(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
31 October 2013 (31.10.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/163055 A1

(51) International Patent Classification:
C23C 16/00 (2006.01)

(21) International Application Number:
PCT/US2013/037520

(22) International Filing Date:
22 April 2013 (22.04.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/639,164 27 April 2012 (27.04.2012) US

(71) Applicant: **ARKEMA INC.** [US/US]; 900 First Avenue, King of Prussia, Pennsylvania 19406 (US).

(72) Inventor: **FAHEY, Kaitlyn**; 668 Laguna Drive, Carlsbad, California 92008 (US).

(74) Agents: **MORREALE, Lynn B.** et al.; Arkema Inc., 900 First Avenue, King of Prussia, Pennsylvania 19406 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

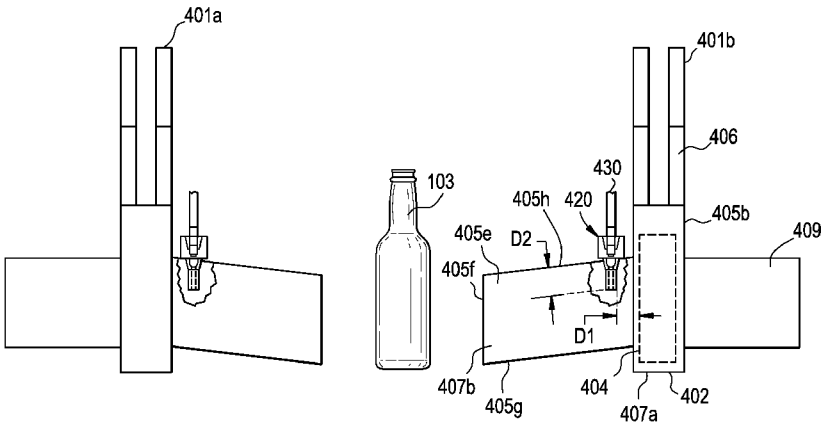
Published:

— *with international search report (Art. 21(3))*

WO 2013/163055 A1

(54) Title: HOOD FOR METAL-OXIDE VAPOR COATING GLASS CONTAINERS

FIG. 4



(57) Abstract: An apparatus for coating glass articles with a chemical compound includes a coating hood section defining an interior chamber having an inlet and an outlet, the outlet being positioned adjacent the glass articles. A blower is positioned in the interior chamber to carry air from the inlet towards the outlet. An injector is configured to deliver the chemical compound into the interior chamber, the injector being positioned in the interior chamber at a location that is downstream of the blower. The injector extends into the interior chamber by a pre-determined distance that is selected to prevent premature vaporization of the chemical compound.

HOOD FOR METAL-OXIDE VAPOR COATING GLASS CONTAINERS

FIELD OF THE INVENTION

This invention relates to a hood for coating glass containers with a metal-oxide vapor.

BACKGROUND OF THE INVENTION

This invention is concerned with a hood for vapor coating glass containers to control the amount and placement of the metal-oxide coating on the container sidewalls and finish of the glass containers.

As described in U.S. Patent Nos. 5,599,369 and 5,140,940, which are both incorporated by reference herein in their entirety, the desirability of applying a metal-oxide coating to the exterior of a glass container has long been recognized. Such coatings, which include tin, titanium, or other reactive metallic compounds, or organometallic compounds, protect the glass container from surface damage, such as abrasions and scratches, which result in a loss of tensile strength for the glass container. The need for high tensile strength in a glass container is particularly acute when containers are mass produced, move rapidly in close proximity along high speed conveyor lines, and are subsequently filled with carbonated beverages, beer, wine, foodstuffs and the like that produce gaseous pressure within the container.

The metal-oxide coating is typically applied when the glass container emerges in a heated, fully shaped condition from a glassware forming machine, that is at the "hot end" of the system. The containers are transported away from the forming machine by a conveyor. Temperatures in excess of 400 degrees Centigrade exist at the surface of the glass containers, so that when a heat decomposable inorganic metallic, or organometallic, compound is applied thereto, the compound reacts immediately and is converted to a metal-oxide coating.

One well-known and previously widely used technique for applying a protective coating to the hot glass containers calls for spraying the opposite sides of the containers as they travel on a conveyor in single file through spray heads positioned for optimal coating of the glass surface of a particular container. Receivers

are positioned on the opposite side of the conveyor in alignment with the respective spray heads. Pressurized air or inert gas with the coating compound entrained therein is discharged from one or a plurality of spray heads at a significant positive pressure, while the receivers are usually maintained at a relatively low pressure. The resultant pressure differential increases the velocity, and thus the effectiveness, of the coating-precursor compound. Coating system of this nature are disclosed, inter alia, in U.S. Pat. No. 3,516,811, to Gatchet, et al., and U.S. Pat. No. 3,684,469, to Goetzer, et al., each of which is incorporated by reference herein in their entirety.

The above-described coating systems, however, are what may be termed "open-sided," and may be adversely influenced by ambient conditions in the facility where the glass containers are formed.

A second, well-known, and widely employed technique for applying a protective coating to hot glass containers relies upon a formed sheet-metal coating hood with spray heads and associated receivers situated therein. The hood obviates many of the problems associated with the open-ended spray systems discussed above. For example, it isolates the glass containers from ambient conditions, and furnishes a controlled atmosphere which enhances the coating operations. The hood includes an exhaust system which captures most of the air-entrained coating compound not adhering to the containers, thus reducing the problem of venting the system and minimizing the opportunity for the coating compound to attack building components. Also, that hood can significantly raise the coating efficiency of the systems, with attendant cost savings.

Coating hoods substantially representative of the prior art are disclosed in U.S. Pat. No. 3,819,404 to Scholes et al.; U.S. Pat. No. 3,933,457, to Scholes; and U.S. Pat. No. 4,389,234 to Lindner, each of which is incorporated by reference herein in their entirety. U.S. Pat. No. 4,389,234 to Lindner describes a coating hood including a tunnel for allowing containers to pass therethrough, and a vertically adjustable flat roof for accommodating containers of various sizes. At least two jet slots are located in each side wall, and at least two receivers or suction slots are aligned therewith. The jet and suction slots are interspersed opposite each other in each sidewall. The coating compound is introduced through at least one feedpoint, and blowers secured to the sidewalls furnish an inner and an outer loop of high-velocity air, of which the

inner loop contains the coating compound, to the interior of the hood. Baffles are situated in the flow path of the high-velocity air so that the jets issuing from the jet slots are well defined, and thus better suited for their intended function.

SUMMARY OF THE INVENTION

According to one aspect of the invention, an apparatus for coating glass articles with a chemical compound includes a coating hood section defining an interior chamber having an inlet and an outlet, the outlet being positioned adjacent the glass articles. A blower is positioned in the interior chamber to carry air from the inlet towards the outlet. An injector is configured to deliver the chemical compound into the interior chamber, the injector being positioned in the interior chamber at a location that is downstream of the blower.

According to another aspect of the invention, an apparatus for coating glass articles with a chemical compound includes a coating hood section defining an interior chamber; and an injector, which is configured to deliver the chemical compound into the interior chamber of the coating hood section, that extends into the interior chamber by a pre-determined distance that is selected to prevent premature vaporization of the chemical compound.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

The invention is best understood from the following detailed description when read in connection with the accompanying drawing. Included in the drawing are the following figures:

FIG. 1 depicts a side elevation view of a prior art coating hood for bottles or jars, the hood having a flat inner wall with vapor slots.

FIG. 2 depicts a cross-sectional plan view of the prior art coating hood of FIG. 1 taken along lines 2-2 of FIG. 1.

FIG. 3 depicts a plan view showing another prior art coating hood coating hood having an inner-wall configuration designed to reduce inner surface temperature.

FIG. 4 depicts a front elevation view of a coating hood, which is shown schematically, according to the instant invention.

FIG. 5 depicts a right-side elevation schematic view of the coating hood of FIG. 4.

FIG. 6 depicts a cross-sectional schematic view of the coating hood of FIG. 5 taken along the lines 6-6.

FIG. 7 depicts another cross-sectional schematic view of the coating hood of FIG. 5 (blower motors omitted), depicting the flow path of vapor through the coating hood.

FIG. 8 depicts a cross-sectional view of a segment of tubing mounted to the injector of FIG. 4.

DETAILED DESCRIPTION OF THE DRAWING FIGURES

The invention is best understood from the following detailed description when read in connection with the accompanying drawing figures, which shows exemplary embodiments of the invention selected for illustrative purposes. The invention will be illustrated with reference to the figures. Such figures are intended to be illustrative rather than limiting and are included herewith to facilitate the explanation of the present invention.

This invention is applicable to the common case of coating bottles using monobutyltinchloride (MBTC); however, the apparatus described herein is applicable generally to the coating of glass with films of tin oxide, titanium oxide or other single metal oxide, or with a mixture of a plurality thereof, using organometallic compounds, metal halides or other suitable compounds as the coating-chemical precursor.

The present invention will be best understood by a brief initial discussion of a coating hood of the prior art. FIGS. 1 and 2 show a partially schematic view of a double-vapor-loop coating hood 100 for bottles according to U.S. Pat. No. 4,389,234. Each vapor loop has blowing slots 101, and on the opposite side of the conveyor,

suction slots 102, which guide the circulating vapors at high velocity against the passing bottles 103. The liquid coating chemical is fed to each side of the hood through pipes 104 by blowers 105 from appropriate supply sources. Bottles coated in this type of hood using MBTC receive a uniform tin oxide coating at a relatively low chemical consumption. However, such hoods nevertheless require cleaning from time to time to remove crust from the interior, in order to maintain proper coating efficiency. The blowing slots 101 and suction slots 102 have flat sides 106. Under the conditions of high temperature encountered in forming glass articles, side 106 becomes hot due to the radiation of substantial amounts of heat from the bottles 103. In the coating application of the hood shown in FIG. 1, the circulating vapors can become quite hot, and, buildup of a metal oxide crust is found on the blowers, the inner walls of the hood and on the inside of suction slots 102.

Turning now to prior art FIG. 3 of U.S. Patent No. 5,140,940 to Lindner, there is shown a conventional double-loop coating hood 300 which is similar to the high-efficiency conventional coating hood of the prior art, depicted in FIGS. 1 and 2. By changing the configuration of slots 101 and 102, Linder teaches that a substantial improvement in the economy of production of glass articles can be effected.

In prior art FIG. 3, the coating hood is shown generally at 300. Blowing slots 101 and suction slots 102 of FIGS. 1 and 2 are modified as shown for blowing slots 301 and suction slots 302 in hood 300, the modification being shown as the elimination of the flat side 106, such that the side walls 310 of the blowing slots 301 and suction slots 302 meet in vertical lines 312 in the interior of the hood. As a result of the conformation of the blowing slots 301 and suction slots 302, Linder teaches that thermal radiation from the hot bottles is spread over the inner surfaces 314 of the walls of the blowing and suction slots. Lindner teaches that because inner surfaces 314 are significantly larger than the inner-wall surface of the conventional coating hood of FIG. 1, the radiation energy per unit of wall surface is reduced by a factor which is a function of the ratio of the wall surfaces of the respective slots. Therefore, the inner surface temperature in the active part of the hood is from about 50 degrees Centigrade to about 150 degrees Centigrade lower than in a conventional hood of FIGS. 1 and 2. Linder teaches that this reduces crust buildup and therefore less need for cleaning.

The pipes 104 in prior art FIGS. 1-3 distribute the liquid coating chemical at a location that is directly above the fan blades of the blowers. Consequently, the fan blades of the blowers and the areas of the hood in close proximity to the fan blades get coated with the liquid coating chemical. This is viewed as inefficient because the hoods require frequent cleaning.

Turning now to FIGS. 4-6 of the instant invention, a double vapor loop coating hood is shown generally at 400. The coating hood 400 is substantially similar to the hoods 100 and 300 of FIGS. 1-3, thus, the previous description of those hoods also applies to the coating hood 400.

The coating hood 400 generally includes two opposing hood sections 401a and 401b that are substantially identical. Although not shown, a central hood portion is positioned between the opposing hood sections 401a and 401b. Further details of the central hood portion can be found in U.S. Patent No. 4,668,268, which is incorporated by reference in its entirety for all purposes. The bottles 103 pass through an enclosed space that is defined between the opposing hood sections 401a and 401b. The enclosed space limits the escapement of the coating compound into the atmosphere.

The features the hood section 401b will be described hereinafter, however, it should be understood that the hood sections 401a and 401b are substantially identical. Thus, the foregoing description of the hood section 401b also applies to hood section 401a. The hood section 401b includes a plenum housing 402. The plenum housing 402 includes a rectangular shaped base portion 407a and a manifold portion 407b that extends from the front end of the base portion 407a.

As best shown in FIGS. 5 and 6, three substantially enclosed interior chambers 403a-403c are defined in the plenum housing 402. The interior chamber 403a of the housing 402 is defined by the following walls of the housing 402: top wall 405h, bottom wall 405g, front wall 405f, outer wall 405a, rear wall 405b, and interior wall 405c. The interior chamber 403b of the housing 402 is defined by the following walls of the housing 402: top wall 405h, bottom wall 405g, front wall 405f, interior wall 405c, interior wall 405d, and rear wall 405b. Lastly, the interior chamber 403c of the housing 402 is defined by the following walls of the housing 402: top wall 405h,

bottom wall 405g, front wall 405f, outer wall 405e, rear wall 405b, and interior wall 405d.

Referring to FIGS. 5 and 6, the interior chambers 403a and 403c are in fluid communication by virtue of a C-shaped hollow passage 406. Thus, fluid vapor travel from interior chamber 403a to chamber 403c via hollow passage 406.

Referring now to FIG. 6, a series of openings or slots 411a and 411b are defined on the front wall 405f of the plenum housing 402. Slots 411a are configured as blowing slots, whereas slots 411b are configured as suction slots. The blowing slots 411a may be referred to herein as an outlet or outlets, and the suction slots 411b may be referred to herein as an inlet or inlets. The purpose of the blowing and suction slots were described previously.

Two blowers 408 and 409 are mounted to the housing 402. Each blower 408 and 409 has a rotating fan blade 404 that is attached to a motor by a shaft. The fan blade 404 of the blower 408 is positioned in interior chamber 403b, and the fan blade 404 of the blower 408 is positioned in interior chamber 403c. The motors of the blowers 408 and 409 are optionally positioned outside of the housing 402.

In lieu of the previously-described pipes 104 that distribute the liquid coating directly onto the fan blades of a blower, the hood section 401b includes a injector 420 that is spaced from the pressure side of the blower fan blade 404 to reduce the potential for coating the fan blades and the surrounding areas of the housing 402 with the liquid coating chemical. Such positioning of the injector 420 simplifies cleaning of the hood section 401b and also maximizes the volume of the liquid coating chemical that is applied to the surfaces of the bottle 103.

As shown in FIG. 4, the injector 420 is mounted to the top wall 405h of the housing 402 adjacent to the fan blade 404 of the blower 408. The proximal end of the injector 420 is fluidly connected to a conduit 430 (a portion of which is shown) through which liquid coating chemical is distributed from a liquid coating supply (not shown). The side wall 405e of the housing 402 is partially cut-away to reveal the distal end of the injector 420.

As shown in FIG. 4, the distal end of the injector 420 of the hood section 401b is positioned downstream of the blower fan blade 404, and is spaced axially by a distance 'D1' from the blower fan blade 404. Distance D1 may be 0.5 to 5 inches, for example. It should be understood that distance D1 is not limited to any particular dimension.

The distal end of the injector 420 extends into the interior of the manifold portion 407b of the housing 402 by a distance 'D2.' Distance D2 may be 0.1 to 2 inches, for example. According to one exemplary aspect of the invention, distance D2 is 0.25 inches. It should be understood that distance D2 is not limited to any particular dimension.

Although not shown, another injector 420 may be mounted to the top wall 405h of the housing 402 in the vicinity of the other blower 409 of the hood section 401b.

FIG. 8 depicts a cross-sectional view of the hollow conduit 430 mounted to the injector 420. The injector 420 includes a feed insert 432 and a nut 434 that is threadedly mounted to the feed insert 432. The nut 434 includes an exterior threaded section 436 that is threadedly engaged with interior threads 438 of the feed insert 432. The feed insert 432 includes a threaded region 433 on its exterior surface that is threadedly engaged with a threaded region (not shown) that is provided on the top wall 405h of the housing 402 (see FIG. 4).

The hollow conduit 430, feed insert 432 and nut 434 each have a substantially cylindrical hollow body. The hollow conduit 430 is positioned through a central bore 440 that is defined through the nut 434. The conduit 430 also extends into a central bore 446 that is defined through the feed insert 432. Upon threadedly mating the nut 434 onto the feed insert 432, the nut 434 may apply a radial pressure onto the hollow conduit 430, thereby retaining the hollow conduit 430 in a substantially fixed position within the hole 440 of the nut 434. The terminal end 442 of the hollow conduit 430 bears on a diagonal shoulder 444 that is defined on the central bore 446. The diagonal shoulder 444 and the central bore 446 of the feed insert 432 are sized to prevent the terminal end 442 of the hollow conduit 430 from passing into the interior of the housing 402 of the hood section 401b.

As noted above, the vertical distance D2, which the distal end of the feed insert 432 protrudes into the manifold portion 407b of the hood section 401b, is carefully selected to prevent the premature vaporization of the liquid coating chemical within the distal end of the conduit 430 or the bore 446 of the feed insert 432. The accumulation of vaporized coating chemical on the interior surfaces of the conduit 430 and/or the bore 446 of the feed insert 432 could result in a blockage within the injector 420.

Referring back to FIG. 7, according to one exemplary method of operating the double vapor loop coating hood 400, the blowers 408 and 409 of each hood section 401a and 401b are first activated. The coating chemical is then delivered into the chamber 403b of each hood section 401a and 401b via the injectors 420. Thereafter the bottles 103 are conveyed along a path between the hood sections 401a and 401b, as indicated by arrow 454.

As noted above, the coating hood 400 has a double vapor loop. The primary loop 450 is depicted by air streams 450a-450d, whereas, the recycle loop 452 is depicted by air streams 452a-452d.

In the primary loop 450, the pressure side of the blowers 408 in the hood sections 401a and 401b propel air streams 450c and 450a past the injectors 420 of the hood sections 401a and 401b, respectively. Upon mixing with the coating chemical that is distributed by the injectors 420, the air streams 450c and 450a become entrained with vaporized coating chemical. The coating entrained air streams 450c and 450a are propelled out of the blowing slots 441a that are associated with the interior chambers 403b of the hood sections 401a and 401b, respectively, by the pressure side of the blowers 408. The coating entrained streams 450c and 450a pass over the bottles 103 that are positioned in front of those blowing slots 441a that are associated with the interior chambers 403c of the hood sections 401a and 401b, respectively, thereby coating the bottles 103 with the vaporized coating chemical.

The vacuum side of the blowers 408 of the hood sections 401a and 401b draws the air streams 450a and 450c through the suction slots 441b and into the interior chambers 403b of the hood sections 401a and 401b, respectively. The vacuum side of the blowers 408 of the hood sections 401a and 401b draws the coating entrained air

streams 450b and 450d through the interior chambers 403 of the hood sections 401a and 401b, respectively. The primary loop then repeats as the pressure side of the blowers 408 propels the air streams 450c and 450a past the injectors 420 of the hood sections 401a and 401b, respectively.

As described above, the coating entrained air streams 450a and 450c contact the bottles 103. As the coating entrained air streams 450a and 450c contact the bottles 103, a portion of the coating entrained air streams 450a and 450c scatters outward toward the outer periphery of the hood sections. That scattered portion of the coating entrained air streams 450a and 450c is captured in the recycle loop 452.

In the recycle loop 452, the pressure side of the blowers 409 in the hood sections 401a and 401b propel air streams 452a and 452c out of the blowing slots 441a that are associated with the interior chambers 403c of the hood sections 401a and 401b, respectively. The air streams 452a and 452c mix with the scattered portion of the coating entrained air streams 450a and 450c of the primary loop 450. The coating entrained streams 452a and 452c of the recycle loop 452 pass over the bottles 103 that are positioned in front of those blowing slots 441a that are associated with the interior chambers 403c of the hood sections 401a and 401b, respectively, thereby twice coating the bottles 103 with the vaporized coating chemical.

As noted previously, the interior chambers 403a and 403c of each hood section are fluidly connected by passage 406. Thus, it follows that the vacuum side of the blowers 409 that are positioned in the interior chambers 403c of the hood sections 401b and 401a draw the coating entrained air streams 452a and 452c through the suction slots 441b that are associated with the interior chambers 403a of the hood sections 401b and 401a, respectively. The vacuum side of the blowers 409 then draw the air streams 452d and 452b through the passage 406 and into the interior chambers 403c of the hood sections 401b and 401a, respectively. The recycle loop then repeats as the pressure side of the blowers 409 in the hood sections 401a and 401b propel air streams 452a and 452c out of the blowing slots 441a that are associated with the interior chambers 403c of the hood sections 401a and 401b, respectively.

It should be understood that the above described method is not limited to any particular step or sequence of steps.

While preferred embodiments of the invention have been shown and described herein, it will be understood that such embodiments are provided by way of example only. Numerous variations, changes and substitutions will occur to those skilled in the art without departing from the spirit of the invention. Accordingly, it is intended that the appended claims cover all such variations as fall within the spirit and scope of the invention.

What is claimed:

1. An apparatus for coating glass articles with a chemical compound comprising:

a coating hood section defining an interior chamber having an inlet and an outlet, the outlet being positioned adjacent the glass articles,

a blower positioned in the interior chamber to carry air from the inlet towards the outlet; and

an injector that is configured to deliver the chemical compound into the interior chamber, the injector being positioned in the interior chamber at a location that is downstream of the blower.

2. The apparatus of claim 1, wherein the injector is positioned adjacent the outlet of the interior chamber.

3. The apparatus of claim 1, wherein the injector is positioned on a pressure side of the blower.

4. The apparatus of claim 1, wherein the apparatus includes two coating hood sections that are positioned opposite each other.

5. The apparatus of claim 1, wherein the coating hood section includes another interior chamber and an additional blower that is positioned in said another interior chamber, the additional blower being configured to carry air from the outlet towards the inlet of said another interior chamber.

6. The apparatus of claim 1, wherein the coating hood assembly includes only one injector.

7. The apparatus of claim 1, wherein the injector extends at least partially within the interior chamber.

8. The apparatus of claim 7, wherein the injector extends into the interior chamber by a pre-determined distance that is selected to prevent premature vaporization of the chemical compound.

9. The apparatus of claim 1, wherein the injector is positioned between the outlet of the interior chamber and the blower.

10. An apparatus for coating glass articles with a chemical compound comprising:

a coating hood section defining an interior chamber; and

an injector, which is configured to deliver the chemical compound into the interior chamber of the coating hood section, extending into the interior chamber by a pre-determined distance that is selected to prevent premature vaporization of the chemical compound.

11. The apparatus of claim 10, wherein the pre-determined distance is about 0.25 inches.

12. The apparatus of claim 10 further comprising a blower that is configured to deliver air into the interior chamber that is to be mixed with the chemical compound.

13. The apparatus of claim 12, wherein the injector is positioned in the interior chamber at a location that is downstream of the blower.

14. The apparatus of claim 10 further comprising a conduit that is connected to the injector through which the chemical compound is transported to the injector.

15. The apparatus of claim 14 further comprising a shoulder formed in the injector, wherein an end of the conduit bears on the shoulder of the injector to prevent further movement of the conduit toward the shoulder.

16. The apparatus of claim 14, wherein the conduit does not extend into the interior chamber.

17. The apparatus of claim 10 further comprising a threaded region defined on the injector that is connected to a surface of the coating hood section.

18. The apparatus of claim 10, wherein the injector comprises a central bore through which the chemical compound is distributed into the interior chamber.

FIG. 1
PRIOR ART

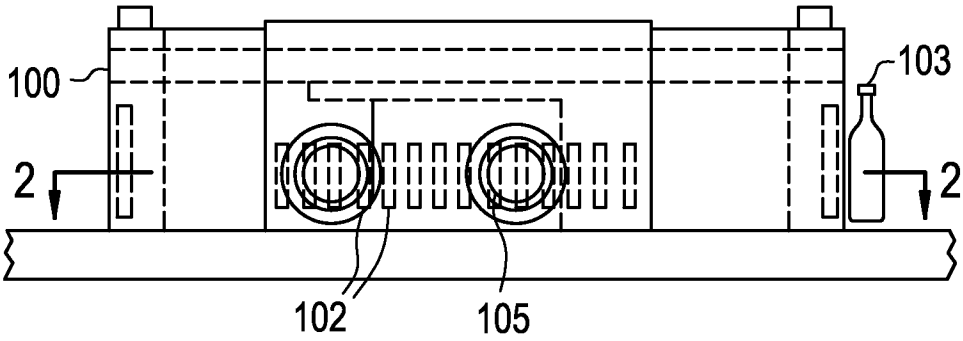


FIG. 2
PRIOR ART

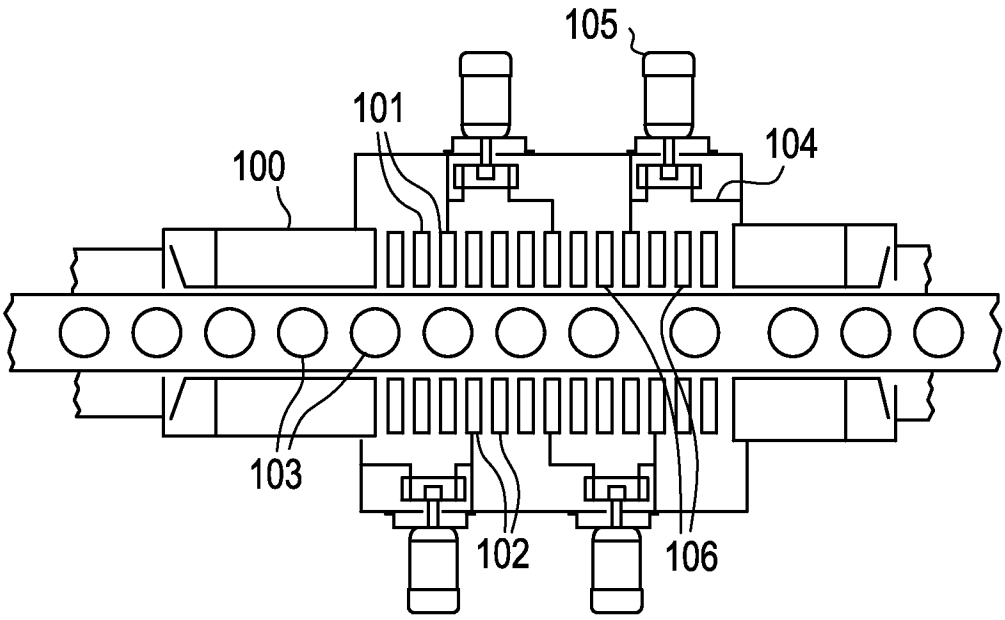


FIG. 3
PRIOR ART

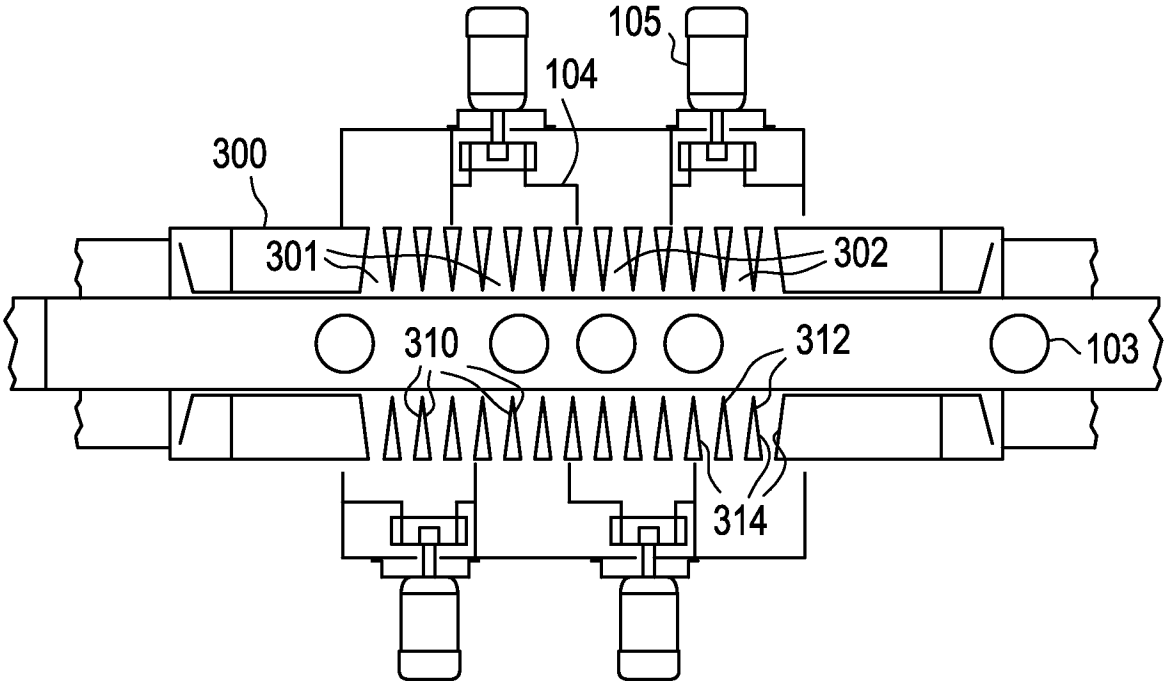


FIG. 4

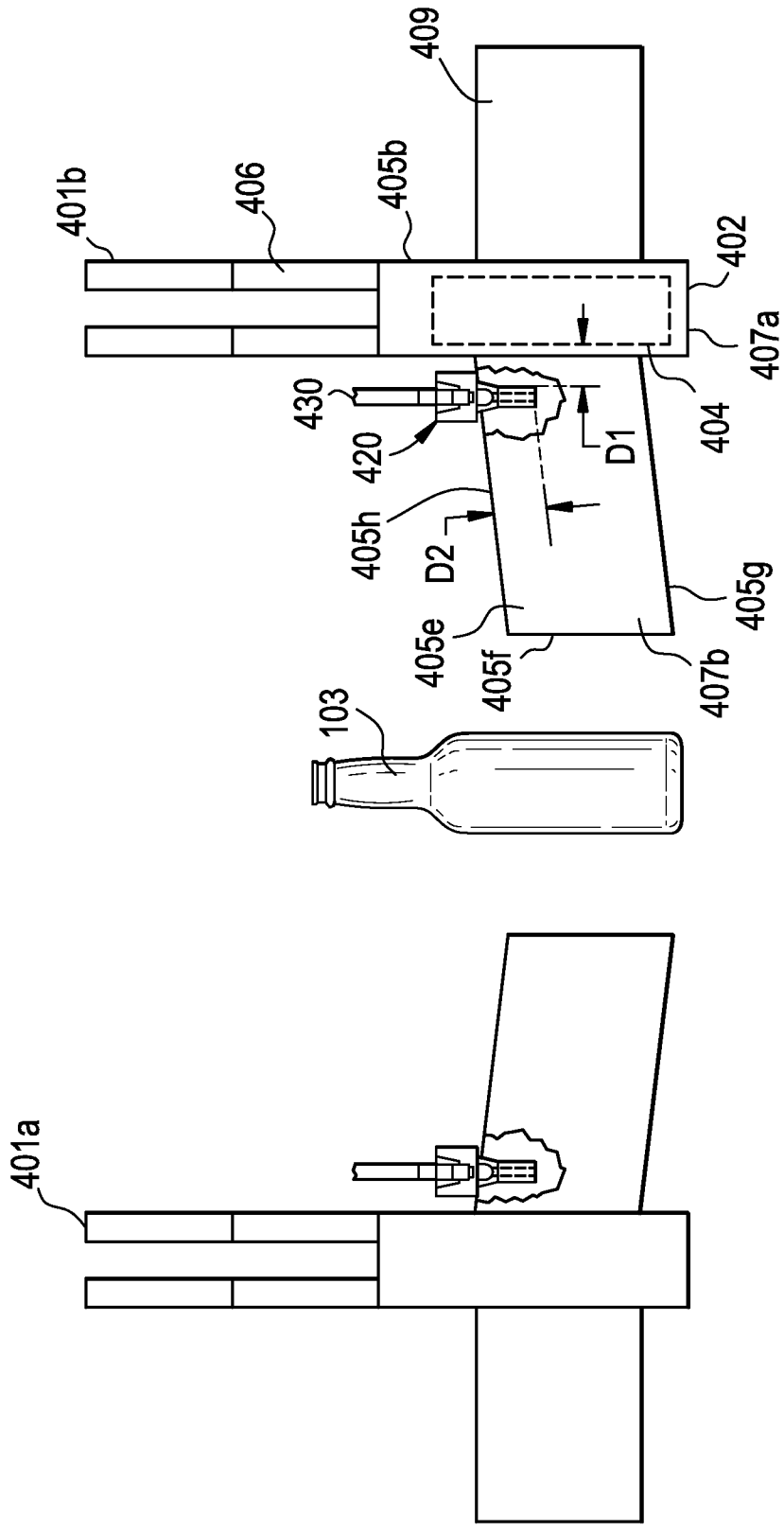

409
401b
406
405b
402
407a
430
420
404
D1
405h
D2
405g
405e
405f
407b
103
401a

FIG. 5

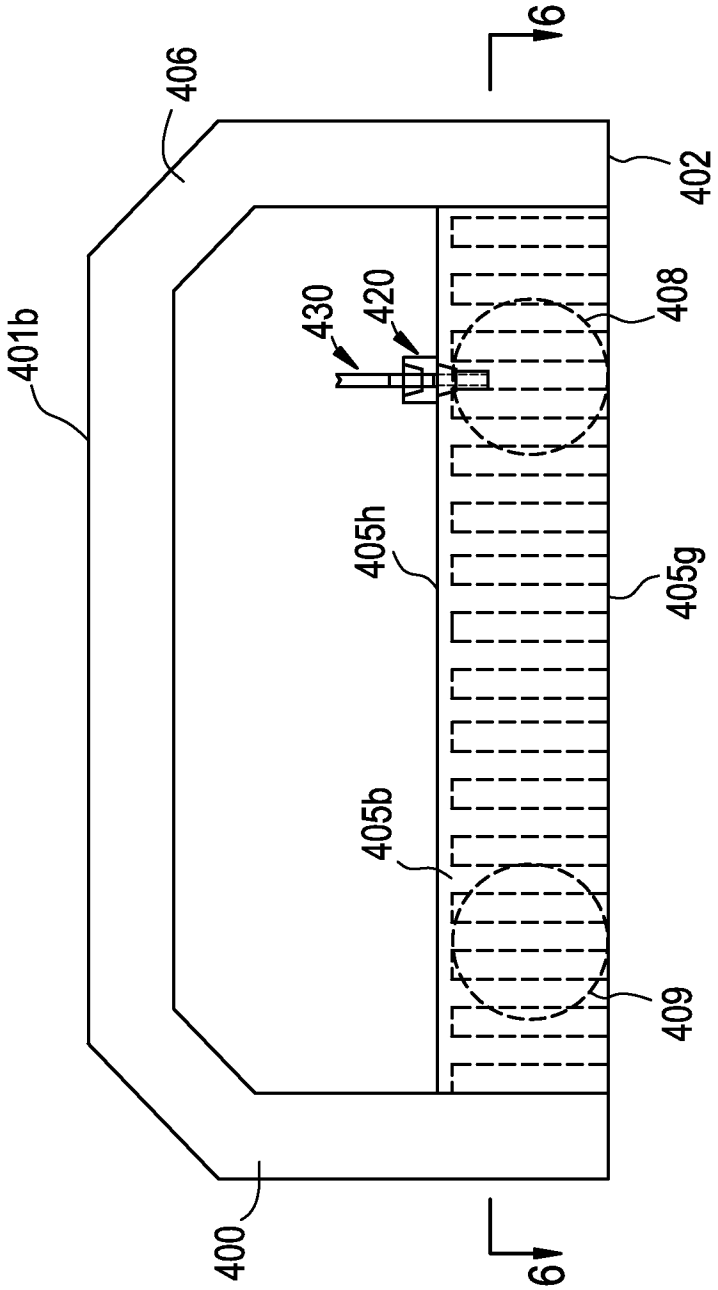


FIG. 6

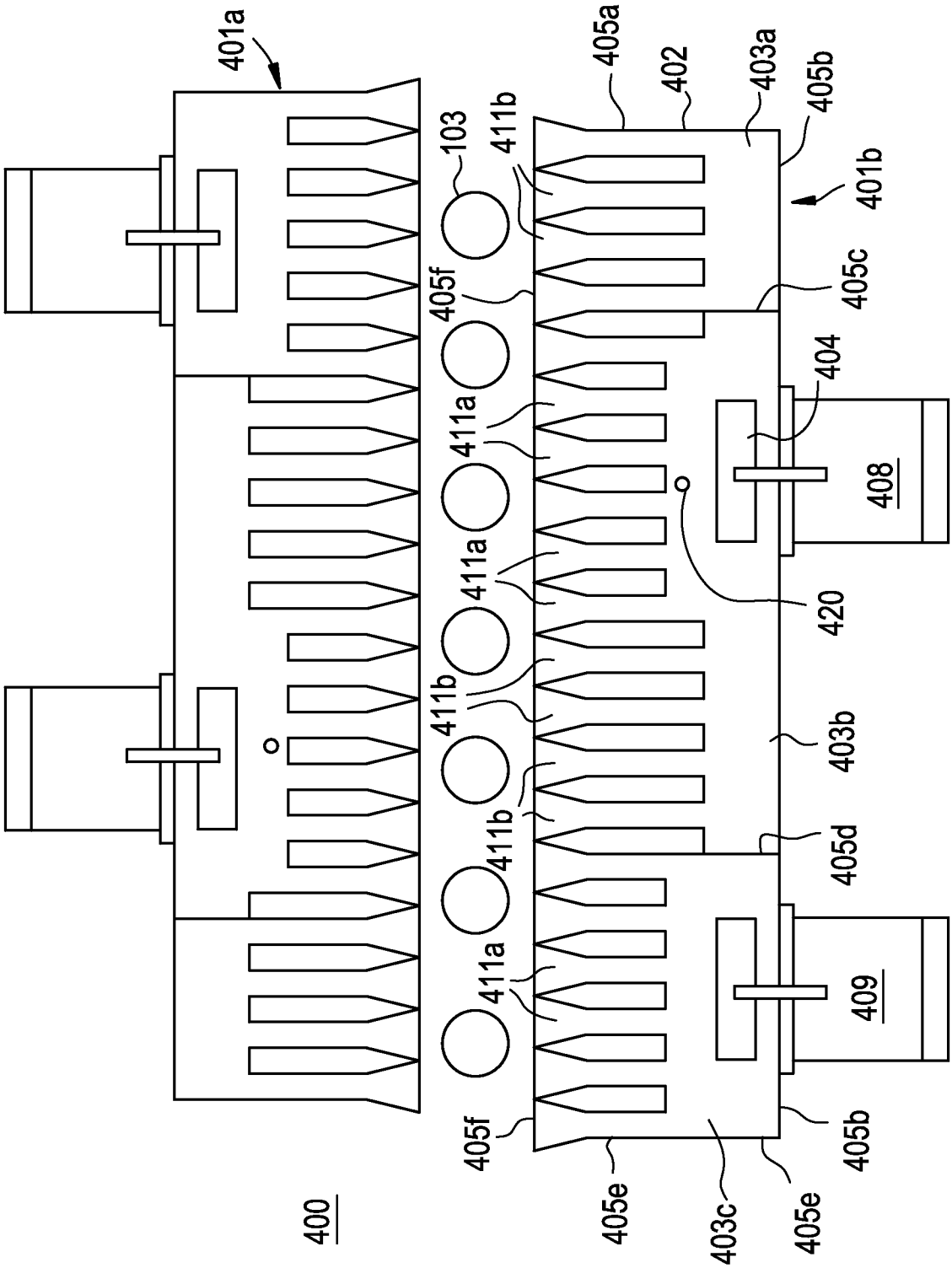

401a
405a
402
403a
405b
401b
103
411b
405f
405c
404
411a
408
420
411b
403b
411b
405d
411a
409
405f
405b
405e
403c
405e
400

FIG. 7

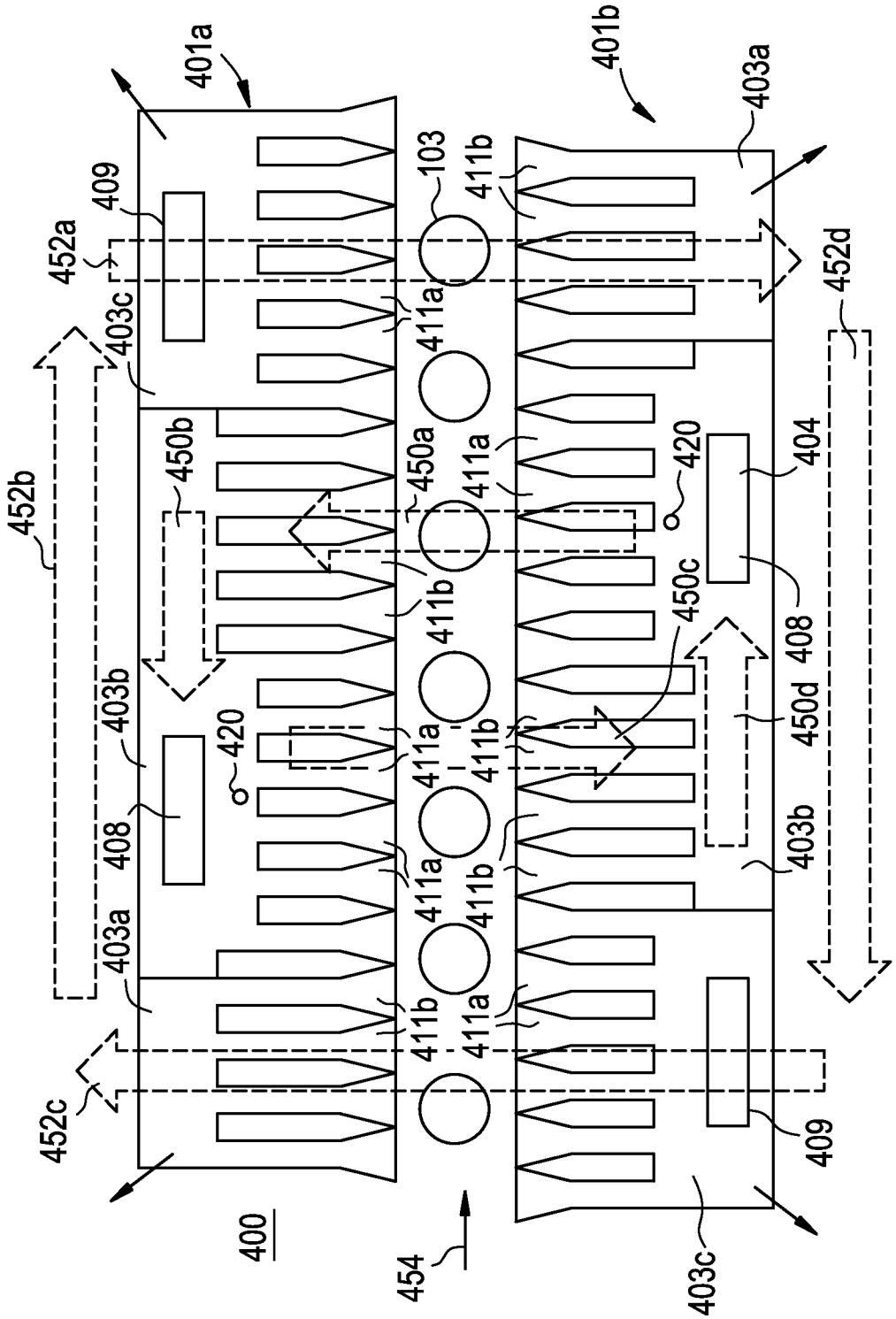
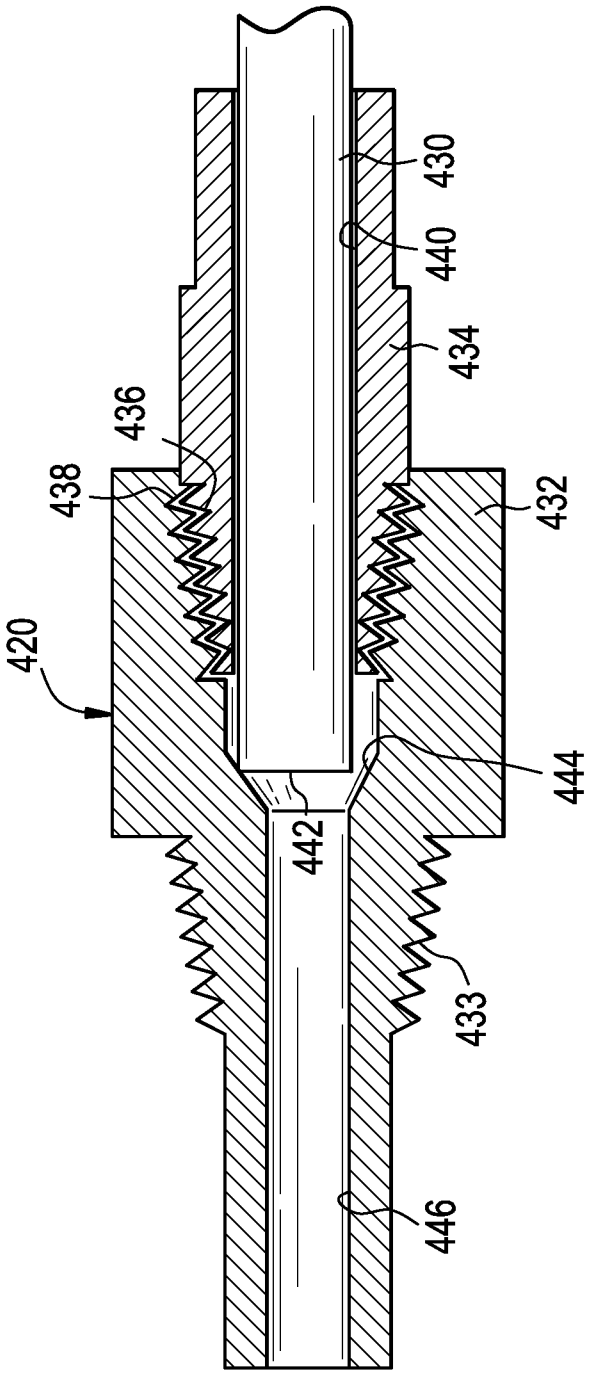

401a
401b
403a
409
103
411b
452a
403c
411a
452d
452b
450b
450a
420
404
450c
411b
408
403b
450d
420
411a
411b
408
403b
411a
411b
403a
411b
411a
452c
409
400
454
403c

FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/037520

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - C23C 16/00 (2013.01)
USPC - 118/720
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - C03C 17/09; C23C 16/00 (2013.01)
USPC - 65/60.1, 60.5, 157; 118/602, 715, 720, 723; 427/255

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - C03C 17/09; C23C 16/00 (2013.01)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,454,873 A (SCHOLES et al) 03 October 1995 (03.10.1995) entire document	1-4,6,7,9
Y		5,8,11,13,16
X	US 5,599,369 A (TOWNSEND et al) 04 February 1997 (04.02.1997) entire document	10,12,14
Y		5,8,11,13,15-18
Y	US 2011/0232568 A1 (O'MOORE et al) 29 September 2011 (29.09.2011) entire document	15,17,18
A	US 5,140,940 A (LINDNER) 25 August 1992 (25.08.1992) entire document	1-18
A	WO 96/20142 A1 (HOFER et al) 04 July 1996 (04.07.1996) entire document	1-18

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 July 2013	30 JUL 2013
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)