallons/min in order to optimally provide operating pressures to maintain the expansion process at rates sufficient to permit adjustments to be made in operating parameters during the extrusion process.

[0277] For typical tubular members **1310**, the extrusion of the tubular member **1310** off of the expandable mandrel **1305** will begin when the pressure of the interior region **1370** reaches, for example, approximately 500 to 9,000 psi. In a preferred embodiment, the extrusion of the tubular member **1310** off of the expandable mandrel **1305** is a function of the tubular member diameter, wall thickness of the tubular member, geometry of the mandrel, the type of lubricant, the composition of the shoe and tubular member, and the yield strength of the tubular member. The optimum flow rate and operating pressures are preferably determined using conventional empirical methods.

[0278] During the extrusion process, the expandable mandrel **1305** may be raised out of the expanded portion of the tubular member **1310** at rates ranging, for example, from about 0 to 5 ft/sec. In a preferred embodiment, during the extrusion process, the expandable mandrel **1305** may be raised out of the expanded portion of the tubular member **1310** at rates ranging from about 0 to 2 ft/sec in order to optimally provide an efficient process, optimally permit operator adjustment of operation parameters, and ensure optimal completion of the extrusion process before curing of the material **1380**.

[0279] When the upper end portion **1355** of the tubular member **1310** is extruded off of the expandable mandrel **1305**, the outer surface of the upper end portion **1355** of the tubular member **1310** will preferably contact the interior surface of the lower end portion of the casing **1215** to form a fluid tight overlapping joint. The contact pressure of the overlapping joint may range, for example, from approximately 50 to 20,000 psi. In a preferred embodiment, the contact pressure of the overlapping joint ranges from approximately 400 to 10,000 psi in order to optimally

provide contact pressure sufficient to ensure annular sealing and provide enough resistance to withstand typical tensile and compressive loads. In a particularly preferred embodiment, the sealing members **1340** will ensure an adequate fluidic and gaseous seal in the overlapping joint.

[0280] In a preferred embodiment, the operating pressure and flow rate of the non hardenable fluidic material **1381** is controllably ramped down when the expandable mandrel **1305** reaches the upper end portion **1355** of the tubular member **1310**. In this manner, the sudden release of pressure caused by the complete extrusion of the tubular member **1310** off of the expandable mandrel **1305** can be minimized. In a preferred embodiment, the operating pressure is reduced in a substantially linear fashion from 100% to about 10% during the end of the extrusion process beginning when the mandrel **1305** has completed approximately all but about 5 feet of the extrusion process.

[0281] Alternatively, or in combination, a shock absorber is provided in the support member **1345** in order to absorb the shock caused by the sudden release of pressure.

[0282] Alternatively, or in combination, a mandrel catching structure is provided in the upper end portion **1355** of the tubular member **1310** in order to catch or at least decelerate the mandrel **1305**.

[0283] Once the extrusion process is completed, the expandable mandrel **1305** is removed from the wellbore **1200**. In a preferred embodiment, either before or after the removal of the expandable mandrel **1305**, the integrity of the fluidic seal of the overlapping joint between the upper portion **1355** of the tubular member **1310** and the lower portion of the casing **1215** is tested using conventional methods. If the fluidic seal of the overlapping joint between the upper portion **1355** of the tubular member **1310** and the lower portion of the casing **1215** is satisfactory, then the uncured portion of the material **1380** within the expanded tubular member **1310** is then removed in a conventional manner. The material **1380** within the annular region **1390** is then allowed to cure.

[0284] As illustrated in FIG. 11f, preferably any remaining cured material **1380** within the interior of the expanded tubular member **1310** is then removed in a conventional manner using a conventional drill string. The resulting new section of casing **1400** includes the expanded tubular member **1310** and an outer annular layer **1405** of cured material **305**. The bottom portion of the apparatus **1300** comprising the shoe **1315** may then be removed by drilling out the shoe **1315** using conventional drilling methods.

[0285] A method of creating a casing in a borehole located in a subterranean formation has been described that includes installing a tubular liner and a mandrel in the borehole. A body of fluidic material is then injected into the borehole. The tubular liner is then radially expanded by extruding the liner off of the mandrel. The injecting preferably includes injecting a hardenable fluidic sealing material into an annular region located between the borehole and the exterior of the tubular liner; and a non hardenable fluidic material into an interior region of the tubular liner below the mandrel. The method preferably includes fluidically isolating the annular region from the interior region before injecting the second quantity of the non hardenable sealing material into the interior region. The injecting the hardenable fluidic sealing

material is preferably provided at operating pressures and flow rates ranging from about 0 to 5000 psi and 0 to 1,500 gallons/min. The injecting of the non hardenable fluidic material is preferably provided at operating pressures and flow rates ranging from about 500 to 9000 psi and 40 to 3,000 gallons/min. The injecting of the non hardenable fluidic material is preferably provided at reduced operating pressures and flow rates during an end portion of the extruding. The non hardenable fluidic material is preferably injected below the mandrel. The method preferably includes pressurizing a region of the tubular liner below the mandrel. The region of the tubular liner below the mandrel is preferably pressurized to pressures ranging from about 500 to 9,000 psi. The method preferably includes fluidically isolating an interior region of the tubular liner from an exterior region of the tubular liner. The method further preferably includes curing the hardenable sealing material, and removing at least a portion of the cured sealing material located within the tubular liner. The method further preferably includes overlapping the tubular liner with an existing wellbore casing. The method further preferably includes sealing the overlap between the tubular liner and the existing wellbore casing. The method further preferably includes supporting the extruded tubular liner using the overlap with the existing wellbore casing. The method further preferably includes testing the integrity of the seal in the overlap between the tubular liner and the existing wellbore casing. The method further preferably includes removing at least a portion of the hardenable fluidic sealing material within the tubular liner before curing. The method further preferably includes lubricating the surface of the mandrel. The method further preferably includes absorbing shock. The method further preferably includes catching the mandrel upon the completion of the extruding.

[0286] An apparatus for creating a casing in a borehole located in a subterranean formation has been described that includes a support member, a mandrel, a tubular member, and a shoe. The support member includes a first fluid passage. The mandrel is coupled to the support member and includes a second fluid passage. The tubular member is coupled to the mandrel. The shoe is coupled to the tubular liner and includes a third fluid passage. The first, second and third fluid passages are operably coupled. The support member preferably further includes a pressure relief passage, and a flow control valve coupled to the first fluid passage and the pressure relief passage. The support member further preferably includes a shock absorber. The support member preferably includes one or more sealing members adapted to prevent foreign material from entering an interior region of the tubular member. The mandrel is preferably expandable. The tubular member is preferably fabricated from materials selected from the group consisting of Oilfield Country Tubular Goods, 13 chromium steel tubing/casing, and plastic casing. The tubular member preferably has inner and outer diameters ranging from about 3 to 15.5 inches and 3.5 to 16 inches, respectively. The tubular member preferably has a plastic yield point ranging from about 40,000 to 135,000 psi. The tubular member preferably includes one or more sealing members at an end portion. The tubular member preferably includes one or more pressure relief holes at an end portion. The tubular member preferably includes a catching member at an end portion for slowing down the mandrel. The shoe preferably includes an inlet port coupled

to the third fluid passage, the inlet port adapted to receive a plug for blocking the inlet port. The shoe preferably is drillable.

[0287] A method of joining a second tubular member to a first tubular member, the first tubular member having an inner diameter greater than an outer diameter of the second tubular member, has been described that includes positioning a mandrel within an interior region of the second tubular member, positioning the first and second tubular members in an overlapping relationship, pressurizing a portion of the interior region of the second tubular member; and extruding the second tubular member off of the mandrel into engagement with the first tubular member. The pressurizing of the portion of the interior region of the second tubular member is preferably provided at operating pressures ranging from about 500 to 9,000 psi. The pressurizing of the portion of the interior region of the second tubular member is preferably provided at reduced operating pressures during a latter portion of the extruding. The method further preferably includes sealing the overlap between the first and second tubular members. The method further preferably includes supporting the extruded first tubular member using the overlap with the second tubular member. The method further preferably includes lubricating the surface of the mandrel. The method further preferably includes absorbing shock.

[0288] A liner for use in creating a new section of wellbore casing in a subterranean formation adjacent to an already existing section of wellbore casing has been described that includes an annular member. The annular member includes one or more sealing members at an end portion of the annular member, and one or more pressure relief passages at an end portion of the annular member.

[0289] A wellbore casing has been described that includes a tubular liner and an annular body of a cured fluidic sealing material. The tubular liner is formed by the process of extruding the tubular liner off of a mandrel. The tubular liner is preferably formed by the process of placing the tubular liner and mandrel within the wellbore, and pressurizing an interior portion of the tubular liner. The annular body of the cured fluidic sealing material is preferably formed by the process of injecting a body of hardenable fluidic sealing material into an annular region external of the tubular liner. During the pressurizing, the interior portion of the tubular liner is preferably fluidically isolated from an exterior portion of the tubular liner. The interior portion of the tubular liner is preferably pressurized to pressures ranging from about 500 to 9,000 psi. The tubular liner preferably overlaps with an existing wellbore casing. The wellbore casing preferably further includes a seal positioned in the overlap between the tubular liner and the existing wellbore casing. Tubular liner is preferably supported the overlap with the existing wellbore casing.

[0290] A method of repairing an existing section of a wellbore casing within a borehole has been described that includes installing a tubular liner and a mandrel within the wellbore casing, injecting a body of a fluidic material into the borehole, pressurizing a portion of an interior region of the tubular liner, and radially expanding the liner in the borehole by extruding the liner off of the mandrel. In a preferred embodiment, the fluidic material is selected from the group consisting of slag mix, cement, drilling mud, and epoxy. In a preferred embodiment, the method further

includes fluidically isolating an interior region of the tubular liner from an exterior region of the tubular liner. In a preferred embodiment, the injecting of the body of fluidic material is provided at operating pressures and flow rates ranging from about 500 to 9,000 psi and 40 to 3,000 gallons/min. In a preferred embodiment, the injecting of the body of fluidic material is provided at reduced operating pressures and flow rates during an end portion of the extruding. In a preferred embodiment, the fluidic material is injected below the mandrel. In a preferred embodiment, a region of the tubular liner below the mandrel is pressurized. In a preferred embodiment, the region of the tubular liner below the mandrel is pressurized to pressures ranging from about 500 to 9,000 psi. In a preferred embodiment, the method further includes overlapping the tubular liner with the existing wellbore casing. In a preferred embodiment, the method further includes sealing the interface between the tubular liner and the existing wellbore casing. In a preferred embodiment, the method further includes supporting the extruded tubular liner using the existing wellbore casing. In a preferred embodiment, the method further includes testing the integrity of the seal in the interface between the tubular liner and the existing wellbore casing. In a preferred embodiment, method further includes lubricating the surface of the mandrel. In a preferred embodiment, the method further includes absorbing shock. In a preferred embodiment, the method further includes catching the mandrel upon the completion of the extruding. In a preferred embodiment, the method further includes expanding the mandrel in a radial direction.

[0291] A tie-back liner for lining an existing wellbore casing has been described that includes a tubular liner and an annular body of a cured fluidic sealing material. The tubular liner is formed by the process of extruding the tubular liner off of a mandrel. The annular body of a cured fluidic sealing material is coupled to the tubular liner. In a preferred embodiment, the tubular liner is formed by the process of placing the tubular liner and mandrel within the wellbore, and pressurizing an interior portion of the tubular liner. In a preferred embodiment, during the pressurizing, the interior portion of the tubular liner is fluidically isolated from an exterior portion of the tubular liner. In a preferred embodiment, the interior portion of the tubular liner is pressurized at pressures ranging from about 500 to 9,000 psi. In a preferred embodiment, the annular body of a cured fluidic sealing material is formed by the process of injecting a body of hardenable fluidic sealing material into an annular region between the existing wellbore casing and the tubular liner. In a preferred embodiment, the tubular liner overlaps with another existing wellbore casing. In a preferred embodiment, the tie-back liner further includes a seal positioned in the overlap between the tubular liner and the other existing wellbore casing. In a preferred embodiment, tubular liner is supported by the overlap with the other existing wellbore casing.

[0292] An apparatus for expanding a tubular member has been described that includes a support member, a mandrel, a tubular member, and a shoe. The support member includes a first fluid passage. The mandrel is coupled to the support member. The mandrel includes a second fluid passage operably coupled to the first fluid passage, an interior portion, and an exterior portion. The interior portion of the mandrel is drillable. The tubular member is coupled to the mandrel. The shoe is coupled to the tubular member. The shoe

includes a third fluid passage operably coupled to the second fluid passage, an interior portion, and an exterior portion. The interior portion of the shoe is drillable. Preferably, the interior portion of the mandrel includes a tubular member and a load bearing member. Preferably, the load bearing member comprises a drillable body. Preferably, the interior portion of the shoe includes a tubular member, and a load bearing member. Preferably, the load bearing member comprises a drillable body. Preferably, the exterior portion of the mandrel comprises an expansion cone. Preferably, the expansion cone is fabricated from materials selected from the group consisting of tool steel, titanium, and ceramic. Preferably, the expansion cone has a surface hardness ranging from about 58 to 62 Rockwell C. Preferably at least a portion of the apparatus is drillable.

[0293] Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

What is claimed is:

1. A method of joining a second tubular member to a first tubular member in a pipeline, the first tubular member having an inner diameter greater than an outer diameter of the second tubular member, comprising:

positioning an expansion device within an interior region of the second tubular member;

pressurizing a portion of the interior region of the second tubular member; and

radially expanding and plastically deforming the second tubular member using the expansion device into engagement with the first tubular member;

wherein an interface between the expansion device and the second tubular member does not include a fluid tight seal.

2. A method of fluidically isolating a section of pipeline tubing, comprising:

running a length of expandable tubing into pipeline-lined borehole and positioning the expandable tubing across a section of pipeline to be fluidically isolated; and

plastically deforming at least one portion of the expandable tubing to increase the diameter of the portion to sealingly engage the pipeline to be fluidically isolated by displacing an expansion device therethrough in the longitudinal direction.

3. A tubular liner in a pipeline, comprising:

an annular member, the annular member comprising one or more sealing members at an end portion of the annular member; and

one or more pressure relief passages defined only at the end portion of the annular member.

4. A tubular liner in a pipeline, comprising:

an annular member having a first portion, a second portion, and a third portion;

wherein the wall thickness and outside diameter of the first, second and third portions range from about $\frac{3}{8}$ to 1.5 inches and 3.5 to 16 inches, $\frac{1}{8}$ to 1.25 inches and 3.5 to 19 inches, and $\frac{1}{8}$ to 1.25 inches and 3.5 to 19 inches, respectively.

5. An apparatus for expanding a tubular liner in a pipeline, comprising:

a support member;

an expansion device coupled to the support member;

a tubular liner coupled to the expansion device; and

a shoe coupled to the tubular liner, the shoe defining a passage;

wherein the interface between the expansion device and the tubular liner is not fluid tight.

6. A system for joining a second tubular member to a first tubular member in a pipeline, the first tubular member having an inner diameter greater than an outer diameter of the second tubular member, comprising:

means for positioning an expansion device within an interior region of the second tubular member;

means for pressurizing a portion of the interior region of the second tubular member; and

means for radially expanding and plastically deforming the second tubular member using the expansion device into engagement with the first tubular member;

wherein an interface between the expansion device and the second tubular member does not include a fluid tight seal.

7. A system for fluidically isolating a section of pipeline tubing, comprising:

means for running a length of expandable tubing into pipeline-lined borehole and positioning the expandable tubing across a section of pipeline to be fluidically isolated; and

means for plastically deforming at least one portion of the expandable tubing to increase the diameter of the portion to sealingly engage the pipeline to be

fluidically isolated by displacing an expansion device there-through in the longitudinal direction.

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