

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

JUUL LABS, INC.,

Petitioner,

v.

NJOY, LLC,

Patent Owner.

Case No. IPR2023-00161

U.S. Patent No. 10,334,881

**DECLARATION OF ROBERT H. STURGES REGARDING
U.S. PATENT NO. 10,334,881**

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I, Robert H. Sturges, Ph.D., being of legal age, hereby declare, affirm, and state the following:

I. INTRODUCTION

1. I have been retained by JUUL Labs, Inc. (“JLI” or “Petitioner”), as an independent expert in this proceeding before the Patent Trial and Appeal Board (“PTAB” or “Board”). I understand that JLI is requesting that the Board institute an Inter Partes Review (“IPR”) proceeding of U.S. Patent No. 10,334,881 (the “’881 patent”) (Ex. 1001) in IPR2023-00161.

2. I am providing this testimony for consideration by the Patent Trial and Appeal Board in this proceeding. I have personal knowledge of the facts and opinions set forth in this declaration and all of the opinions and conclusions found in this declaration are my own.

3. I am being compensated at my standard hourly rate, of \$635, for my services. I am also being reimbursed for reasonable and customary expenses associated with my work and time in this investigation. I have no personal or financial stake or interest in the outcome of the present proceedings, and my compensation is not dependent in any way upon the outcome of this proceeding.

II. QUALIFICATIONS AND EXPERIENCE

4. I am currently a Professor Emeritus at Virginia Polytechnic Institute (“Virginia Tech”). I retired from Virginia Tech on September 1, 2017 after 20 years

of service as a Professor in the Department of Mechanical and Industrial Systems Engineering. I continue to work on projects with current Ph.D. level graduate students at Virginia Tech's Corporate Research Center.

5. Prior to joining Virginia Tech, I was first an Assistant Professor and then later an Associate Professor in the Mechanical Engineering Department at Carnegie Mellon University from 1987 to 1997.

6. In my past work, I have extensively studied and designed various fluid power systems, including a robotic arm and robotic end effectors. In the latter, I applied fluid "resistors" that rely on porous media to provide resistance to flow. I have also applied heat transfer fundamentals to design and build variations of commercial steam engines used in my undergraduate labs at Carnegie Mellon University and my graduate course in Sustainability at Virginia Tech. In addition, I have taught undergraduate courses focused on fundamental mechanics and the conservation of energy, including basic principles of fluid flow and heat transfer.

7. I earned my combined Bachelor of Science and Master of Science degrees, in Mechanical Engineering, from the Massachusetts Institute of Technology in June 1969.

8. I earned my Ph.D., in Mechanical Engineering, from Carnegie Mellon University in December of 1986.

9. Based on my background, experience, education and professional activities, I consider myself an expert in the fields of mechanical design, mechatronics, and manufacturing, including systems that employ heat, mass and fluid transfer.

10. I believe I meet the criteria for a person having ordinary skill in the art (“POSITA”) for this patent.

11. Additional details about my employment history, fields of expertise, and publications are further described in my curriculum vitae, which is attached as Exhibit A to this report.

III. MATERIALS CONSIDERED

12. In forming my opinion I have relied on the following documents:

Petitioner’s Exhibit List	Description
1001	U.S. Patent No. 10,334,881 (“’881 Patent”)
1002	Patent Prosecution History of the ’881 Patent
1003	<i>NJOY, LLC v. JUUL Labs, Inc.</i> , C.A. No. 1:23-cv-00917 (D. Del.), Complaint filed on August
1004	Certified English Translation of Chinese Patent Publication No. CN201238610 (“Xia”)
1005	Certified English Translation of Chinese Patent Publication No. CN101366554 (“Wang”)
1006	Certified English Translation of Chinese Patent No. CN 201085044Y (“Fang”)
1007	Declaration of Robert Sturges and CV

Petitioner's Exhibit List	Description
1008	Chinese National IP Association ("CNIPA") Database Search Results (For Xia);
1009	Global Dossier - United States Patent and Trademark Office Search Results for Xia
1010	European Patent Office Search Results Espacenet (For Xia)
1011	Chinese National IP Association ("CNIPA") Database Search Results for Fang
1012	Global Dossier - United States Patent and Trademark Office Search Results for Fang
1013	European Patent Office Search Results Espacenet for Fang
1014	<i>Fuma International LLC v. R.J. Reynolds Vapor Company</i> , Case No. 1:19-cv-260, D.I. 122 (M.D.N.C., October 20, 2020) (RJR Brief)
1015	<i>Fuma International LLC v. R.J. Reynolds Vapor Company</i> , Case No. 1:19-cv-260, D.I. 139 (M.D.N.C., May 24, 2021) (MSJ Order)
1016	August 22, 2006 Tariff Classification for Nicotine Inhaler and Parts From China
1017	<i>Fuma International LLC v. R.J. Reynolds Vapor Company</i> , Case No. 1:19-cv-260, D.I. 76-47 (December 20, 20109) (Declaration of Wang Shanhong)
1018	<i>Fuma International LLC v. R.J. Reynolds Vapor Company</i> , Case No. 1:19-cv-260, D.I. 83 (January 13. 2020) (Fuma CC Brief)
1019	10-13-2023_NJOY Email_Re_Alleged Priority Date (<i>See In Re Vaporizer Devices, Cartridges Used Therewith, and Components Thereof</i> , before the International Trade Commission, 337-TA-1372)

Petitioner's Exhibit List	Description
1020	<i>Fuma International LLC v. R.J. Reynolds Vapor Company</i> , Case No. 1:19-cv-260, D.I. 95 (March 23, 2020) (Markman Order)
1021	<i>Fuma International LLC v. R.J. Reynolds Vapor Company</i> , Case No. 1:19-cv-260, D.I. 133 (November 25, 2020) (Fuma SJ Brief)
1022	<i>In Re Vaporizer Devices, Cartridges Used Therewith, and Components Thereof</i> , 337-TA-1368, NJOY's Initial Invalidity Contentions and Exhibits
1023	<i>Fuma International LLC v. R.J. Reynolds Vapor Company</i> , Case No. 1:19-cv-260, Conley Deposition Transcript
1024	<i>Fuma International LLC v. R.J. Reynolds Vapor Company</i> , Case No. 1:19-cv-260, Conley Deposition Ex. 2A
1025	<i>Fuma International LLC v. R.J. Reynolds Vapor Company</i> , Case No. 1:19-cv-260, Dkt. 120 (Fuma Brief)
1026	Affidavit for Certified English Translation of Chinese Patent Publication No. CN201238610 ("Xia")
1027	Chinese Patent Publication No. CN201238610 ("Xia")
1028	Affidavit for Certified English Translation and Chinese Patent Publication No. CN101366554 ("Wang")
1029	Chinese Patent Publication No. CN101366554 ("Wang")
1030	Affidavit for Certified English Translation and Chinese Patent No. CN 201085044Y ("Fang")
1031	Chinese Patent No. CN 201085044Y ("Fang")
1032	337-TA-1372 NJOY's Initial Domestic Industry Contentions Ex. 4

Petitioner's Exhibit List	Description
1033	337-TA-1372 NJOY's Infringement Allegations Filed With Complaint, Ex. 9

IV. PRIORITY DATE

13. I have been instructed to use July 27, 2009 as the alleged priority date for the purposes of this declaration. I note for example, that the '881 patent claims priority to multiple provisional applications, the earliest of which was filed on July 27, 2009. I also understand that a date of conception and reduction to practice of July 28, 2009 has been alleged by the patent owner in other proceedings involving the '881 patent. At this stage, I take no position on whether the claim to that date is proper because my analysis does not change under either date.

V. PERSON OF ORDINARY SKILL IN THE ART

14. I understand that a person of ordinary skill in the art ("POSITA") is a hypothetical person who is presumed to be aware of pertinent art, including knowledge in the art, thinks along conventional wisdom in the art, and is a person of ordinary creativity.

15. I understand that this hypothetical person of ordinary skill in the art is considered to have the normal skills and knowledge of a person in the technical field.

16. In the previous North Carolina district court litigation (*Fuma International LLC v. R.J. Reynolds Vapor Company*, Case No. 1:19-cv-260 (M.D.N.C. 2019)), the then-owner of the '881 patent asserted that a POSITA at the time of the purported invention would have had a mechanical or electrical engineering degree, industrial design degree, or a similar technical degree, or equivalent work experience, and 5 to 10 years of experience in electromechanical devices. I meet these qualifications and did as of the alleged priority date of the '881 patent of July 27, 2009.

17. Based on my experience, I have a good understanding of the capabilities of a person of ordinary skill in the art in the time frame leading up to the claimed priority date of the '881 patent. I have personal experience in these areas, as well as, working with, and training, persons of ordinary skill in the art as of July 27, 2009, and earlier, and I am knowledgeable as to what a person of ordinary skill in the art would have understood from the prior art references described below and from the state of the art at the time.

VI. LEGAL STANDARDS

A. Claim Construction

18. In preparing and expressing my opinions and considering the subject matter of the '881 patent, I am relying on certain basic legal principles that counsel has explained to me. These principles are discussed below.

19. I understand that the scope of a patent is defined by its claims. I understand that a claim can be:

- a. a method claim, which covers a process/activity, or
- b. an apparatus claim, which covers a physical machine, etc.

20. I understand that the first step in determining the validity of a claim is for the claim to be properly construed. I have been further advised that, in an *inter partes* review proceeding, the claims of a patent are typically given their ordinary and customary meaning as would be understood by one of ordinary skill in the art in the context of the claims and the patent disclosure (specification).

21. I further understand that an inventor can provide special definitions for specific claim term(s) within the patent. However, any special definition for a claim term must be set forth in the specification with reasonable clarity and precision.

B. Invalidity

22. I have been informed that a claim may be invalid as obvious if the subject matter described by the claim as a whole would have been obvious to a POSITA at the time the claimed invention was made. I understand that the standard for obviousness in an *inter partes* review proceeding is by a preponderance of the evidence.

23. I have also been informed that a determination of obviousness involves an analysis of the scope and content of the prior art, the similarities between the

claimed invention and the prior art, and the level of ordinary skill in the art. I have been informed and understand that a prior art reference should be viewed as a whole.

24. I have been informed that in considering whether an invention for a claimed combination would have been obvious, I may assess whether there are apparent reasons to combine known elements in the prior art in the manner claimed in view of interrelated teachings of multiple prior art references, the effects of demands known to the design community or present in the market place, and/or the background knowledge possessed by a POSITA. I also understand that other principles may be relied on in evaluating whether a claimed invention would have been obvious.

25. I have been informed that, in making a determination as to whether or not the claimed invention would have been obvious to a POSITA, one may consider certain objective indicators of non-obviousness if they are present, such as: commercial success of product(s) practicing the claimed invention; long-felt but unsolved need; teaching away; unexpected results; copying; and praise by others in the field. I understand that for such objective evidence to be relevant to the non-obviousness of a claim, however, there must be a causal relationship (called a “nexus”) between the claim and the evidence. I also understand that this nexus must be based on a novel element of the claim rather than something available in the prior art.

26. I have also been informed and understand that when considering the obviousness of a patent claim, one should consider whether a reason or motivation existed for combining the elements of the references in the manner claimed, and that the prior art must create a reasonable expectation of success in producing the claimed subject matter.

VII. TABLE OF CLAIMS

Claim 1	Claim 1 Shorthand ¹
1[p] An apparatus comprising:	1[p] apparatus
1[a1] a power source,	1[a1] power source
1[a2] wherein the power source includes a battery,	1[a2] battery
1[a3] wherein the power source includes an electrically conductive portion; and,	1[a3] electrically conductive portion of power source
1[b1] a cartridge having a housing that comprises an interior,	1[b1] cartridge housing interior
1[b2] wherein the housing includes a first end and a second end that is opposite the first end, wherein the housing includes a first aperture on the first end and a second aperture on the second end,	1[b2] two ends/two apertures
1[c] wherein the housing includes an airflow passageway that extends centrally and axially with respect to the housing intermediate of the first aperture on the first end of the housing and the second aperture on the second end of the housing,	1[c] central/axial airflow passageway between apertures

¹ Shorthand is for convenience only, is not controlling, and is not the basis for the analysis herein.

1[d] wherein the airflow passageway is configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing	1[d] airflow passageway/airflow between apertures
1[e] wherein the first end of the housing includes an electrically conductive portion that is adapted to mechanically and electrically couple to the electrically conductive portion of the power source,	1[e] conductive First End to Power Source
1[f] wherein the housing includes a solution holding medium adapted to hold a solution in the interior of the housing,	1[f] solution holding medium
1[g] wherein the housing includes a heating element located in the interior of the housing, wherein the heating element extends transversely across the airflow passageway, wherein the airflow through the passageway passes on both transverse sides of the element,	1[g] heating element in housing, transverse to airflow
1[h] wherein the solution holding medium surrounds the airflow passageway and the heating element in the interior of the housing and intermediate of the first end and the second end,	1[h] surrounds passageway and heating element
1[i] wherein the heating element is electrically configured to vaporize at least a portion of the solution to be contained in the solution holding medium for oral provision to an individual in an airflow from the second aperture responsive to electrical power received from the battery through the electrically conductive portions of the cartridge and the power source.	1[i] electrical heating element to vaporize liquid for delivery via second aperture
Claim 2	Claim 2 Shorthand
[2] The cartridge of claim 1, wherein the heating element is a coil having a maximum diameter, the airflow passageway having a length having a circular cross section having a diameter along a majority of the length, the maximum diameter of the coil being smaller than the diameter of the	[2] coil diameter less than passageway cross section

circular cross section of the length of the airflow passageway.	
Claim 3	Claim 3 Shorthand
[3] The cartridge of claim 2, wherein the first aperture on the first end is located centrally and axially with respect to the housing, the first aperture having a cross-sectional area measured perpendicular to a central longitudinal axis of the housing, the interior of the airflow passageway between the heating element and the second aperture being no smaller in cross-sectional area than the cross-sectional area of the first aperture.	[3] central/axial first aperture equal to or smaller than airflow passageway and second aperture
Claim 4	Claim 4 Shorthand
[4] The cartridge of claim 3, wherein the first aperture on the first end is smaller than the second aperture on the second end.	[4] first aperture smaller than second aperture
Claim 5	Claim 5 Shorthand
[5] The cartridge of claim 1, wherein the solution holding medium includes at least one of an absorbent material and a reservoir.	[5] absorbent material or reservoir
Claim 6	Claim 6 Shorthand
[6] The cartridge of claim 1, further comprising a solution in the solution holding medium, the solution comprising one of propylene glycol and nicotine.	[6] propylene glycol or nicotine solution
Claim 7	Claim 7 Shorthand
[7] The cartridge of claim 1, wherein the airflow passageway has a uniform cross-sectional area measured perpendicular to a central longitudinal axis of the housing between the heating element and the second aperture.	[7] uniform airflow passageway between the heating element and the second aperture
Claim 8	Claim 8 Shorthand

8[p] A cartridge configured to mechanically and electrically couple to a power source of an electronic vaporizer, the cartridge comprising:	8[p] electrical/mechanical cartridge
8[a1] a housing having an interior and a solution holding medium reservoir adapted to hold a solution,	8[a1] reservoir
8[a2] the housing having a first end and a second end that is opposite the first end, the housing having a first aperture on the first end and a second aperture on the second end,	8[a2] two ends/two apertures
8[a3] the first end of the housing having an electrically conductive portion adapted to mechanically and electrically couple to the electrically conductive portion of the power source;	8[a3] conductive first end to power source
8[b1] an airflow passageway in the interior of the housing extending centrally and axially with respect to the housing intermediate of the first aperture on the first end of the housing and the second aperture on the second end of the housing,	8[b1] central/axial airflow passageway between apertures,
8[b2] the airflow passageway being configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing; and	8[b2] airflow passageway allows airflow between apertures
8[c1] a heating element located in the interior of the housing, the heating element being located within and extending transversely across the airflow passageway, the airflow through the passageway passing on both transverse sides of the heating element,	8[c1] heating element in housing and transverse to airflow
8[c2] both the heating element and the airflow passageway being surrounded by the solution holding medium reservoir,	8[c2] solution holding medium reservoir surrounding airflow passageway and heating element
8[c3] the heating element being electrically configured to vaporize at least a portion of the solution to be contained in the solution holding	8[c3] electrical heating element to vaporize liquid

medium reservoir for oral provision to an individual in an airflow from the second aperture responsive to electrical power received from the battery through the electrically conductive portions of the cartridge and the power source.	for delivery via second aperture
Claim 9	Claim 9 Shorthand
[9] The cartridge of claim 8, further in combination with the power source including a battery and the electrically conductive portion, the electrically conductive portion of the power source being mechanically and electrically coupled to the electrically conductive portion of the first end of the housing.	[9] power source and first end electrically/mechanically coupled.
Claim 10	Claim 10 Shorthand
[10] The cartridge of claim 9, wherein the heating element is a coil having a maximum diameter, the airflow passage way having a length having a circular cross section having a diameter along a majority of the length, the maximum diameter of the coil being smaller than the diameter of the circular cross section of the length of the airflow passageway.	[10] coil heating element with max. diameter relative to circular airflow passageway
Claim 11	Claim 11 Shorthand
[11] The cartridge of claim 10, wherein the first aperture on the first end is located centrally and axially with respect to the housing, the first aperture having a cross-sectional area measured perpendicular to a central longitudinal axis of the housing, the interior of the airflow passageway between the heating element and the second aperture being no smaller in cross-sectional area than the cross-sectional area of the first aperture.	[11] central/axial first aperture equal to or smaller than airflow passageway and second aperture
Claim 12	Claim 12 Shorthand

[12] The cartridge of claim 11, wherein the first aperture on the first end is smaller than the second aperture on the second end.	[12] first aperture smaller than second aperture
Claim 13	Claim 13 Shorthand
[13] 13. The cartridge of claim 8, wherein the solution holding medium reservoir includes an absorbent material.	[13] absorbent material
Claim 14	Claim 14 Shorthand
[14] The cartridge of claim 8, further comprising a solution in the solution holding medium reservoir, the solution comprising one of propylene glycol and nicotine.	[14] propylene glycol and nicotine solution
Claim 15	Claim 15 Shorthand
[15] The cartridge of claim 8, wherein the airflow passageway has a uniform cross-sectional area measured perpendicular to a central longitudinal axis of the housing between the heating element and the second aperture.	[15] uniform airflow passageway between the heating element and the second aperture
Claim 16	Claim 16 Shorthand
16[p] A cartridge configured to mechanically and electrically couple to a power source of an electronic vaporizer, the cartridge comprising:	16[p] electrical/mechanical cartridge:
16[a1] a housing having an interior and a solution holding medium adapted to hold a solution in the interior of the housing,	16[a1] solution holding medium
16[a2] the housing having a first end and a second end that is opposite the first end, the housing having a central longitudinal axis extending through the first end and the second end, the housing having a first aperture on the first end and a second aperture on the second end,	16[a2] two ends/two apertures and housing with axis
16[a3] the first aperture having a cross-sectional area measured perpendicular to the central longitudinal axis of the housing,	16[a3] first aperture with measurement

16[a4] the first end of the housing having an electrically conductive portion adapted to mechanically and electrically couple to an electrically conductive portion of the power source;	16[a4] conductive first end to power source
16[b1] an airflow passageway in the interior of the housing, the airflow passageway having a length extending centrally and axially with respect to the housing intermediate of the first aperture on the first end of the housing and the second aperture on the second end of the housing,	16[b1] central/axial airflow passageway between apertures
16[b2] the airflow passageway being configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing,	16[b2] airflow passageway/airflow between apertures
16[b3] the airflow passageway having an exterior adjacent to the solution holding medium along a majority of the length of the airflow passageway,	16[b3] airflow passageway with exterior adjacent to the solution holding medium along majority of passageway
16[b4] the airflow passageway having an interior having a uniform cross-sectional area measured perpendicular to the central longitudinal axis of the housing and extending continuously along a majority of the length of the airflow passageway; and	16[b4] uniform airflow passageway between the heating element and the second aperture along a majority of the length of passageway
16[c1] a heating element located in the interior of the housing and extending transversely across the airflow passageway, the airflow through the passageway passing on both transverse sides of the heating element,	16[c1] heating element in housing and transverse to airflow
16[c2] a plane perpendicular to the central longitudinal axis of the housing passing through the heating element and the solution holding medium,	16[c2] plane through the heating element and the solution holding medium
16[c3] the airflow passageway having an interior between the heating element and the second	16[c3] first aperture equal to or smaller than airflow

aperture no smaller in cross-sectional area than the cross-sectional area of the first aperture,	passageway and second aperture
16[c4] the heating element being connected to the electrically conductive portion of the first end of the housing,	16[c4] heating element electrically connected to first end
16[c5] the heating element being electrically configured to vaporize at least a portion of the solution to be contained in the solution holding medium for oral provision to an individual in an airflow from the second aperture responsive to electrical power received from the power source through the electrically conductive portion of the cartridge.	16[c5] electrical heating element to vaporize liquid for delivery via second aperture
Claim 17	Claim 17 Shorthand
[17] The cartridge of claim 16, further in combination with the power source including a battery and the electrically conductive portion, the electrically conductive portion of the power source being mechanically and electrically coupled to the electrically conductive portion of the first end of the housing.	[17] power source and first end electrically/mechanically coupled.
Claim 18	Claim 18 Shorthand
[18] The cartridge of claim 16, wherein the heating element is a coil having a maximum diameter and the uniform cross-sectional area of the airflow passageway is a circle having a diameter, the maximum diameter of the coil being smaller than the diameter of the circle of the uniform cross-sectional area of the airflow passageway.	[18] coil heating element with max. diameter relative to circle airflow passageway
Claim 19	Claim 19 Shorthand
[19] The cartridge of claim 18, wherein the first aperture on the first end is located centrally and axially with respect to the housing.	[19] central/axial first aperture
Claim 20	Claim 20 Shorthand

[20] The cartridge of claim 19, wherein the first aperture on the first end is smaller than the second aperture on the second end.	[20] first aperture equal to or smaller than airflow passageway and second aperture
Claim 21	Claim 21 Shorthand
[21] The cartridge of claim 16, wherein the heating element is a coil having a maximum diameter and the uniform cross-sectional area of the airflow passageway is a circle having a diameter, the maximum diameter of the coil being smaller than the diameter of the circle of the uniform cross-sectional area of the airflow passageway.	[21] coil heating element with max. diameter relative to circle airflow passageway
Claim 22	Claim 22 Shorthand
[22] The cartridge of claim 16, wherein the first aperture on the first end is located centrally and axially with respect to the housing.	[22] central/axial first aperture
Claim 23	Claim 23 Shorthand
[23] The cartridge of claim 16, wherein the first aperture on the first end is smaller than the second aperture on the second end.	[23] first aperture equal to or smaller than airflow passageway and second aperture
Claim 24	Claim 24 Shorthand
[24] The cartridge of claim 16, wherein the solution holding medium includes at least one of an absorbent material and a reservoir.	[24] absorbent material or reservoir
Claim 25	Claim 25 Shorthand
[25] The cartridge of claim 16, further comprising a solution, wherein the solution comprises one of propylene glycol and nicotine.	[25] propylene glycol and nicotine solution
Claim 26	Claim 26 Shorthand

[26] The cartridge of claim 16, wherein the heating element is in operative connection with a wicking material, and the wicking material is operative to attract a portion of the solution from the solution holding medium located immediately adjacent opposite ends of the heating element toward the heating element.	[26] heating element with wicking material between solution holding medium.
Claim 27	Claim 27 Shorthand
[27] The cartridge of claim 16, wherein the airflow passageway has a uniform cross-sectional area measured perpendicular to the central longitudinal axis of the housing between the heating element and the second aperture.	[27] uniform airflow passageway between the heating element and the second aperture

VIII. PRIOR LITIGATION

A. Claim Construction

27. I understand certain terms of the '881 patent have been previously construed in *Fuma International LLC v. R.J. Reynolds Vapor Company*, Case No. 1:19-cv-260, D.I. 95 (M.D.N.C., March 23, 2020). *See* Ex. 1020 (Markman Order).

Term	Construction
solution holding medium '881 patent Claim 1, 16	A location, container, or mechanism to hold the solution, including but not limited to at least one of an absorbent material, a chamber, a reservoir, a capsule, or any combination thereof.
the power source includes an electrically conductive portion / the housing includes an electrically conductive portion that is adapted to	Ordinary meaning: "A portion that is electrically conductive."

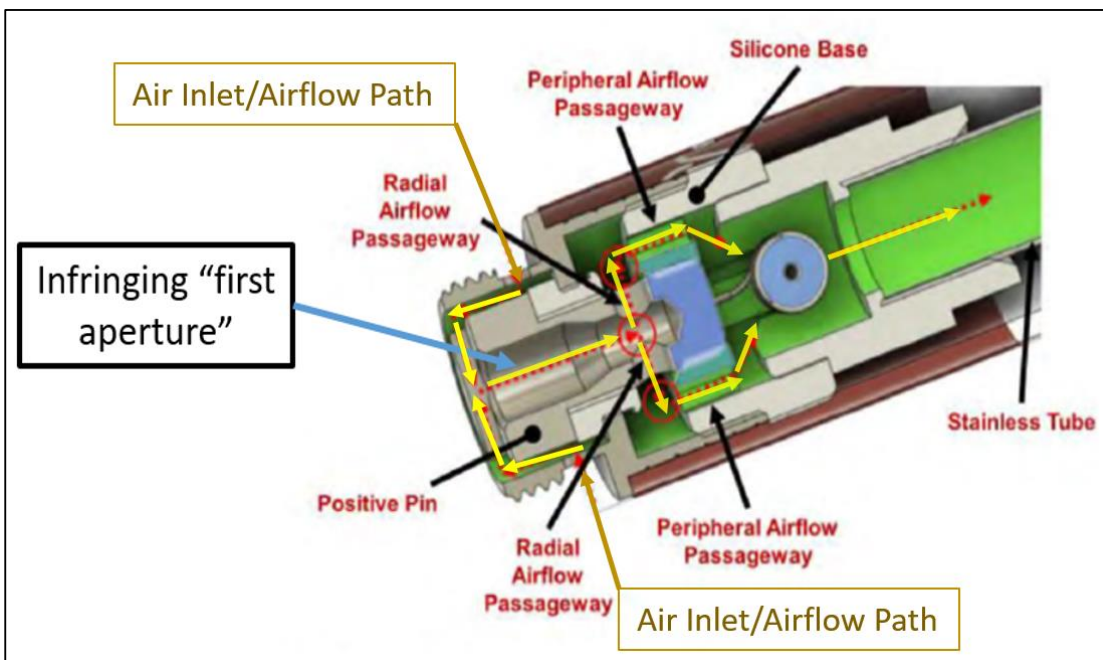
Term	Construction
mechanically and electrically couple to the electrically conductive portion of the power source '881 patent, claim 1 the housing having an electrically conductive portion adapted to mechanically and electrically couple to the electrically conductive portion of the power source '881 patent, claim 8 the housing having an electrically conductive portion adapted to mechanically and electrically couple to an electrically conductive portion of the power source '881 patent, claim 16	
wherein the heating element is electrically configured to vaporize at least a portion of the solution to be contained in the solution holding medium '881 patent, claim 1 the heating element being electrically configured to vaporize at least a portion of the solution to be contained in the solution holding medium reservoir '881 patent, claim 8 the heating element being electrically configured to vaporize at least a portion of the solution to be contained in the solution holding medium	Ordinary meaning. The solution can be, but need not be, in the solution holding medium when vaporized by the heating element.

Term	Construction
‘881 patent, claim 16	
an airflow passageway that extends centrally and axially with respect to the housing intermediate of the first aperture on the first end of the housing and the second aperture on the second end of the housing; wherein the airflow passageway is configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing ‘881 patent, claim 1 an airflow passageway in the interior of the housing extending centrally and axially with respect to the housing intermediate of the first aperture on the first end of the housing and the second aperture on the second end of the housing, the airflow passageway being configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing. ‘881 patent, claim 8 an airflow passageway in the interior of the housing, the airflow passageway having a length extending centrally and axially with respect to the housing intermediate of the first aperture on the first end of the housing and the second aperture on the second end of the housing, the airflow passageway being configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing ‘881 patent, col. 19:37–44 (Claim 16).	The airflow passageway extends in a straight path through the center of the cartridge from a first opening on the first end to a second opening on the opposite end of the cartridge

B. Summary Judgment of Infringement

28. In the prior litigation, the North Carolina District Court granted summary judgment that accused RJR products infringed asserted claims of the '881 patent. Ex. 1015 (MSJ Order) at 14-18. In those summary judgment proceedings, the patent owner took—and the District Court adopted—positions relevant to this petition, including positions regarding the claimed first aperture and claimed airflow passageway.

29. **Aperture:** On summary judgement, the plaintiff/patent owner asserted that the claimed “first aperture on the first end” of the cartridge housing is met by a single opening inside the housing, where air entering the cartridge converges at that opening to pass through to the alleged airflow passageway. Ex. 1021 (Dkt. 133, Fuma Reply Brief) at 9-12. The following figure depicts the accused apparatus, including its side inlets (which are located on the exterior of the cartridge and allow air to enter the cartridge), the resulting air flow, and the interior central aperture located inside the cartridge housing:

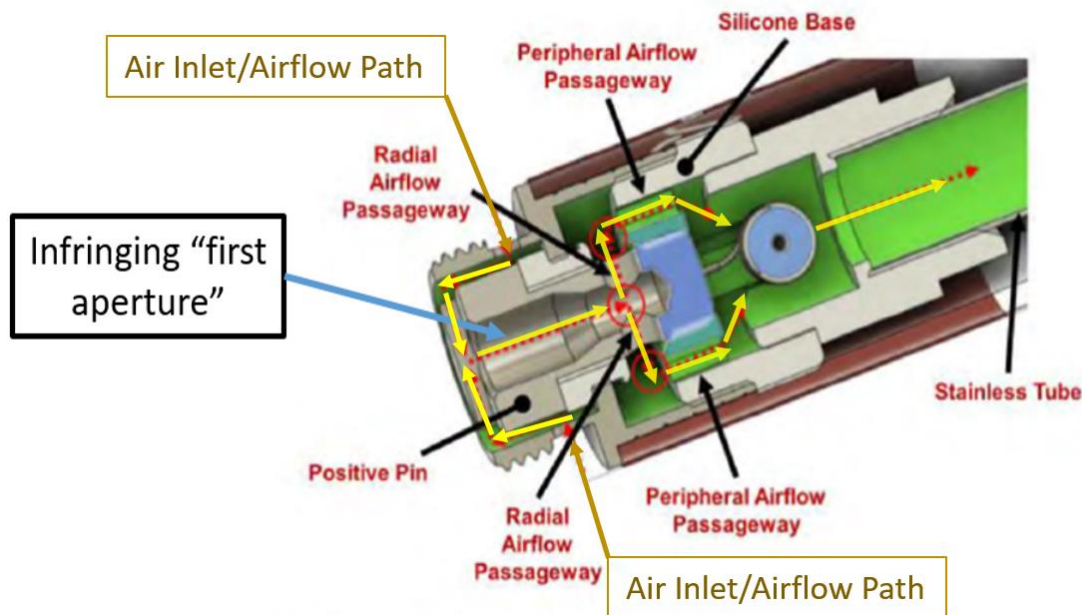


Ex. 1014, 44.

30. The District Court agreed with plaintiff and explicitly held that the aperture internal to the device, at the beginning of the internal passageway, *i.e.* the hole within the internally-contained “positive pin” depicted above, meets the requirement for a first aperture “on the first end.” Ex. 1015 (Dkt. 139, MSJ Order) at 14-18. The District Court held that the defendant’s argument to the contrary was incorrect because it improperly restricted the scope of the claimed “first aperture” to apertures at the very edge of the cartridge housing, *i.e.*, the side inlets that originally draw in air to the cartridge. The District Court held instead that an aperture internal to the device satisfies a first aperture on the first end of the housing. *Id.*

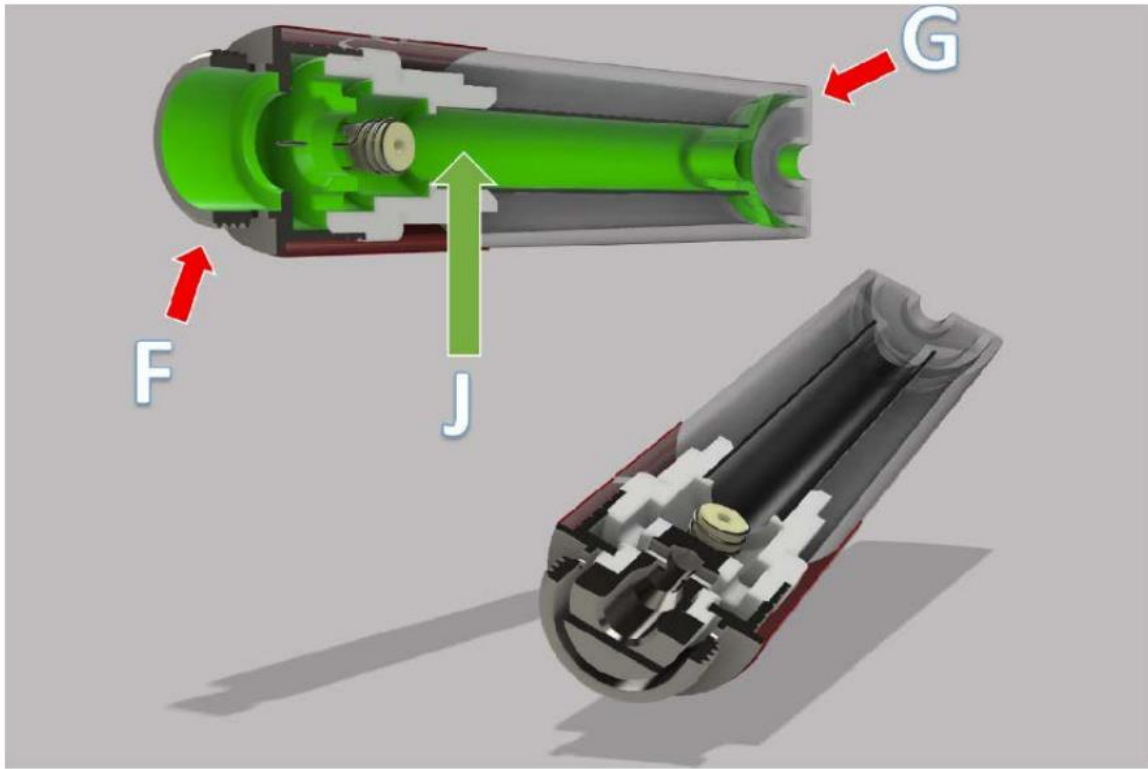
31. **Airflow Passageway:** In addition, plaintiff argued, and the District Court found, that the accused device included the '881 patent's claimed "airflow passageway that extends centrally and axially with respect to the housing" as a matter of law.

32. In doing so, the Court rejected defendant's argument that the accused airflow passageway (shown below in green) did not meet this limitation because the passageway obstructed airflow (by among other things the positive pin and silicone base) and directed it away from the center, rather than allowing it to flow along the central axis, making the passageway not centrally and axially located. Ex. 1014 (RJR Brief) at 14-18.



Id., 15 (annotated).

33. The District Court disagreed and explained that defendant improperly “conflat[ed] the airflow’s path with the airflow passageway.” Ex. 1015 (MSJ Order) at 14-18. Although “[t]he positive pin and silicone base [in the image above] obstruct airflow and alter the airflow’s path” they do not alter the “interior airflow passageway, which at all times extends straight through the center of the [accused product]’s cartridge to the second end as required by the claim.” Ex. 1015, 14-18 (emphasis added unless otherwise noted). The figure below from that litigation omits some of those obstructions in the accused passageway and shows that, without those obstructions, the passageway itself (highlighted in green) extends straight through the center of the housing:



Ex. 1025 (Dkt. 120, Fuma SJ Brief) at 17.

IX. RELEVANT TECHNICAL BACKGROUND AT THE TIME OF THE '881 PATENT

A. Electronic Cigarettes

34. The '881 patent relates to “[e]lectronic cigarettes (also referred to as e-cigarettes or personal vaporizers).” Ex. 1001 at 1:18-19.

35. Electronic cigarettes, often called “e-cigarettes,” are hand-held electronic devices that produce a vapor intended to be inhaled by a user. The vapor is produced by the e-cigarette when a heating element (powered by a battery) vaporizes a liquid (typically containing nicotine), often called an “e-liquid.” E-

cigarettes are usually structured such that cartridges containing e-liquid are replaceable by users to refill the e-cigarette. E-cigarettes have been around since the early 2000's, at least. Han Li—sometimes translated as Hon Lik—a Chinese pharmacist, was one of the first developers of electronic cigarettes. Li began filing for patents in this field in 2003 and products based on his designs were first introduced to the U.S. market in 2006.

36. Early electronic cigarettes were styled to mimic traditional cigarettes, and became known as “cigalikes,” but were replaced by larger rechargeable and refillable options with replaceable cartridges.

B. Basic Components of E-Cigarettes

37. Early e-cigarette devices shared the same basic structure, and included an “electronic atomizer, “a lithium ion battery,” and a “cartridge...attached to a plastic mouthpiece tip” that “contain[ed] nicotine and propylene glycol,” similar to the alleged invention of the '881 patent. Ex. 1016 (August 22, 2006 Tariff Classification for Early Imported Electronic Cigarette).

38. As acknowledged in the '881 patent, “[c]onventional electronic cigarette designs” already existed that “generally include[d] a battery, a heating element, and a mouth piece” to vaporize a “liquid solution” containing “nicotine” to transmit the vapor to a user. Ex. 1001, '881 Patent, at Background (1:21-30). These

known devices utilized a “mouthpiece” with “battery”-powered “heating elements” to “vaporize the solution” within the “mouthpiece.” *Id.*

39. The claims of the ’881 patent are also directed to a purported invention, in which the conventional design is separated into two coupled parts, one including the battery/power source and another—a “cartridge”—that “may include a heating element” and “a solution that is positioned proximate to the heating element.” Ex. 1001, 1:34-57. As discussed in the prior art below, however, early versions of rechargeable and refillable e-cigarettes utilized two primary components: (1) a cartridge (with a solution of nicotine), and; (2) a power source, with a battery.

40. Indeed, dividing an e-cigarette like this was already established in the art. For example, each of the prior art references Xia (the primary reference of Ground 1) and Wang (the primary reference of Ground 2) discloses an e-cigarette that features two coupled parts, one that includes a battery and another comprising a cartridge that includes, among other things, a heating element and a solution positioned proximate that heating element:

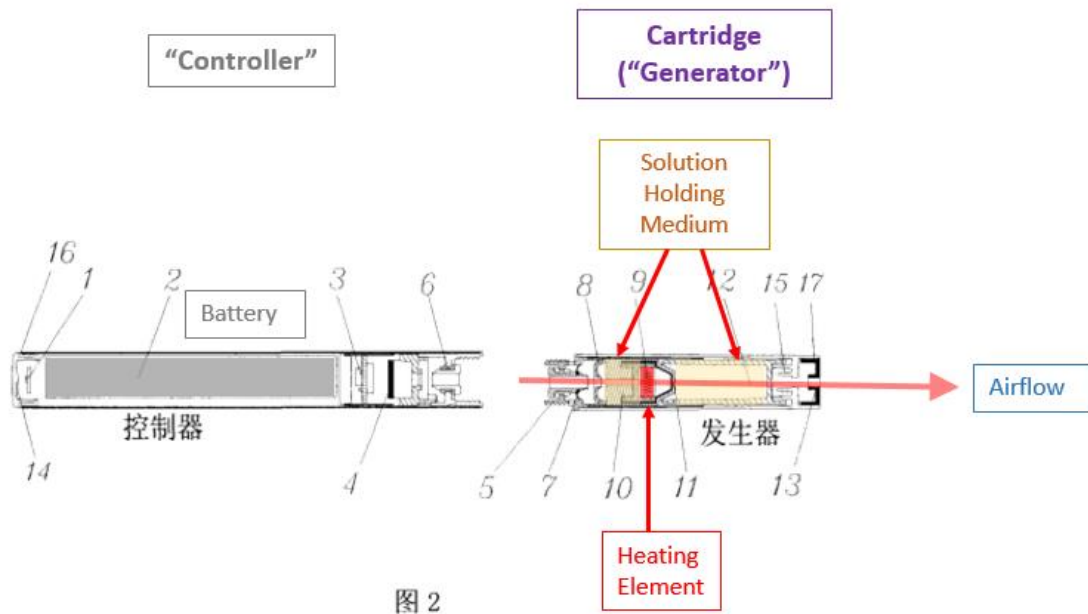
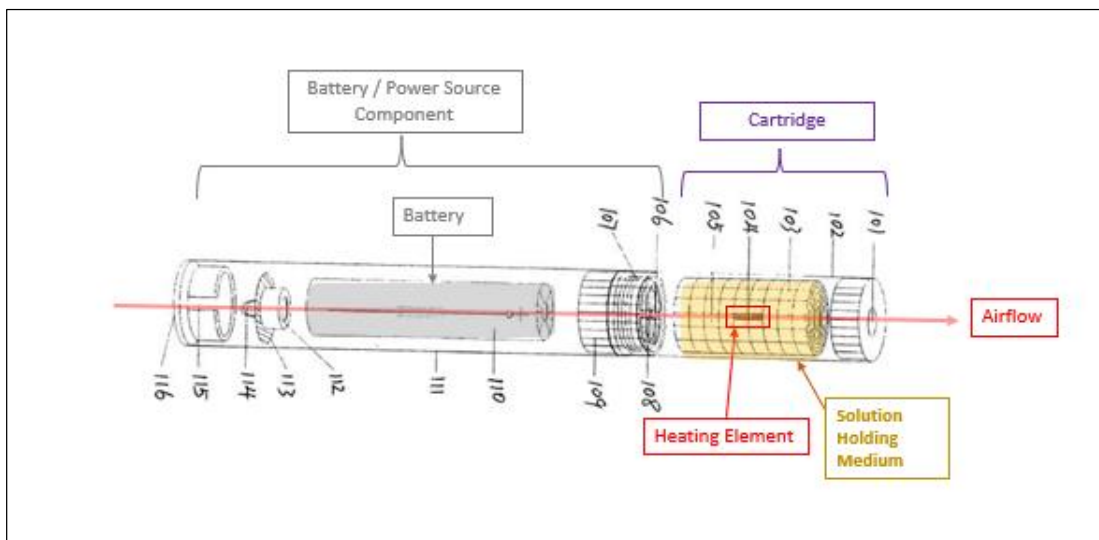


图 2

Ex. 1004 (Xia), Fig. 2 (annotated).

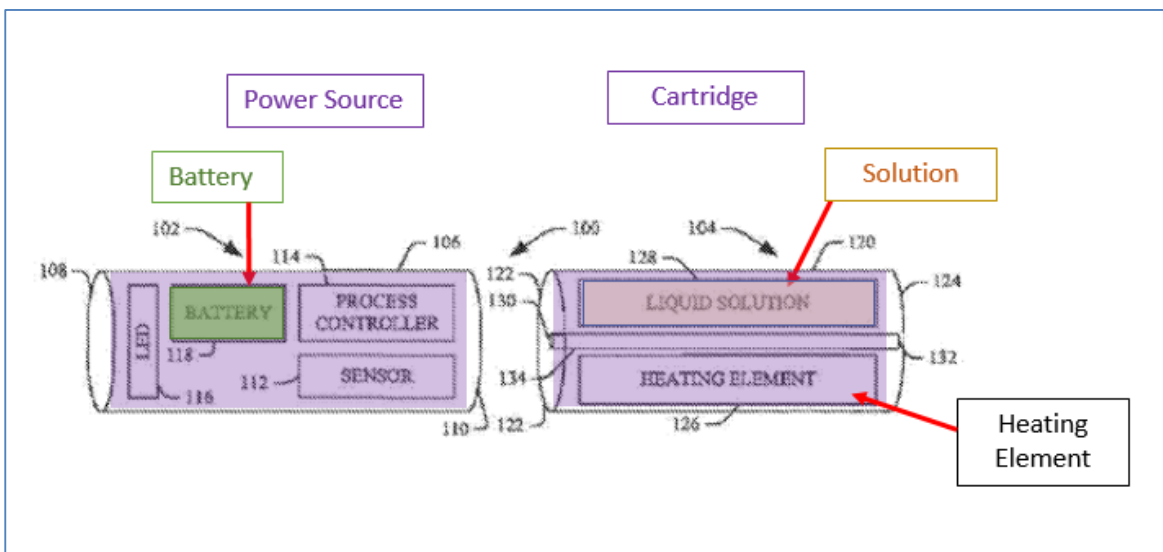


41. Ex. 1005 (Wang), Fig. 1 (annotated). Moreover, Gregory Conley, the first-named inventor and then-president of Patent Owner's predecessor-in-interest,

testified that the only possible inventive aspect of his “invention” (as set forth in the similar claim 1 of the ’881 patent’s parent, U.S. 9,532,604) was that he moved the heating element in or around the airflow passageway so that vaporization occurs “in the airflow” instead of outside it. Ex. 1023 (Conley 12/4/19 Dep. Tr.) at 57:16-59:8; *see also* 24:16-25:4, 33:9-34:8, 38:1-42:15, 47:9-14; Ex. 1024 (Conley Dep. Ex. 2A). But as depicted above and described below, all references I describe here disclose that concept.

X. ’881 PATENT OVERVIEW

42. The ’881 patent relates to “[e]lectronic cigarettes (also referred to as e-cigarettes or personal vaporizers).” Ex. 1001 at 1:18-19. The ’881 Patent allegedly discloses “electronic vaporizers, and more particularly pertaining to cartridges that comprise heating elements configured to vaporize a solution” comprising a “housing,” a “heating element,” a “solution,” and an “adapter...configured to electrically or electronically couple a power source...with a heating element.” *See* Ex. 1001 at 1:37-61.



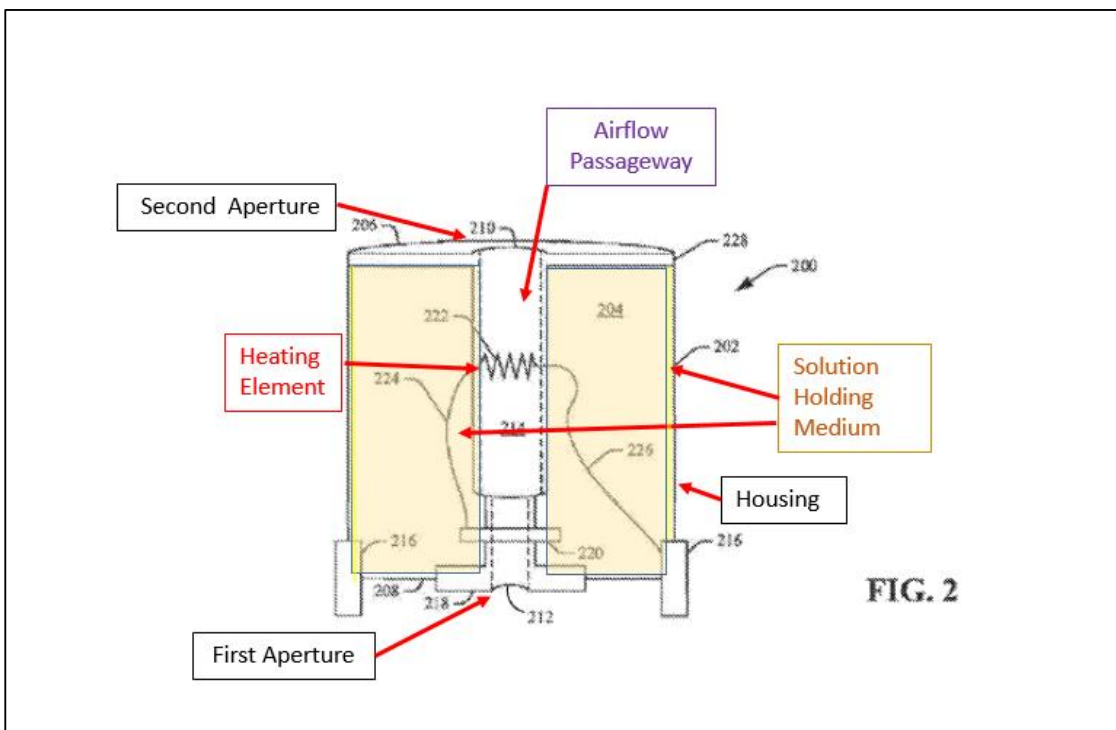
Ex. 1001, Fig. 1 (annotated).

43. “The power source 102 and the cartridge 104 are configured to be mechanically and electrically coupled to one another” through an electrically conductive threaded portion. Ex. 1001 at 2:62-3:2 (teaching “an electrically conductive threaded fastener” and “an electrically conductive threaded receiver” that “can be coupled to one another, thereby mechanically and electrically coupling the power source 102 with the cartridge 104”).

44. The cartridge 104 further “comprises a housing 120 that has an interior,” “a first end 122,” and “a second end 124.” Ex. 1001 at 3:44-46 and FIG. 1 (annotated). Additionally, “[t]he first end 122 of the cartridge 104 comprises a first aperture 130 that is located at approximately the center of the first end 122” and “[t]he second end 124 comprises a second aperture 132 that is located at

approximately the center of the second end 124.” Ex. 1001 at 4:28-32. “An airflow passageway 134 extends between the first aperture 130 and the second aperture 132 axially proximate to the center of the housing 120” and is configured to provide for airflow from the first to the second aperture. Ex. 1001 at 4:33-35; 17:31-33.

45. As illustrated in Fig. 2 (annotated below), a solution holding medium 204, which may comprise “an absorbent material, capsule, or reservoir” stores the solution that is ultimately vaporized. *Id.*, 4:5-9. The solution holding medium 204 surrounds the central airflow passageway 214. *Id.*, Fig. 2, 17:46-47. “The heating element 222 can comprise wicking material that draws the liquid solution from the absorbent material 204” (i.e., solution holding medium). *Id.*, 6:44-47.



Ex. 1001, Fig. 2 (annotated).

46. As further shown above, a solution holding medium—depicted as “an absorbent material 204”—stores the solution that is ultimately vaporized. *Id.*, 4:5-9. The patent further describes that heating element 222 may be “in the airflow passageway”; “on the exterior of the airflow passageway”; or “on the interior and the exterior of the airflow passageway.” *Id.*, 5:52-53; 6:62-7:19.

47. According to the description of the '881 Patent, the purported invention of the patent is an “adapter . . . configured to electrically or electronically couple a power source (such as a battery) having a first configuration with a heating element having a second configuration.” Ex. 1001 at 1:34-61. More specifically, the patent

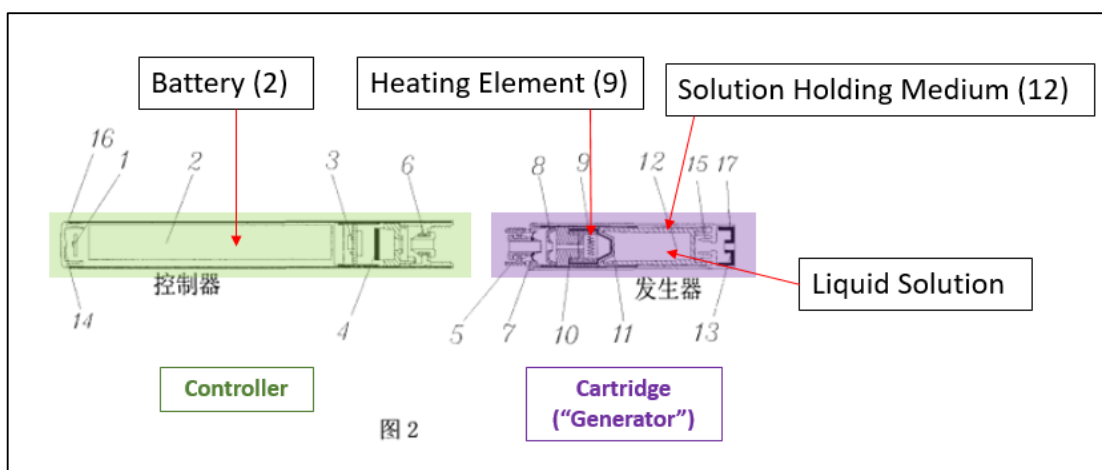
purports to have invented a manufacturer-agnostic adapter, such that “[t]he adapters described herein are configured to electrically or electronically couple power sources from a first manufacturer with a heating element from a second manufacturer,” which is allegedly beneficial because “[t]ypically, the power source (battery) is significantly more expensive than associated cartridges, and once a user purchases a power source they may not wish to purchase a different power source from a different manufacturer even if the tastes of the user change over time.” *Id.*, 1:58-2:7. The other aspects of the e-cigarettes described in the ’881 patent were known in the art by the ’881 patent’s own admission. For example, the ’881 patent explains “various aspects . . . pertaining to cartridges that comprise heating elements configured to vaporize a solution” in the “Background” section, and concedes these were known elements.

48. The allegedly inventive adapter is not recited in the claims as anything more than was already contained in the art. For example, the claims of the ’881 patent do not recite anything more than any ordinary adapter that connects a cartridge to a power source, the most detailed being dependent claim 9, which merely recites “[t]he cartridge of claim 8, further in combination with the power source including a battery and the electrically conductive portion, the electrically conductive portion of the power source being mechanically and electrically coupled to the electrically conductive portion of the first end of the housing.”

XI. DESCRIPTION OF PRIOR ART

A. CN 201238610Y to Xia

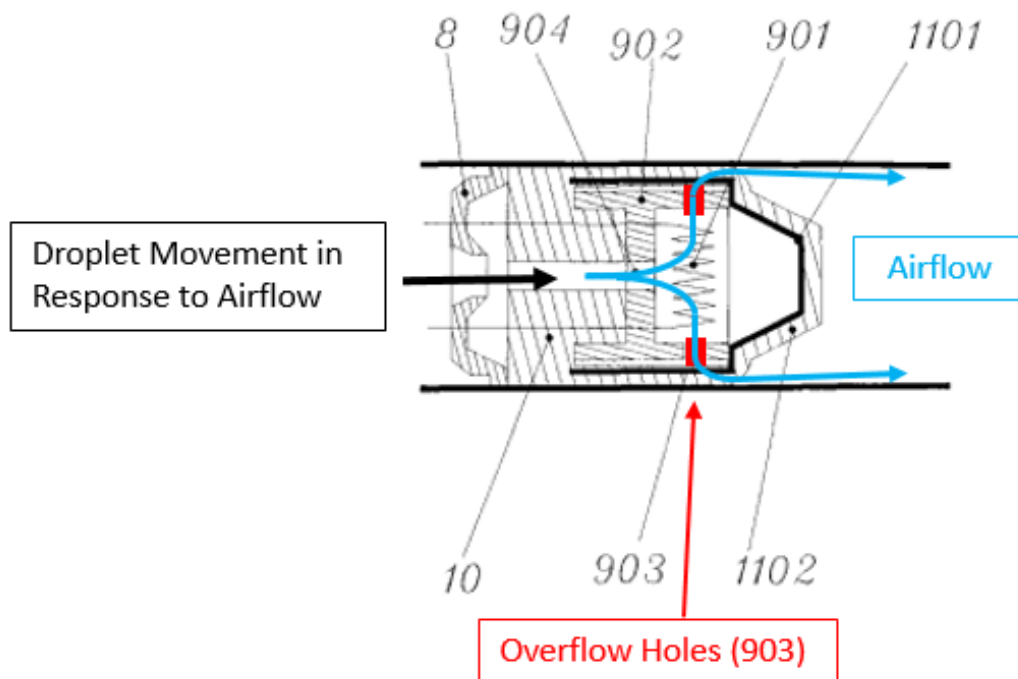
49. Chinese Patent No. CN 201238610Y to Xia (“Xia”) was published on May 20, 2009. Ex. 1004.² Xia describes an “atomizing electronic cigarette,” with a cartridge component on the right in Figure 2 below, which attaches to a controller component, including a battery, on the left, forming an e-cigarette.



Ex. 1004, Fig. 2.

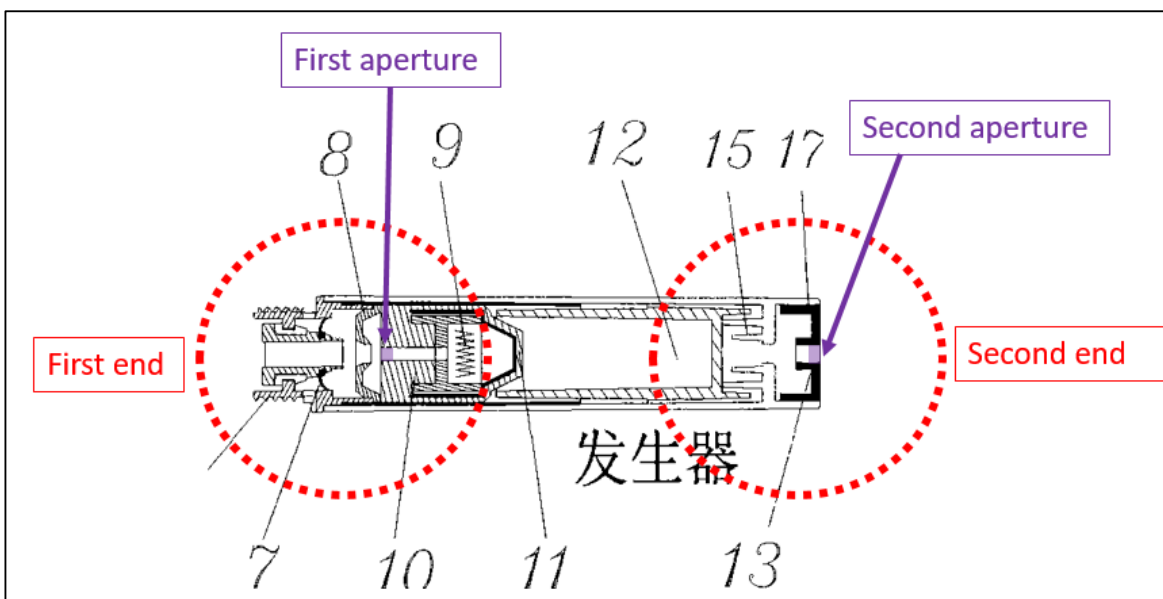
² In addition to the face of Xia identifying May 20, 2009 as the patent’s grant date, the Chinese National IP Association’s (“CNIPA”) patent application database identifies May 20, 2009 as the date of publication. Ex. 1008 pss-system.cponline.CNIPA.gov.cn (“CNIPA Patent Database”). So too does the U.S.P.T.O’s Global Dossier website. Ex. 1009, *see also* <https://globaldossier.uspto.gov/#/result/publication/CN/201238610/98262>; *see also* European Patent Office Search Results Espacenet Ex. 1010.

50. Upon use of the combined device, air flows in through air inlet holes on the first end of the cartridge. Ex. 1004, 7. Xia describes that “under the action of airflow, small droplets are sucked into the other side of the heat insulation seat 902 through the spray hole 904 in the heat insulation seat 902,” where “[u]nder the action of the heating wire 901, the liquid is instantly atomized and flows out of the heater 9 from the overflow holes 903, then flows...through the gap between the soft suction nozzle and the liquid storage chamber 12 as the airflow channel, and is finally sucked out through the soft suction nozzle 13.” Ex. 1004 at 12-13. Figure 4, annotated below, shows that there are two identical overflow holes.



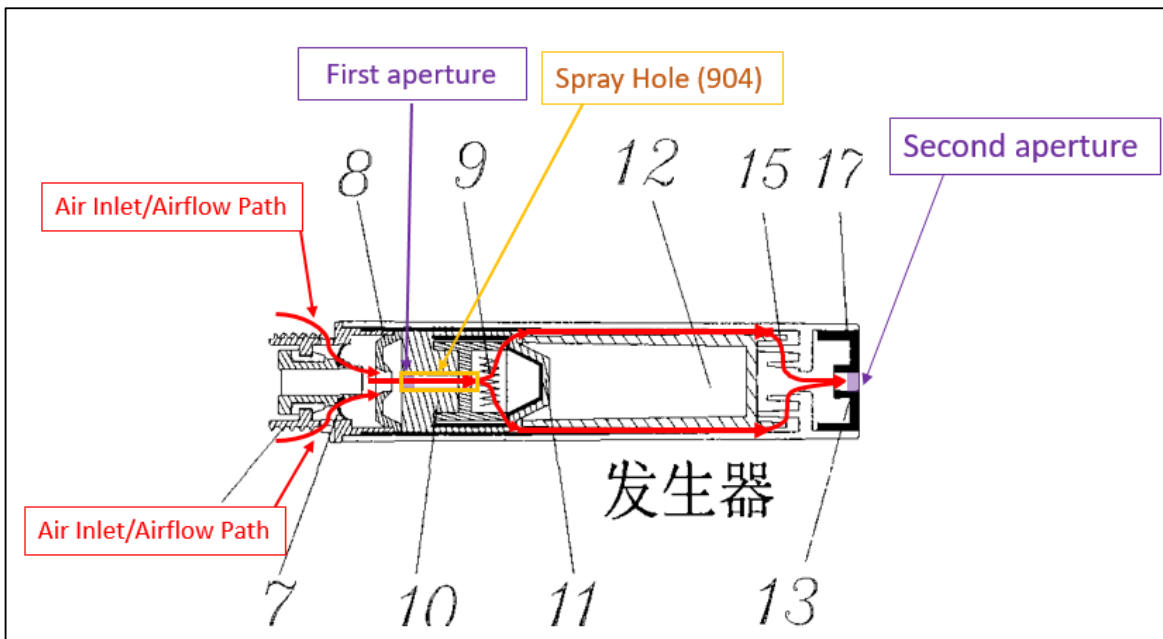
Ex. 1004, Fig. 4.

51. Xia describes that its cartridge (shown below in annotated Figure 2) includes a first aperture on its first end, a second aperture on its second end. As shown below, Xia's first aperture is inside the cartridge, just like the first aperture in the infringing device in the prior North Carolina District Court litigation

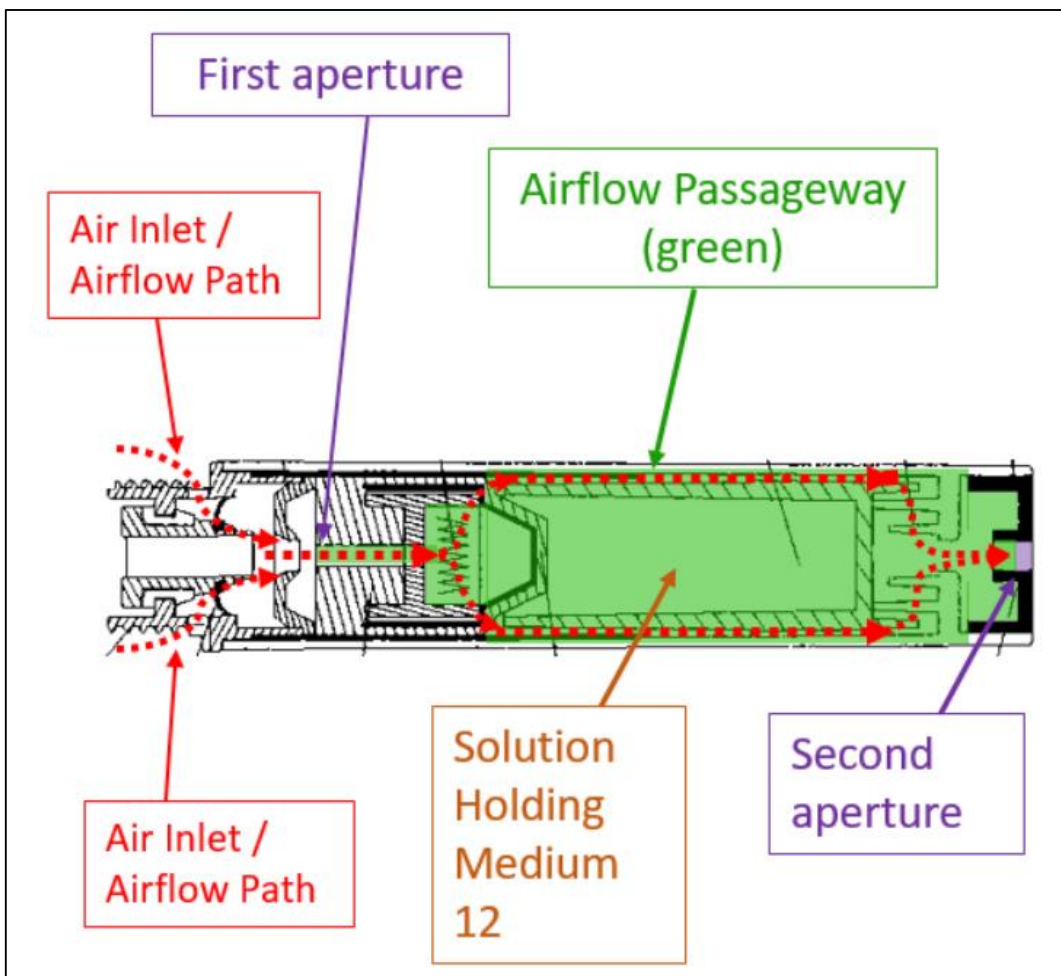


Ex. 1004, Fig. 2 (partial, annotated). The figure below is annotated to depict the airflow within the Xia device. Air enters the inlets on the exterior of the cartridge, flows through the first aperture at the left end of spray hole 904, into the heating element area, is diverted to the sides by the solution holding medium 12, and flows

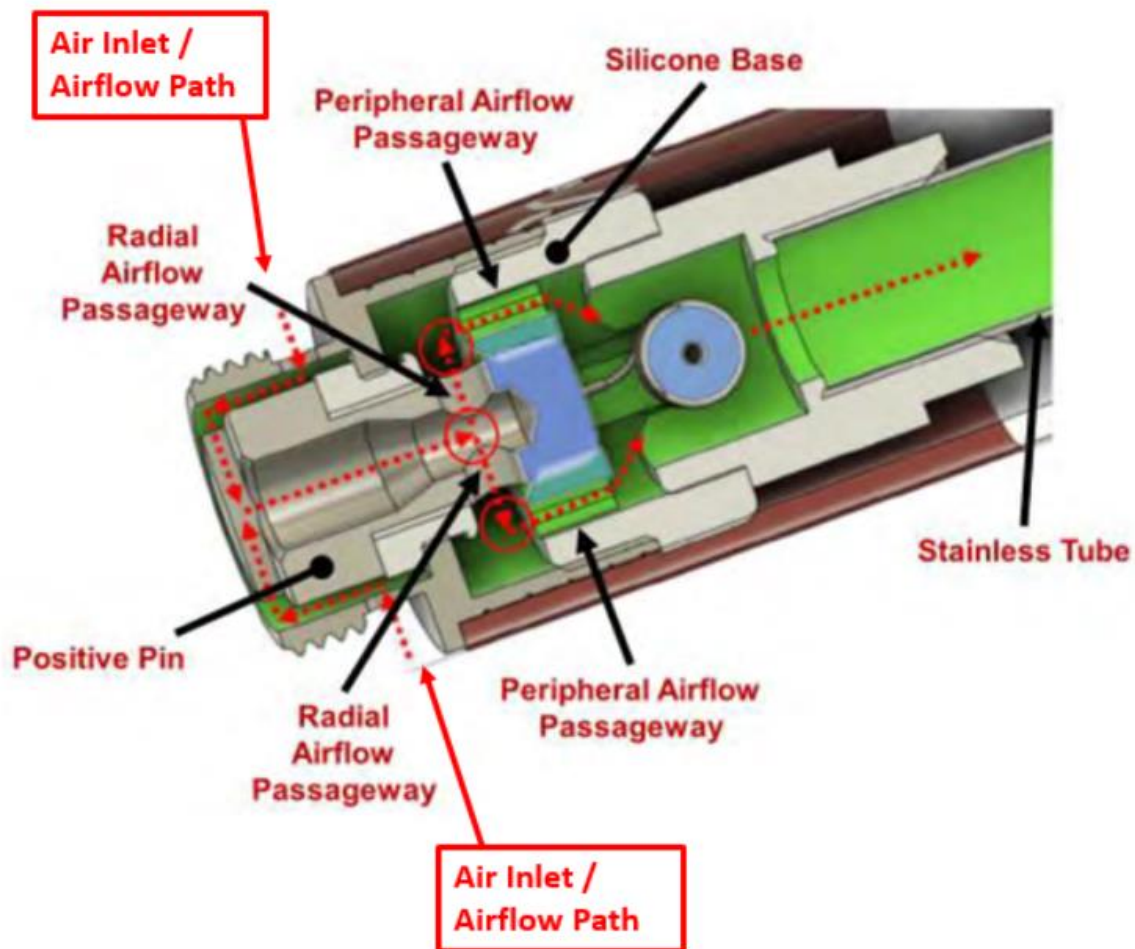
out the soft suction nozzle 13 to the user.



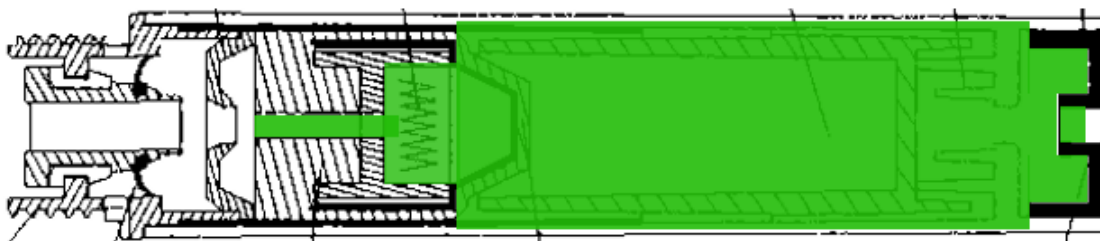
Ex. 1004, annotated Fig. 2 excerpt. Xia's airflow passageway is annotated in green below and is a structural component that extends from the first aperture to the second aperture. Consistent with the prior North Carolina district court summary judgment decision, this airflow passageway is central and axial with respect to the housing even though it contains obstacles (such as the solution holding medium) that divert the airflow itself away from the center:



Thus, Xia's central passageway, which contains objects that divert the airflow away from the center, is substantively the same as that in the infringing RJR device:



As shown above for the product in the district court case, Xia's airflow passageway is depicted below omitting obstructions inside it:

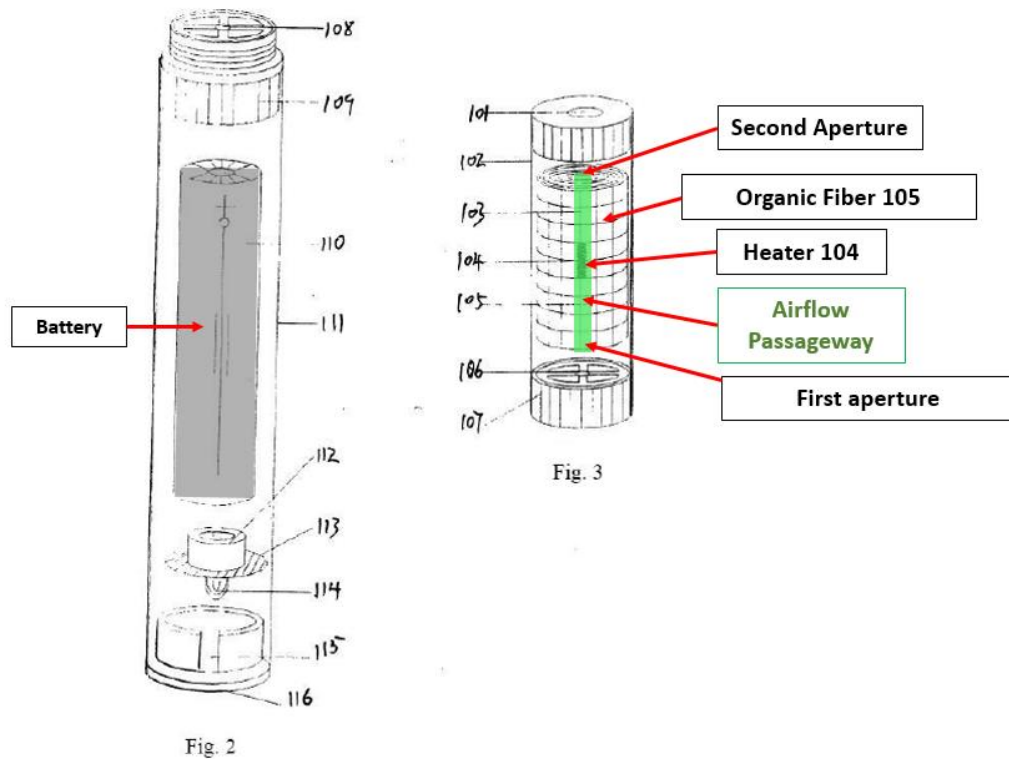


Ex. 1004, Fig. 2.

B. CN 101366554A to Wang

52. Chinese Patent Application Publication No. CN 101366554A to Wang (“Wang”) was published on February 18, 2009. Ex. 1005 at 1.

53. As shown below, Wang discloses an e-cigarette comprising battery-holding component (left annotated Figure 2) and an attachable cartridge (right annotated Figure 3). As annotated below, the cartridge contains a heater 104 and solution holding medium in the form of an absorbent organic fiber 105, which is positioned around that heater. *Id.*, 6. In the prior North Carolina district court litigation, the inventor Mr. Wang confirmed that his invention’s absorbent organic fiber 105 “**surrounds a complete central air passageway**, in which the heater is positioned.” Ex. 1017 (Wang Decl., describing a product he testified embodies the Wang reference invention), 4-5. That central air passageway is annotated below in green and extends from a first aperture and a second aperture. In my view, a POSITA would understand from Wang’s figures and description, that his cartridge has this central airway through the middle of the absorbent organic fiber, across the centrally located heater and out the second aperture:



Ex. 1005, Figs. 2-3 (annotated).

54. Wang states “[t]he cigarette rod...[and] the cigarette holder...are connected together to form a shape consistent with that of the common cigarette.” Ex. 1005 at 5. “The cigarette rod shell 111 adopts a longer cylindrical shape of a cigarette body.... The cigarette rod shell is a hollow cylinder.... One end of the shell is one end of the air outlet 108, and is connected to the input end of the cigarette holder along with the output end 109. The other end of the shell is one end of the air inlet 115 on the indicating lamp cover 116, and forms an uninterrupted airflow channel together with a gap inside the shell 111.” *Id.* at 5-6. Wang’s central air

passageway is also depicted in Wang's Figure 5, which illustrates that the organic fiber 105 comprises fiber or paper that is rolled up so that it defines and contains a central passageway (which in Fig. 3 is where the heater is shown placed). Ex. 1005, Fig. 5. Again, this passageway is annotated below in green to show what would be understood from this and the other figures and the Wang specification:

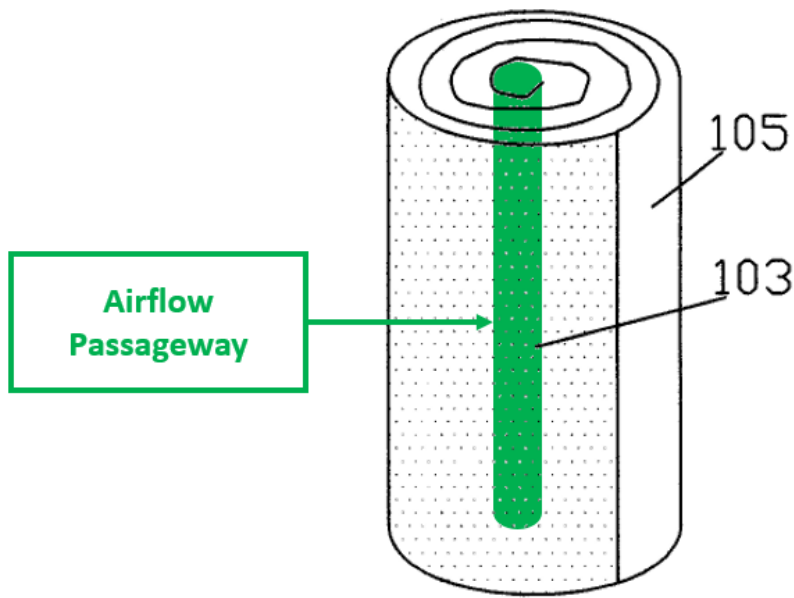


图 5

Ex. 1005, Fig. 5 (annotated), 7, 8 (referencing “an internal gap of the cigarette rod”).

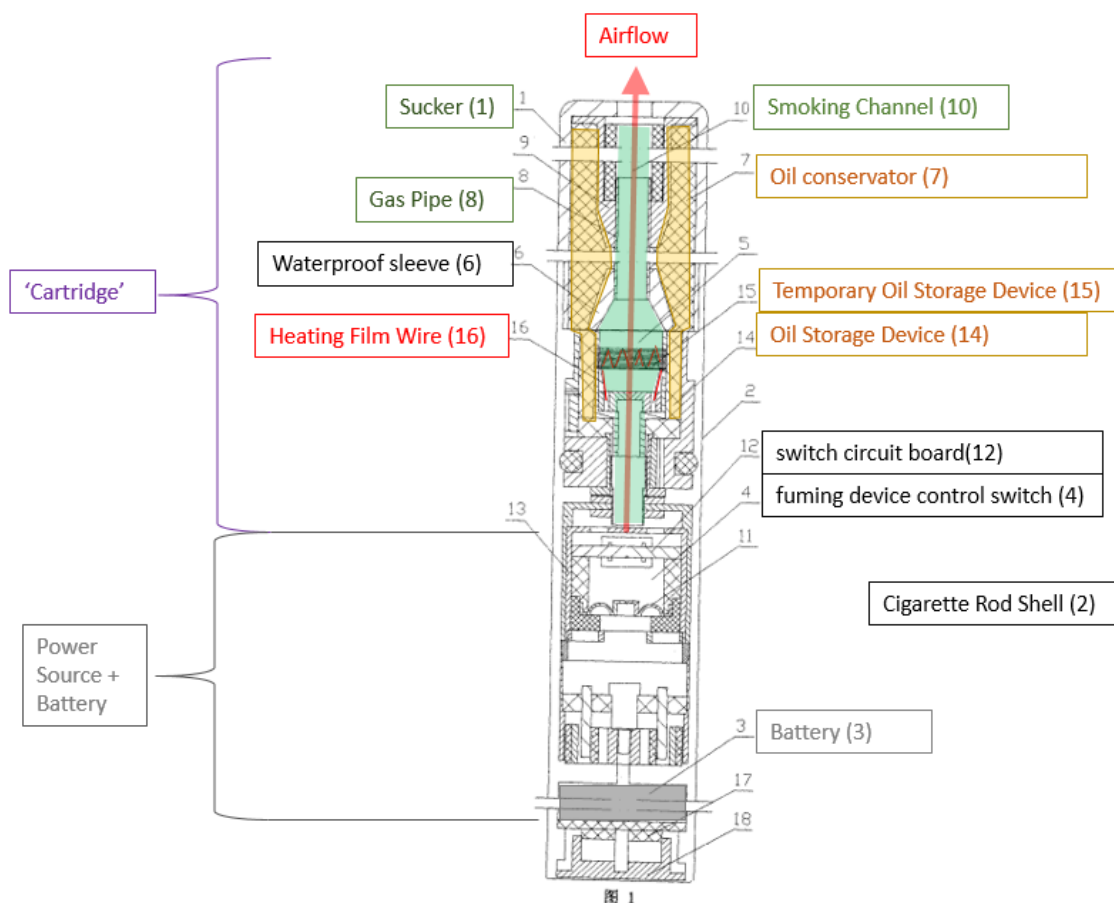
55. Mr. Wang also described his invention as containing “a liquid element” situated “along the diameter of the electronic cigarette [that] surrounds a complete central air passageway, in which the heater is positioned.” Ex. 1017 (Wang Decl.) at 4-5 (emphasis added). A POSITA would know that, in the context of the device,

the air flows down the middle because that is where the heater is located, and it must pick up the vapor and deliver it to the user. Ex. 1005, 8 (“air inlet 106” and “air outlet 101” are part of the “complete airflow channel”; “the smoke generated by the tobacco extract 103 instantly heated by the heater 104 is partially sucked out from the air outlet 101 of the cigarette holder.”)

C. CN 201085044Y to Fang

56. Chinese Patent Application Publication No. CN 201085044Y to Fang (“Fang”) was published on July 16, 2008. Ex. 1006, 1; Ex. 1011 (CNIPA); Ex. 1013, (Espacenet); Ex. 1012 (US Global Dossier). In the parallel ITC litigation, NJOY has taken the position that Fang was published on July 16, 2008. Ex. 1022 (NJOY’s Invalidity Contentions) at 14; Ex. A-9, 1.

57. As shown for example in annotated Figure 1 below, Fang discloses an e-cigarette, including a: (1) cigarette rod shell; (2) battery; (3) heating film wire; and (4) a gas pipe, that forms a centrally and axially located airflow passageway (smoking channel (10)) from the heating element to the mouthpiece, described as a “sucker (1).” While the Chinese words may have different English translations, the meanings in this context would have been clear to a POSITA working in this field.



58. Fang, Fig. 1 (annotated). Although the device is shown as a single unit, in Figure 1, it has two distinct functional areas: (1) a top portion (as oriented above) that can be described as a ‘cartridge’, with components for storing and vaporizing nicotine oil and; (2) a power source, with a battery, in mechanical and electrical contact with the cartridge portion. I understand that Patent Owner has taken the position that Fang has or renders obvious “a cartridge” in parallel litigation. Ex. 1022 (NJOY’s Invalidity Contentions), Ex. A at 137 (element 43.A)] (citing “Fang 044 at Abstract; p.4 ¶1,4; p.6 ¶1–4; Figs. 1–3”). I also understand that Patent Owner

also has taken the position that Fang has or renders obvious “a power supply portion comprising a rechargeable battery” and that the cartridge is “configured for separable attachment to the power supply portion.” *Id.* at 140 (elements 44.B-C), citing “Fang 044 at p.4 ¶ 4; p.5 ¶ 3; p.6 ¶¶ 1 , 4–5; p.7 ¶ 2; Figs. 1–3”). I agree that both features are disclosed by Fang.

XII. MOTIVATION TO COMBINE AND REASONABLE EXPECTATION OF SUCCESS

59. A POSITA would have been motivated to combine Xia with Wang and/or Fang, as they are all directed to the design and operation of handheld, cylindrical, cigarette-like, electronic cigarettes that use a heating element within the device, powered by a battery, to vaporize liquid held within the device, for delivery via airflow to a user’s mouth via suction from the user, through a mouthpiece at the end of the device.

60. Additionally, each of Xia, Wang, and Fang (and the ’881 patent) use very similar cylindrical, cigarette-like structures and internal components to achieve very similar functions. Xia, Wang, and Fang were also all published within the same eleven month period and from Chinese inventors.

61. Additionally, a combination of these references would merely result in the substitution of known elements from Wang or Fang for elements in Xia (as

described in invalidity Ground 1 below) or of known elements from Fang for elements in Wang (Ground 2).

62. The internal components and how they function are very similar across all references (and the '881 patent). They are all from around the same time period, and all from Chinese inventors in a field that was active before and up to the priority date of the '881 patent.

63. For example, as discussed below with respect to specific limitations, combinations of Xia with Wang and Fang merely require known and predictable substitutions of elements to render the Challenged Claims obvious. Because the references are very similar and relate to a predictable subject matter, there would be a high likelihood of success when modifying one reference with the teachings of another. For example, altering the physical arrangement of the known components of the device in Xia, such as a heater or a battery, with similar components such as those in Wang and Fang, would not result in unpredictable results

64. Any arguable distinctions between any individual one of the prior art references discussed in this petition and the '881 patent that Patent Owner may argue for are basic design choices that any POSITA would consider.

65. Any of the references anticipate or at least individually render all claims of the '881 patent invalid through rather obvious, simple variations of the disclosures. However, multiple references, including combinations, are discussed

here, solely to address arguments that Patent Owner may make, although I do not agree with them.

XIII. INVALIDITY GROUNDS

66. In general, I do not see anything that could be considered new or non-obvious as it relates to the '881 patent claims. At the time of the filing of the application, as I have stated previously and as is recounted in the specification, two-part e-cigarette devices using similar structures and techniques were well-known. The prior art discloses precisely the apparatus claimed in the independent claims of the '881 patent. There is nothing surprising about the '881 Patent claims from a technical perspective, when viewed against the backdrop of the substantial prior art.

67. It is my opinion that Grounds 1-2 demonstrate by a preponderance of the evidence that skilled artisans would have considered the claims of the '881 patent obvious at the time of the alleged invention in July 27, 2009. I understand that this is the date Patent owner purports to have conceived of the alleged invention in the '881 patent and that Petition disputes this date, however, the references cited below all pre-date July 27, 2009.

68. The cited references themselves alone and/or in combination disclose the alleged invention for the same reasons and for the same objectives. This makes sense, as the industry at the time was focused on developing rechargeable and refillable e-cigarette devices for a wide audience.

69. My understanding of claim scope is in part informed by the positions taken in the district court ruling described above and Patent Owner's positions in parallel litigations in 337-TA-1368 and 1372, both in terms of arguments Patent Owner has made about disclosures of the prior art references (including the Fang reference) it asserted as invalidating JUUL's patents in the 1368 matter and related claim scope arguments, and also the arguments about claim scope Patent Owner made in asserting the '881 patent against JUUL products in the 1372 matter.

A. Ground 1: Xia in View of Either Wang or Fang Discloses Claims 1-27

70. In my opinion, claims 1-27 are obvious over Xia in view of either Wang or Fang and the knowledge of a POSITA. As explained below, each and every limitation of these claims is found in the prior art references and a POSITA would have had reason to apply the teachings of Wang and/ or Fang to Xia.

1. Claim 1

a. 1[p]: an apparatus comprising:

71. Xia discloses an apparatus, described as an "incombustible atomizing electronic cigarette." Ex. 1004 at 1. Not only does Xia disclose an apparatus, but it specifically discloses an e-cigarette like that claimed. Xia in view of Wang and/or Fang also discloses an apparatus, since each of Wang and Fang does as well.

b. [a1]: a power source,

72. Xia teaches that “[t]he whole device is powered by a 3.7 V lithium-ion battery.” Ex. 1004, 14. Figure 2, below, shows the configuration of this power source in relation to the rest of the apparatus. The claimed “power source” is satisfied by the battery itself, the “controller” portion of the device (illustrated on the left of Figure 2), or the battery combined with related components such as the connecting conductor B6 (within the controller), as a POSITA would understand any of these would constitute “a power source.”

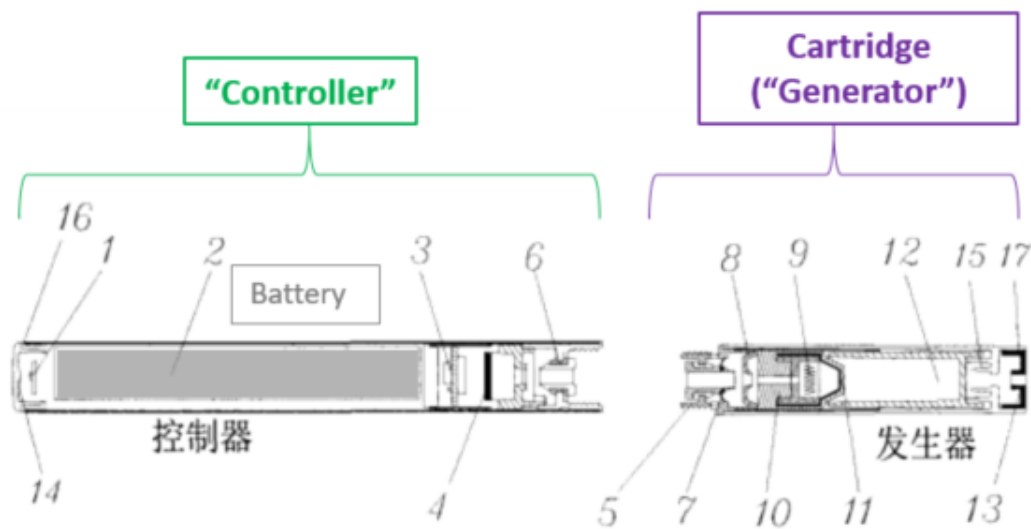


图 2

Ex. 1004, Fig. 2 (annotated).

73. Xia in view of Wang and/or Fang also discloses a power source, because each of Wang and Fang does as well, and in combining the references, a POSITA would have included a power source to power the e-cigarette.

c. 1[a2]: wherein the power source includes a battery,

74. As described above, regarding claim element 1[a1], Xia discloses this limitation. Xia discloses that the “device is powered by a 3.7 V lithium-ion battery.” Ex. 1004, 14; *see also* Figure 2 (element 2).

75. Xia in view of Wang and/or Fang also discloses a battery, because each of Wang and Fang does as well, and in combining the references, a POSITA would have included a battery to power the e-cigarette.

d. 1[a3]: wherein the power source includes an electrically conductive portion; and,

i. Xia

76. Xia discloses multiple electrically conductive portions of the power source. For example, Xia discloses that “[t]he heater 9 is powered by the rechargeable lithium battery 2 through the connecting conductor A5, the connecting conductor B6, and the integrated circuit board 3.” Ex. 1004, 8. In discussing Figure 3, Xia states that “the connecting conductor A 5 and the connecting conductor B 6 form a connecting outer ring,” and that negative and positive electrodes 601, 603

and 602, 604 connect the heater and the battery via the circuit board. Ex. 1004 at 12.

77. Xia describes that when battery 2 powers Xia's heating wire 9, current flows from the battery 2 to the circuit board 3, from circuit board 3 to connecting conductor B6, and from connecting conductor B6 to connecting conductor A5.

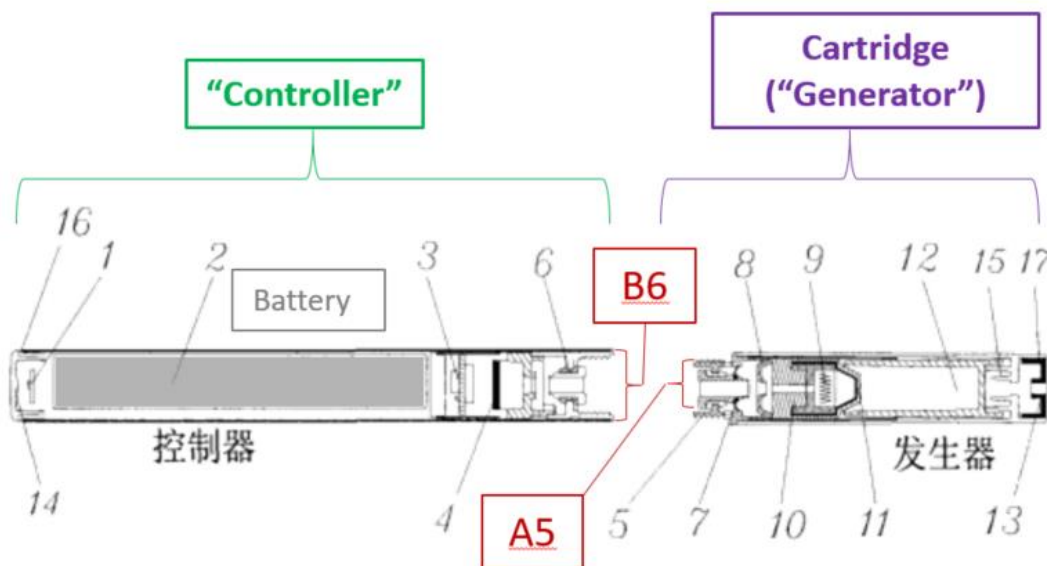
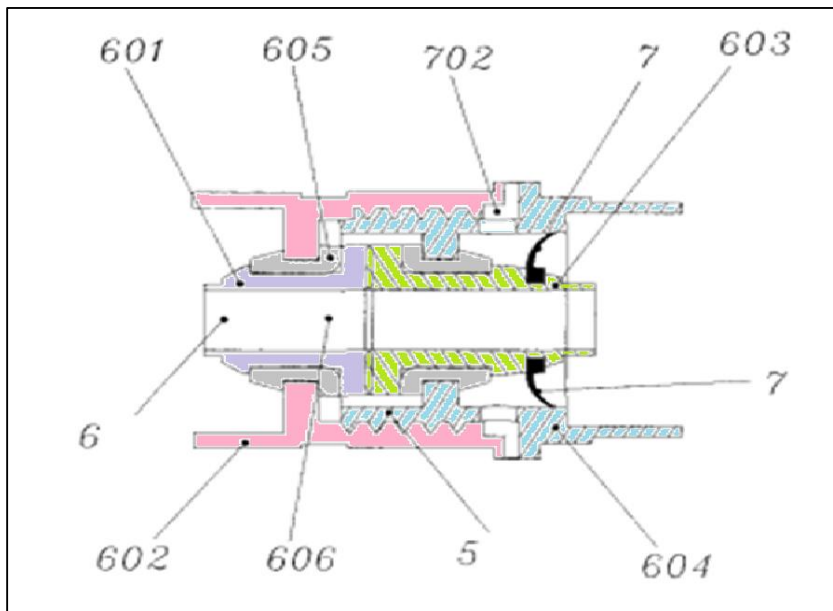


图 2

FIG. 2 (annotated). The connecting conductors B6 and A5 are also illustrated in contact when the two portions of Xia's e-cigarette are connected in FIG. 3, annotated to include coloring below:



Ex. 1003, Fig. 3 (annotated).

78. Thus, connecting conductors A5 and B6, electrodes 601 and 603 on the controller, and the “lead-in wires” of the circuit are each electrically conductive portions of the power source. Xia’s electrically conductive portions include the “lead-in wires” connecting the battery to the circuit board; the circuit board connecting the battery to connecting conductor B6; and connecting conductor B6 itself, including its electrodes 601 and 603 (illustrated in Figure 3). Ex. 1004, 7, 12, 13, 14. For example, a POSITA would understand that all such components must be electrically conductive because as disclosed in Xia, power flows from the battery through them to the heater. Also, a POSITA would understand that the battery 2 itself also necessarily contains an electrically conductive portion, to discharge

current. For example, a POSITA would know that batteries have electrically conductive terminals that can be connected to wires, and that as disclosed in Xia, the battery must necessarily include conductive portions as well.

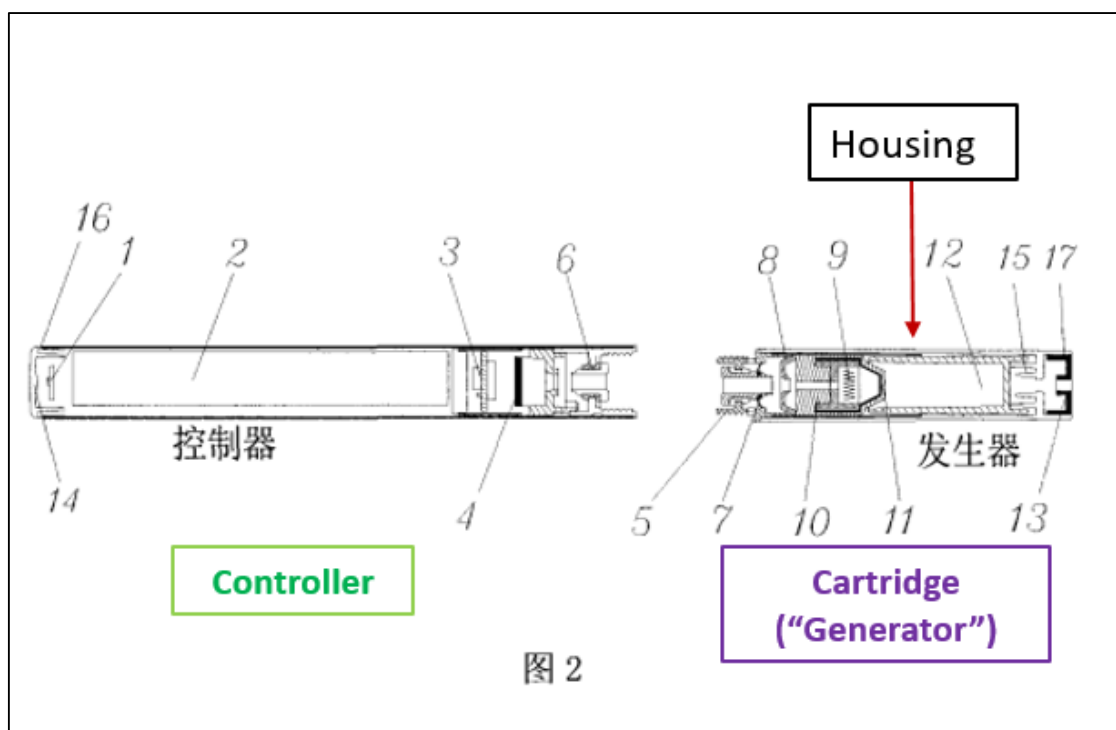
79. In my opinion, Xia's connecting conductor B6 on the controller, electrodes 601 and 603 on the controller, the "lead-in wires" of the circuit in the controller, and the battery 2's conductive portion are each electrically conductive portions of the power source as claimed.

ii. Xia with Wang

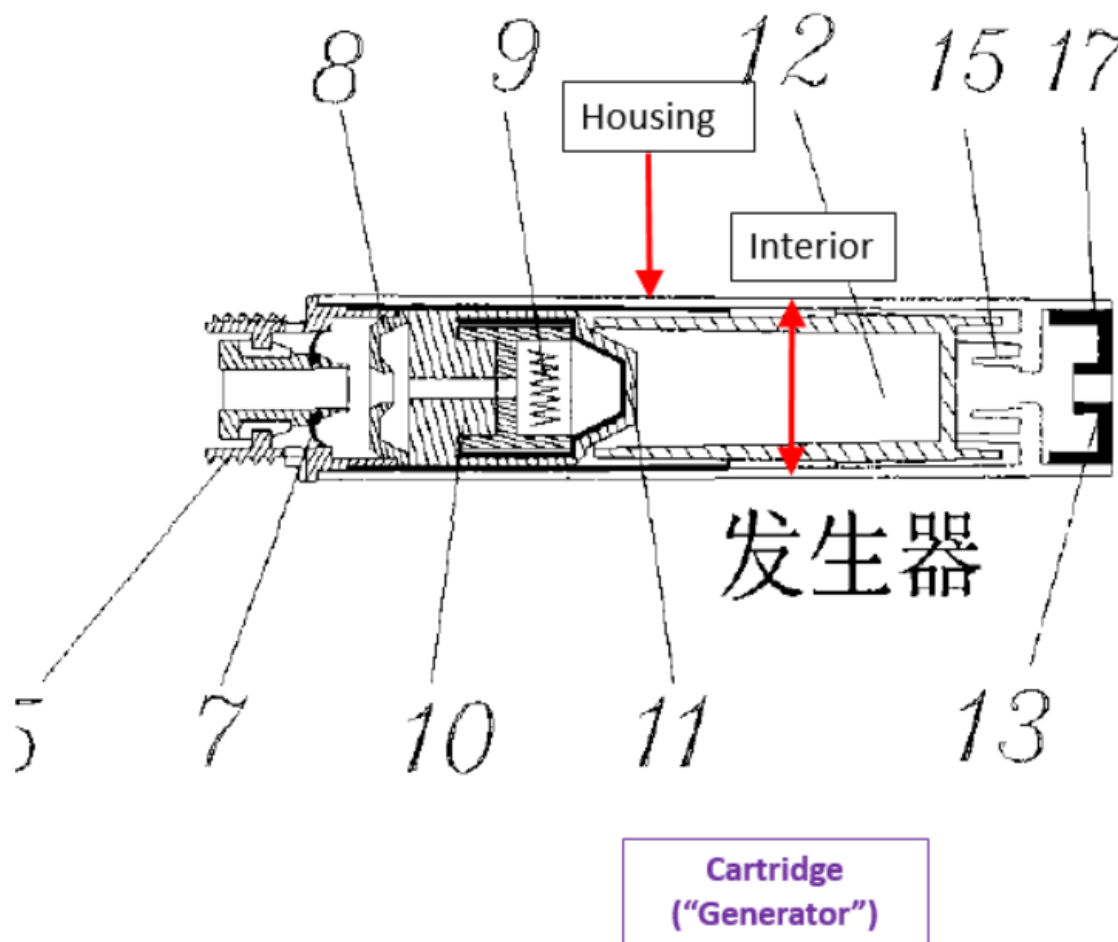
80. Xia in view of Wang also discloses this limitation. For example, as I explain in more detail below, a POSITA would have been motivated to combine Wang with Xia to modify the location of the claimed "first aperture," and in doing so, would have also included Wang's connection components. For example, a POSITA would have modified Xia to include the components that connect Wang's cartridge 102 to its battery-holding component 111, and in doing so would have included Wang's power source (battery 110) and electrically conductive portion (*e.g.*, electrode 119) within that battery-holding portion. I explain the specifics of the combination of Xia with Wang further below as I address other limitations.

e. **1[b1]: a cartridge having a housing that comprises an interior,**

81. Xia discloses a “generator” section of its apparatus, which connects to controller section and comprises a “stainless steel shell,” which serves as the claimed “cartridge” having a “housing,” respectively. As illustrated in Figure 2, the cartridge on the right has a housing that comprises an interior. Ex. 1004, Fig. 2; *id.*, 3 (“stainless steel shells are arranged on an outer surface of the controller and an outer surface of the generator[.]”). For example, the heater and solution holding medium are located in the interior of the housing of the cartridge.



Ex. 1004, Fig. 2 (annotated).



Ex. 1004, Fig. 2 (partial) (annotated).

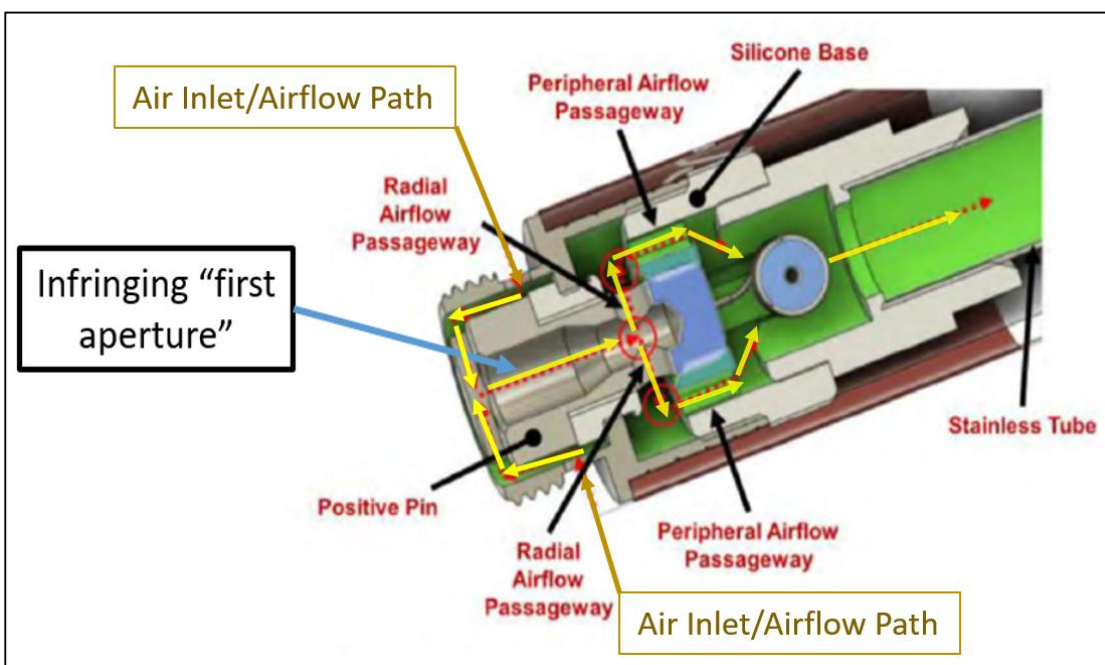
- f. 1[b2]: wherein the housing includes a first end and a second end that is opposite the first end, wherein the housing includes a first aperture on the first end and a second aperture on the second end,

i. Xia

82. Xia discloses this limitation. The '881 patent does not define "first end" or impose any specific requirements about how far it extends with respect to the

housing. Furthermore, a POSITA would understand that first aperture need not be directly on the tip of the first end to be “on a first end” opposite a second end. For example, a “first end” can extend from the very edge of the cartridge at least to the location of the first aperture 904 as shown in Xia.

83. The North Carolina District Court granted summary judgment of infringement finding that a device similar to Xia met this limitation as a matter of law. Ex. 1015 (MSJ Order), 17. The following figure depicts the accused apparatus, with air flowing in through side vents and converging to an internal and central “first aperture”:



84. Adopting the plaintiff’s position (which Patent Owner argues for in parallel litigation — accusing the same product in the same way), the District Court

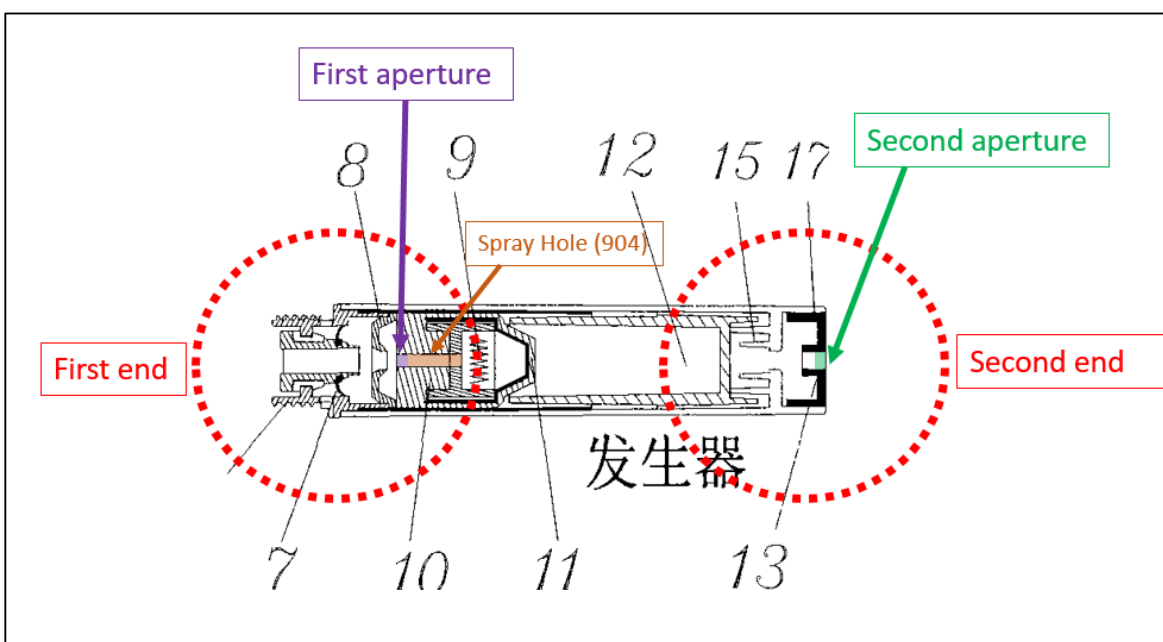
explicitly held that the internal aperture, which receives the airflow via side vents on the exterior of the housing, meets the requirement for a first aperture “on the first end.” Ex. 1024 (Dkt. 122, RJR MSJ); Ex. 1020, at 17 Ex. 1015 (Dkt. 139, MSJ Order) at 14-18. Patent Owner continues to accuse this same product in the parallel ITC case in the same manner as the prior patent owner did. Ex. 1032 (337-TA-1372 Initial Domestic Industry Contentions, Ex. 4) at 4-5.

85. Patent Owner’s infringement contentions against Petitioner in the parallel ITC case also identify a “first end” that is not merely just the very edge of the device:



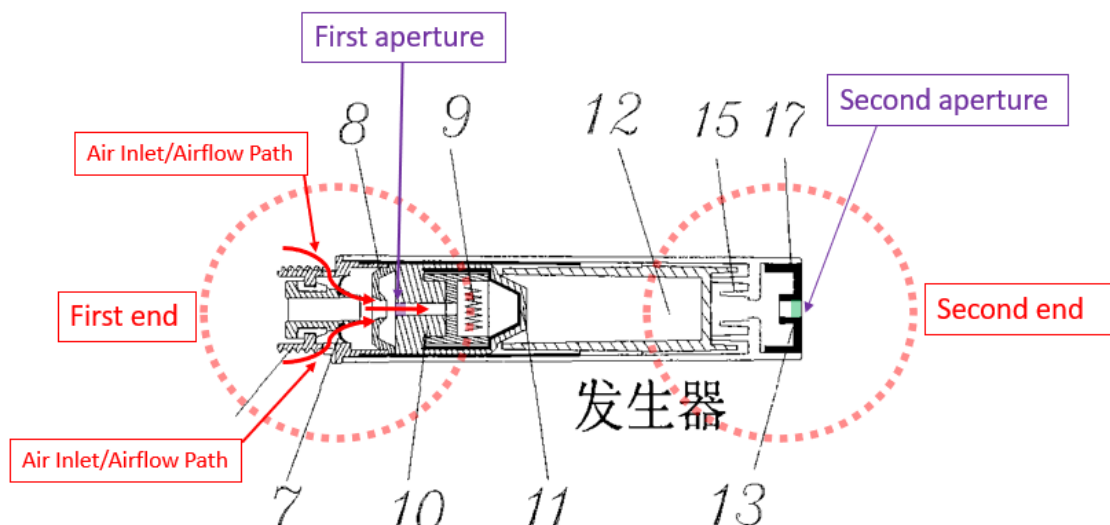
Ex. 1033 at 11.

86. Xia teaches a similar first aperture on the first end, with air flowing in through side vents and converging to an internal and central “first aperture.” As shown in Figure 2 below, the shell of Xia’s generator (the claimed “housing” of the “cartridge”) has first and second ends opposite each other, having a first and second aperture respectively, at the left and right ends of the image.



Ex. 1004, Fig. 2 (partial, annotated); *see also* Ex. 1004, Fig. 4 (ref. no. 904 as the claimed “first aperture”). The aperture at the left most, front edge of spray hole 904 satisfies the requirement of a first aperture on the identified first end, and the hole at the rightmost edge of soft suction nozzle 13 satisfies the requirement the second aperture on the identified second end. Ex. 1004 at 3, 12-13, Fig. 1, Fig. 2.

87. Xia teaches a first aperture on the first end, with air flowing in through side vents converging to an internal and central “first aperture”:



Ex. 1004, Fig. 2 (partial, annotated).

88. A POSITA would also know that it would be a simple modification to move the air intake to the battery side and have air enter centrally on the end of the cartridge.

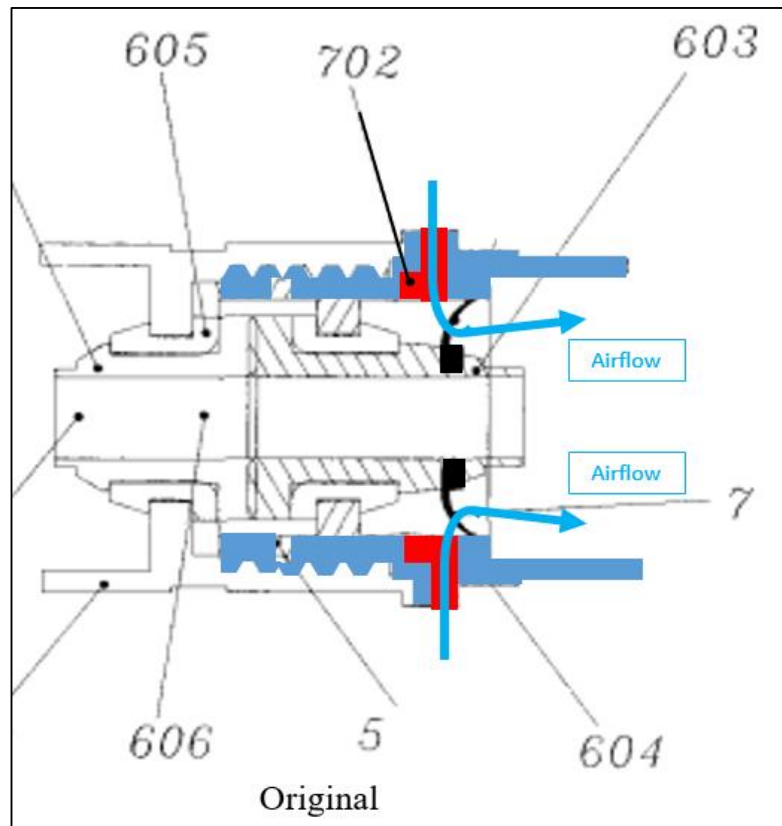
ii. Xia with Wang and/or Fang

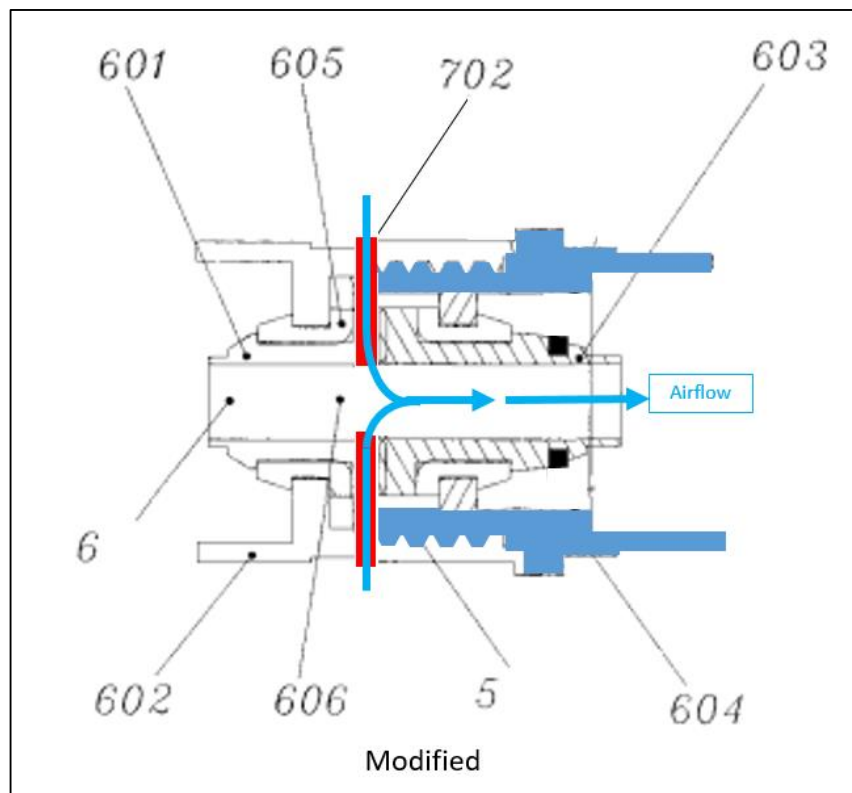
89. If the claimed first aperture were required to be closer to the edge and surface of the first end—and it is not—it was obvious to reposition Xia’s “first aperture” to meet such an additional requirement. For example, as shown below in

connection with element 1[c], it was obvious to modify Xia's cartridge to include a passageway through the center of the solution holding medium as in Wang. In that combination, Wang discloses this limitation because Wang's first and second apertures are "on" the first and second cartridge ends, respectively, as described below and in Ground 2 elements 1[b2]-1[d]. If the apertures are required to be literally on the very edge of the cartridge, that would be an obvious modification under Xia and/or Wang and/or Fang, as it would merely require extension of the passageway to the very edge of the housing, with a central aperture (already present in Wang and Fang), which would also allow the solution holding medium to be extended to the edge of the housing as well, increasing liquid storage capacity as explained in Ground 2, 1[c].

90. A POSITA would have been motivated to modify Xia's cartridge to include this obvious passageway and aperture arrangement shown in Wang, for instance, because, for example, it would be known to any POSITA to be a simpler design, which is easier and cheaper to manufacture. For example, forming an aperture on the outer edge and surface of the end of the cartridge is easier to manufacture because it is easier to access and can be done in more ways than manufacturing an aperture elsewhere on the first end. Having the aperture on the outer edge and surface can also reduce the need for additional parts, for example parts that go within the first end, that would define an aperture.

91. Moving the air intake hole that serves as the claimed first aperture to the edge of the first end of Xia's cartridge could for example be accomplished by moving the air inlets 702 to the controller portion (and extending through a hole in the center of the connection between the cartridge and the controller). In that arrangement, the opening of the connecting conductor A5 would serve as the first aperture if it were made to be open on the end and thus allow airflow down the middle of the housing. For example, I provide the following images illustrating the difference between Xia's original design and an obvious modification of it:





92. In any of the above modifications, the air would flow into the heating element as it does in Xia's original design, except that it would enter from a central aperture at the very edge of air input side of the cartridge. The air then flows centrally toward the heating element via a central and axial passageway connecting the first aperture to element 904 within Xia. That could be accomplished for example by having element 904 extend all the way to the new aperture location on the very left edge of the cartridge.

93. As part of this modification, a POSITA could also remove the vibrating diaphragm 7 from Xia, as the air no longer flows past it, and instead use an air

pressure sensor as in Fang and Wang. For example, when air flowed through holes 702, it went past the diaphragm, making it vibrate, but moving the location of the airflow means the diaphragm no longer vibrates when a user sucks. As such, a POSITA could have, for example, modified the microphone 4 of Xia to use one that is more sensitive to pressure changes, or to a pressure sensor to initiate activation of the heater, and locate that in the battery portion, and not in the disposable, separable cartridge, which is a better placement, as it reduces waste and increases re-use and better supports a direct passageway through the cartridge from beginning to end.

94. This would be obvious straightforward in its own right because a simple pressure sensor is a well-known way to detect suction, as Fang and Wang demonstrate, many microphones are merely sensitive pressure sensors that detect the vibrations in the air caused by sound propagation. A POSITA would have understood that detecting pressure changes (caused by user suction) could decrease the likelihood of inadvertent activation that could occur with a sound sensor, for example by errant sounds such as generated by tapping within a pocket or purse. E-cigarettes are designed to be carried in pockets and purses, for example near or in contact with coins and the like that can cause tapping for example when carried around. The sound detector of Xia, as a POSITA would have known, could inadvertently trigger the heating element if such tapping mirrored the vibrations of the diaphragm for example. This would result in the e-cigarette's vapor being

emitted in the user's pocket or purse for example, making them or their belongings wet and/or sticky with residue and wasting vapor and liquid that could otherwise be inhaled. Overall, this modification simplifies Xia by removing the vibrating diaphragms (which has to be made of a material having specific pliability properties—Xia discloses rubber or silica gel at Ex. 1004 at 12—and therefore from a different type of material than the rest of the e-cigarette), and reduces the risk of inadvertent activation.

95. A POSITA would have known that modifying Xia to use pressure detection (rather than sound detection) would have a reasonable likelihood of success. For example, each of Fang and Wang disclose the use of a pressure sensor in an e-cigarette application for initiating the heater activation. Specifically, Fang states that: “[w]hen the utility model is in use, the smoking channel 10 generates a negative pressure in the atomizer control switch 4 by a suction force of a user, the silicon film-coated tablet 11 bulges in the support 13 towards the direction of the switch circuit board 12, under the control of the Hall element and the field-effect tube, the switch circuit board 12 makes the electric heating film wire 16 be communicated with the battery 3, due to the action of the capillary tubes[.]” Ex 1006 at 5-6. Similarly, Wang states that: “[t]he sensor 112 of the cigarette rod is a switch device that drives the circuit control board 113 and then drives the discharge output of the battery 110. The sensor is used to collect airflow and pressure changes

generated by smoking motions in real time, a method of judging resistance value changes may be adopted, and a specially-made diaphragm device may also be used to sense on-off signals.... Since the motions of the smoker may control the sensor 112, the working time and pause time of the electric heater 104 also change intermittently with the motions of the smoker, thereby atomizing the tobacco extract 103 around it intermittently.” Ex. 1005, 7.

96. Further, Xia’s structure is already set up such that the pressure sensor could be swapped in for its sound sensor in a straightforward way: in Xia, “the airflow passes through . . . the liquid blocking plate” to reach the heating element. That is, the vertical blocking door in item 8 is opened via suction, demonstrating that suction force (negative pressure) propagates through the device when assembled and used. Ex. 1004, 16. That same mechanism can be used in the passageway described in this modification.

g. 1[c]: wherein the housing includes an airflow passageway that extends centrally and axially with respect to the housing intermediate of the first aperture on the first end of the housing and the second aperture on the second end of the housing

i. Xia

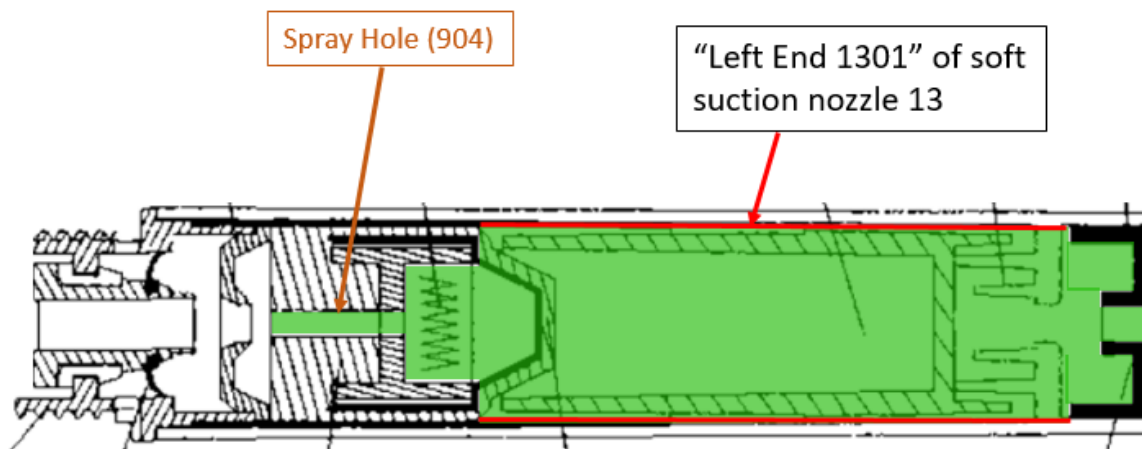
97. Xia discloses an airflow passageway that extends “intermediate of the first aperture...and the second aperture” as claimed.

98. As discussed above, in the prior North Carolina district court litigation, the then-patent owner and plaintiff argued—and the District Court found—that a central and axial passageway that extends in a straight path through the center of the cartridge meets this limitation, even if there are objects in that passageway that obstruct the airflow and direct it away from the center, rather than allowing it to flow along the central axis.

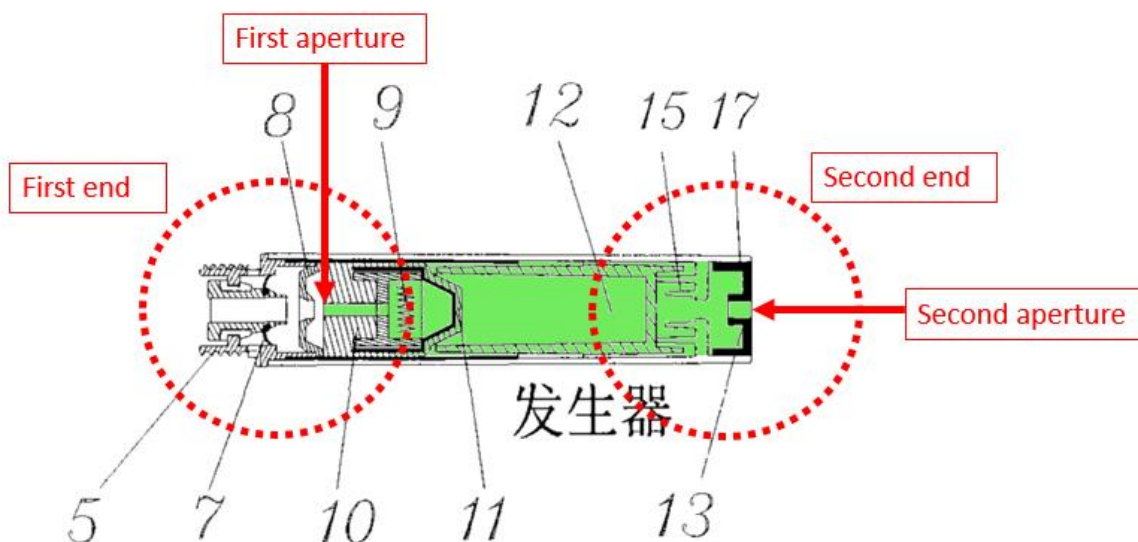
99. For example, Xia states that the airflow (and liquid suspended therein) is “sucked ... through the spray hole 904 ... [and] then flows out of the heater 9 from the overflow holes 903, then flows to the position of the soft suction nozzle 13 through the gap between the soft suction nozzle and the liquid storage chamber 12 as the airflow channel, and is finally sucked out through the soft suction nozzle 13.” Ex. 1004, 8.

100. The airflow passageway in Xia runs along the inner surface of the cartridge housing. For example, Xia discloses an airflow passageway through which air flows and that is defined at least in part by spray hole 904 and a layer of material (such as polypropylene PP material) on the inner surface of the housing. Ex. 1004, (“A left end 1301 of the soft suction nozzle 13 extends to the bottom of the liquid stopping sheet 8, and may be made of environmental-friendly materials such as polypropylene PP, which may effectively prevent internal heat from being

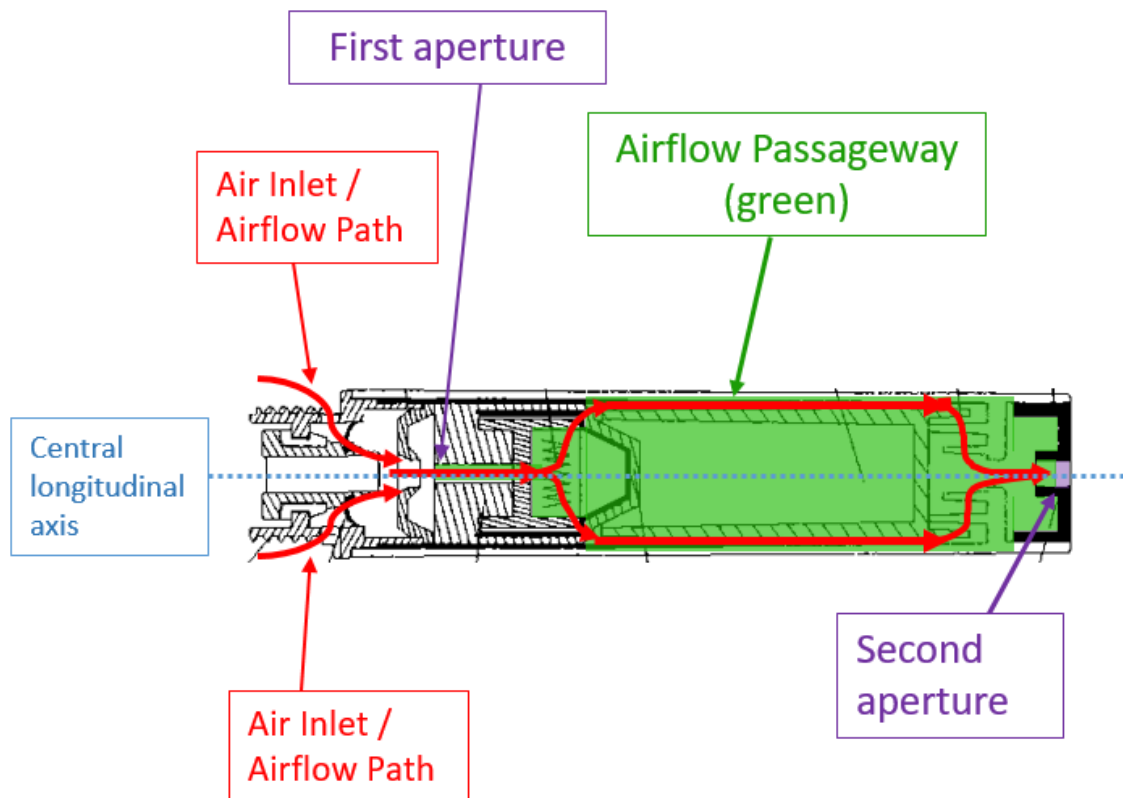
transmitted out.”) 11, Figs. 2, 5. This airflow passageway is highlighted in green in the modified figure below.



Ex. 1004, Fig. 2 (partial, annotated). As shown below, Xia's airflow passageway extends "intermediate of the first aperture...and the second aperture" as claimed.

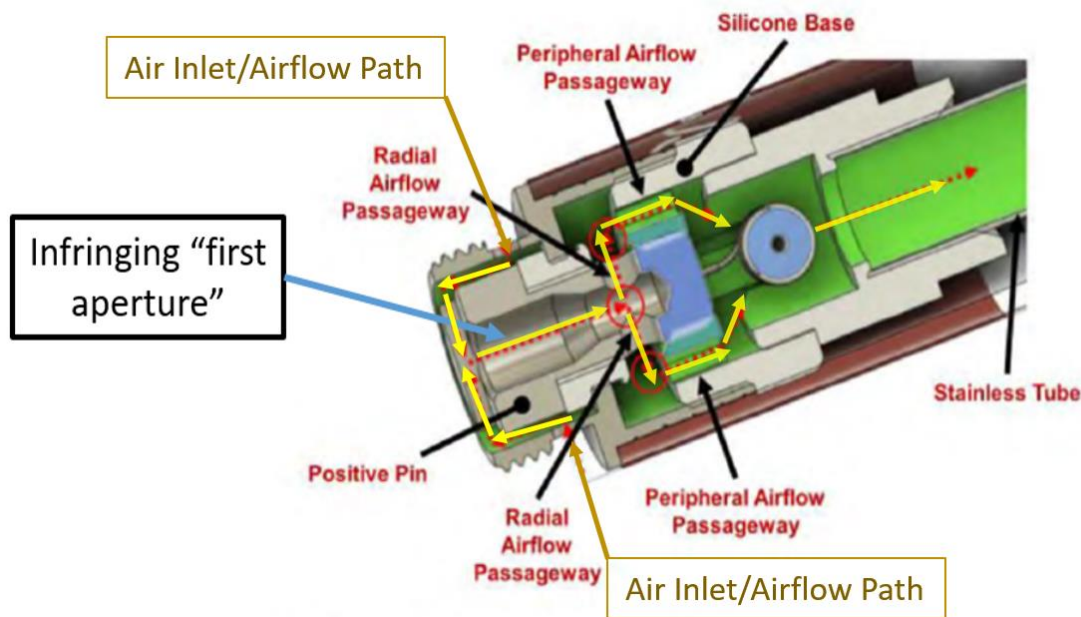


101. In addition, this air passageway is also both interior to the inner surface of the cartridge housing and centrally and axially located with respect to the housing along the length of the cartridge:



102. If NJOY argues the Xia's airflow passageway is not centrally and axially located because air within the passageway flows around certain items, such as the liquid storage container 12, rather than in a straight line, that argument is inconsistent with the its own assertions in the pending ITC investigation where they accuse the RJR Vuse CIRO device, the prior summary judgement decision as to that device, and the positions taken by prior patent owner Fuma in the RJR litigation.

103. As to the prior summary judgment decision, the District Court rejected just such an argument about the actual airflow itself and instead found that a passageway like Xia's satisfied this limitation as a matter of law. Specifically, the North Carolina District Court rejected defendant's argument that the accused airflow passageway (shown below in green) did not meet this limitation because (according to defendant) objects in that passageway obstructed airflow and directed it away from the center, rather than allowing it to flow along the central axis. Ex. 1014 (RJR Brief), 14-18.



Id., 15. The District Court explained that defendant improperly “conflat[ed] the airflow’s path with the airflow passageway.” Ex. 1015, 14-18. Although “[t]he positive pin and silicone base [in the image above] obstruct airflow and alter the

airflow's path" they do not alter the "interior airflow **passageway**, which at all times extends straight through the center of the [accused] cartridge to the second end as required by the claim." Ex. 1015, 14-18.

104. As to Patent Owner's current assertions, it is again contending in the pending ITC investigation that this very same RJR's product and passageway meets the '881 patent claims and this limitation. Ex. 1032, 6.

105. Consistent with the District Court's ruling, prior patentee Fuma's arguments, and Patent Owner's current ITC investigation assertions, Xia's airflow passageway is also therefore centrally and axially located, despite the fact that the air may flow around objects in the passageway.

ii. Xia with Wang

106. If NJOY contradicts itself and all of the foregoing to argue that Xia itself does not disclose or suggest this limitation, it was obvious over Xia in view of Wang. As explained further in connection with 1[h], in at least the part of the device near the heating element, the airflow passageway is inset from the walls of the housing, centrally and axially, with the solution holding medium 10, surrounding it:

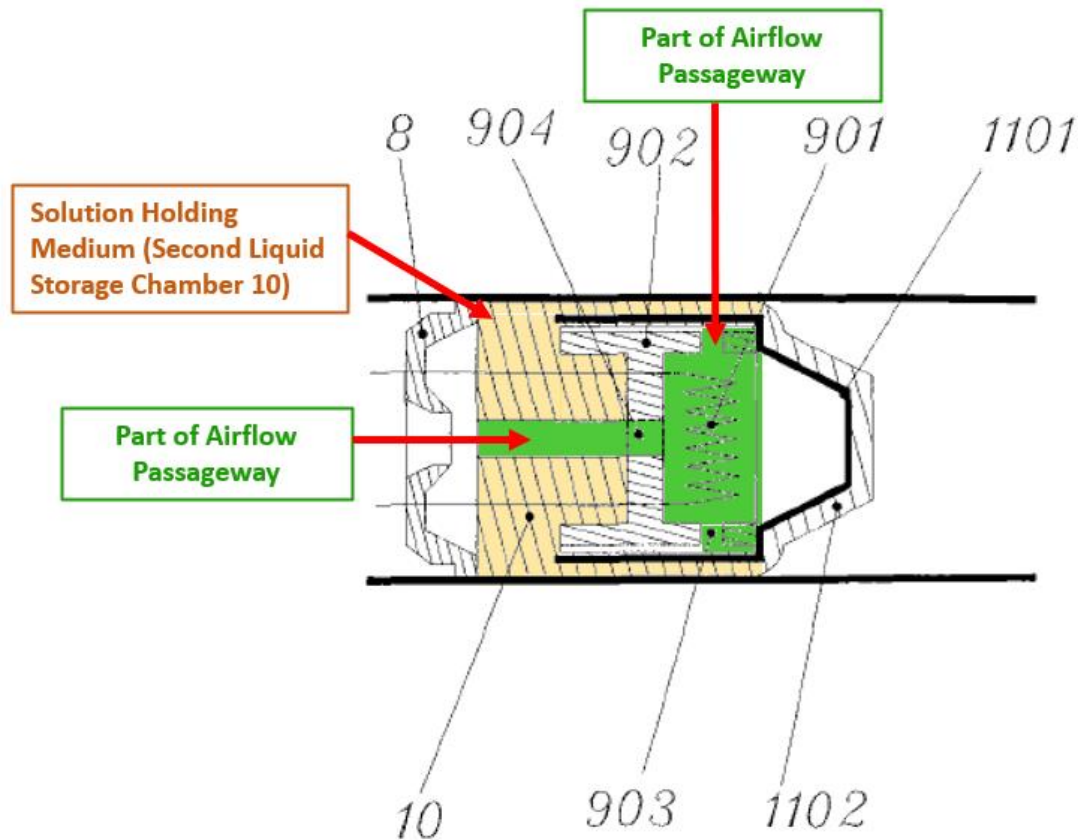
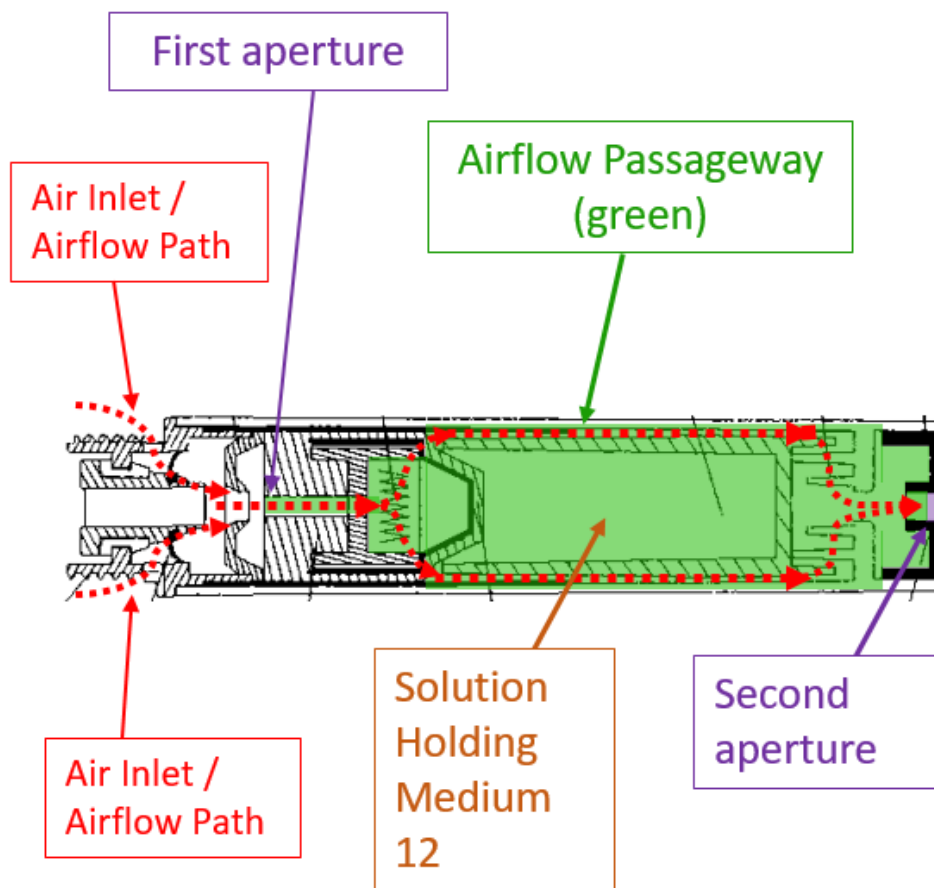


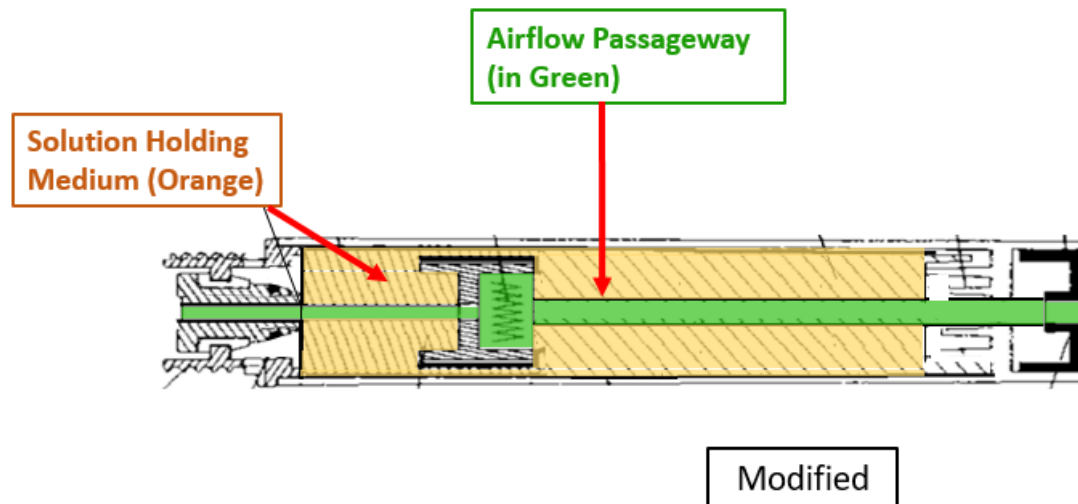
图 4

Ex. 1003, Fig. 4; see 1[h]. Xia's inventors chose to place the remaining storage holding medium, item 12, in the center of the airflow passageway such that the air flows around it:



Ex. 1004, FIG. 2.

107. A POSITA would know that another obvious alternative, with obvious benefits, would have been to extend the architecture in the area of the heating element in Figure 4 leftward and rightward, such that airflow passageway extends through the solution holding medium:



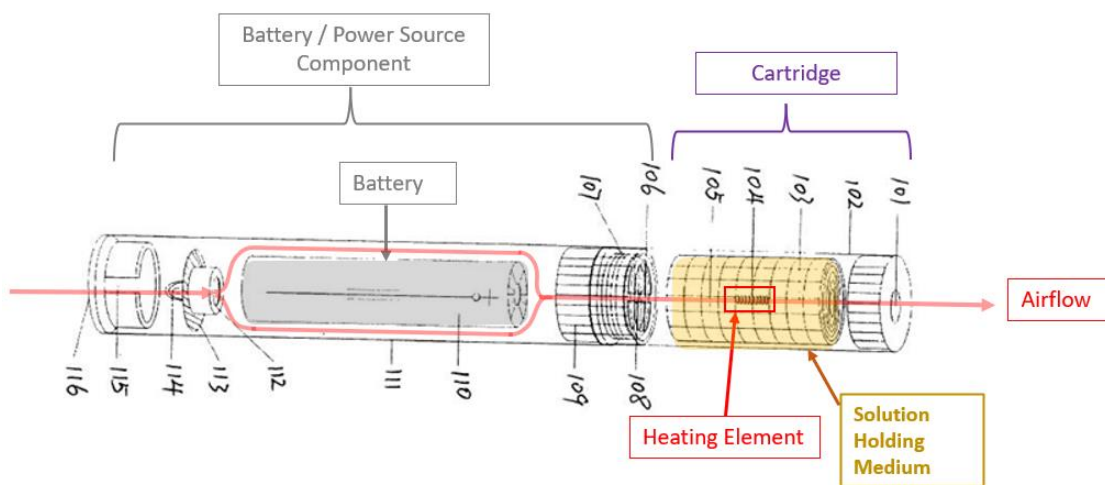
Ex. 1004, FIG. 2 (modified).

108. This obvious modification would make the existing architecture in the heating element area consistent and run along the length of the cartridge. All items would function as they currently do in Xia.

109. Using such a passageway and solution holding medium design in Xia was obvious because, for example, it was the substitution of a known element for another that yields predictable results and it is the use of a known technique to improve a similar item in the same way to yield predictable results.

110. Additionally, this limitation would have been obvious over Xia in view of Wang. For example, Wang discloses that air enters “cigarette holder” (the claimed “cartridge” as explained further in Ground 2) via “air inlet 106”, and exits through “air outlet 101.” Ex. 1005, 8. As Wang demonstrates, the use of a cartridge with the

claimed central and axial airflow passageway was well known. Wang discloses an airflow passageway that extends “intermediate of the first aperture...and the second aperture” as claimed. Wang Figure 1 as annotated below depicts the aforementioned airflow path:



Ex. 1005, FIG. 1 (annotated).

111. Wang also discloses that the airflow passageway is centrally and axially located with respect to the housing. For example, Wang describes the airflow as proceeding centrally and axially, demonstrating that there is a central and axial airflow passageway. “The cigarette rod shell 111 adopts a longer cylindrical shape of a cigarette body.... The cigarette rod shell is a hollow cylinder.... One end of the shell is one end of the air outlet 108, and is connected to the input end of the cigarette holder along with the output end 109. The other end of the shell is one end of the air

inlet 115 on the indicating lamp cover 116, and forms an uninterrupted airflow channel together with a gap inside the shell 111.” Ex. 1005 at 5-6 (emphasis added).

Wang also states that the air flows into the permeable “organic fiber 105,” flowing over the “heater 104,” and exits to the user via “outlet 101”. Ex. 1005, 8; 7. Indeed,

Wang states:

The air inlet 115 of the cigarette rod, an internal gap of the cigarette rod, the air outlet 108 of the cigarette rod, the air inlet 106 of the cigarette holder, an internal gap of the cigarette holder and the air outlet 101 of the cigarette holder form the complete airflow channel.

Ex. 1005, 8.

112. Wang’s “internal gap” or “airflow channel” allows the air flow to move through the space within the cylindrical cartridge as it flows. This structural airflow passageway therefore “extend[s] centrally and axially with respect to the housing,” from the first aperture to the second as claimed. For example, Wang’s air inlet 106 is in the “middle or on a side of the end input 107” and “air outlet 101 of the cigarette holder is placed at the other end of the air inlet 106 of the cigarette holder.” Ex. 1005, 8.

113. Wang teaches an organic fiber 105 that stores the liquid tobacco extract 103: “tobacco extract 103...is natural tobacco absolute oil, a certain proportion of nicotine is mixed in after the tobacco extract is diluted with alcohols in a certain

proportion, and then a mixture quantitatively soaked in the organic fiber 105.” Ex. 1005, 4. As Wang states, “[t]he organic fiber 105 of the cigarette holder is a natural wood fiber or natural absorbent paper.” Ex. 1005 at 7. In Figure 5, this is shown a sheet of paper or other fiber rolled into a cylindrical shape. Such a shape has a cylindrical gap in down the center:

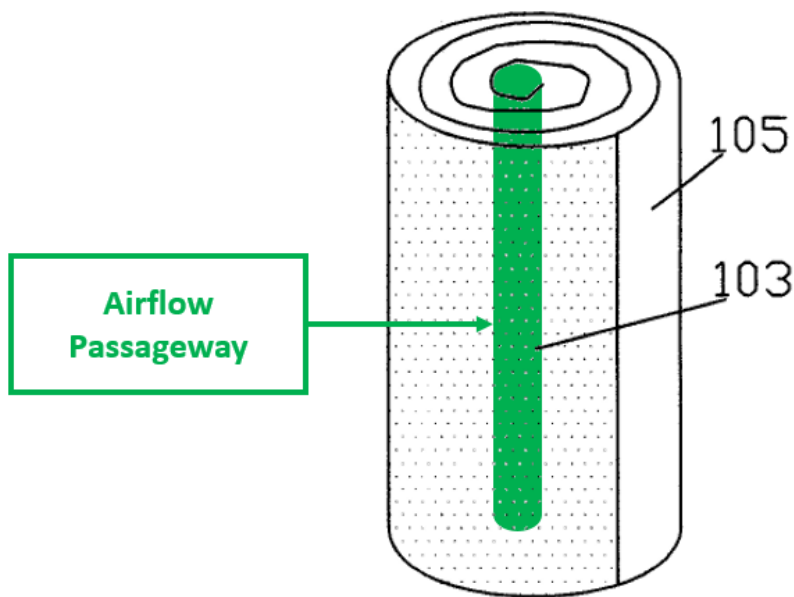


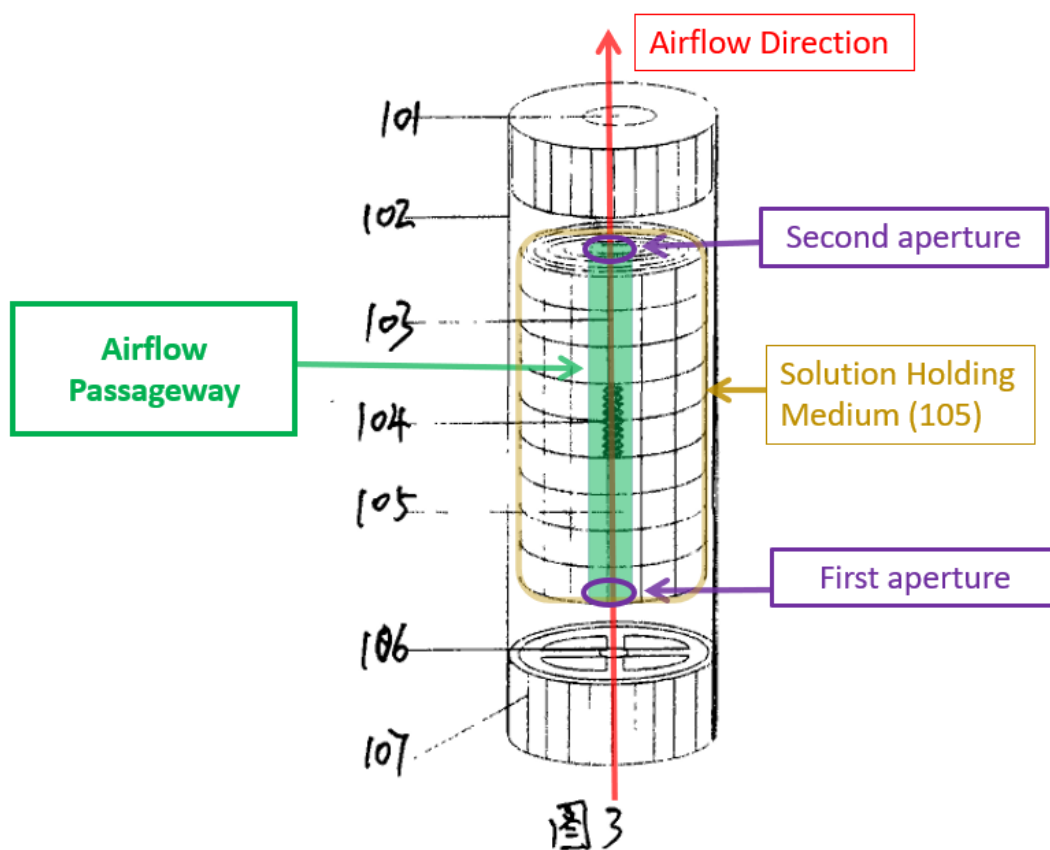
图 5

Ex. 1005, Fig. 5 (annotated).

114. A POSITA would know that the fiber or paper is or could beneficially be rolled so tightly that air only flows through the central chamber, where the heating element is located, which makes sense as the air flow needs to pick up the vapor

being created by the heater and needs to draw liquid droplets to the heater (as is shown and described in Xia).

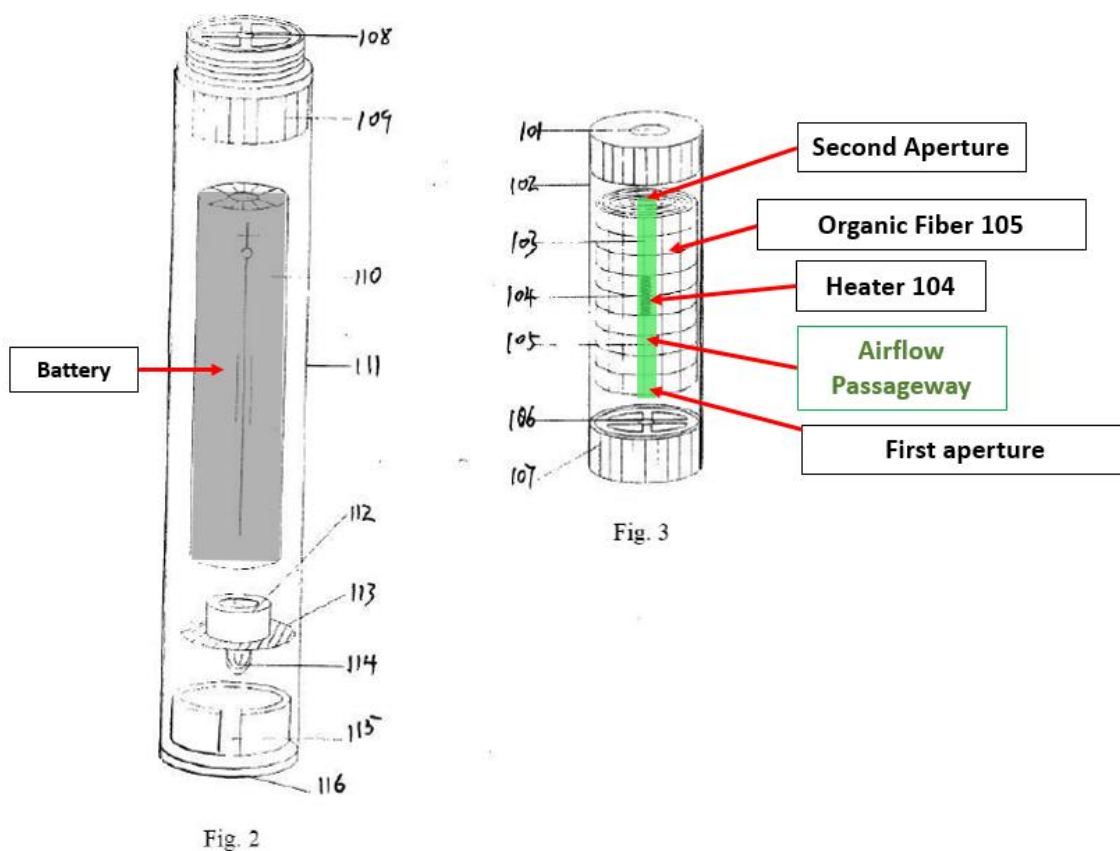
115. As illustrated in Wang's Figure 3, this passageway extends centrally and axially with respect to the housing intermediate of the first aperture on the first end of the housing, the aperture at the lower portion of solution holding medium 15 and the second aperture on the second end of the housing (similar).



Ex. 1005, Fig. 3, 8 (“the smoke generated by the tobacco extract 103 instantly heated by the heater 104 is partially sucked out from the air outlet 101 of the cigarette holder.”). As seen in Figure 3, with added highlighting, the airflow must pass directly through the center via the space provided by rolling the organic fiber 105 around the heating element, in order to reach the shown centrally located heating element and then reach the second aperture. Wang describes air entering the device through “air inlet 115” crosses into the cigarette holder (the claimed cartridge) via “air inlet 106”. Ex. 1005, 8. Air flows into gap in the rolled “organic fiber 105,” flows over the “heater 104,” and exits to the user via “air outlet 101”). Ex. 1005, 7-8; Ex. 1017 (Wang Decl.) at 4-5. Additionally, Wang states that: “[t]he cigarette rod shell 111 adopts a longer cylindrical shape of a cigarette body.... The cigarette rod shell is a hollow cylinder.... One end of the shell is one end of the air outlet 108, and is connected to the input end of the cigarette holder along with the output end 109. The other end of the shell is one end of the air inlet 115 on the indicating lamp cover 116, and forms an uninterrupted airflow channel together with a gap inside the shell 111.” Ex. 1005 at 5-6 (emphasis added).

116. A POSITA reading Wang would have understood that the air flows through Wang’s “airflow channel” such that the airflow passageway extends through the permeable “organic fiber 105” in which the “tobacco extract 103” is held, as it must in order for the airflow to carry the vaporized liquid to the user.

117. In the prior North Carolina district court litigation, the inventor Mr. Wang confirmed that his invention's solution holding medium (absorbent organic fiber 105) "surrounds a complete central air passageway, in which the heater is positioned." Ex. 1017 (Wang Decl.), 4-5. That central air passageway is annotated below in green and extends from a first aperture and a second aperture.



Ex. 1005, Figs. 2-3 (annotated).

118. A POSITA would have been motivated to combine this aspect of Wang with Xia for several reasons with highly obvious benefits, including improved air

flow, temperature, and vapor content. For example, designing an electronic cigarette to have the airflow travel centrally and axially, to the extent it is not already, with respect to the housing for at least a portion of the airflow passageway will prevent the heated vapor from contacting the inner wall of the device such that the potentially harmful heat from the vapor will not be felt by the user's hand. Additionally, designing the airflow passageway in this manner is also a less complex design as it is the most direct pathway for air to enter the device and for nicotine-infused vapor to exit the device for inhalation by the user. It also reduces the pinch points through which the air flows. Making an airflow passageway located centrally and axially, away from the walls of the housing, with the solution holding medium situated between (and around) the air passageway and the outer housing, throughout the length of the housing would provide improved, smoother air flow without pinch points, better temperature control such that it does not get overly hot where a user holds the device, nor overly cool down the vapor when it is cold outside, and vapor content, as well as being simpler and cheaper to design and manufacture (e.g., because it has fewer parts and is more symmetrical).

119. And this obvious substitution and use of Wang's cartridge layout could be easily achieved using Wang's elements that connect the cartridge and battery-holding component, and it would result in predictable results. Xia already uses this architecture for part of its system, in that secondary liquid storage chamber 10, part

of the solution holding medium, is situated between the housing and the central heating element 9 and the portion of the airflow passageway passing over it. *See, e.g.,* element 1[h] below. The only modification would be to make that architecture consistent and run along the length of the cartridge.

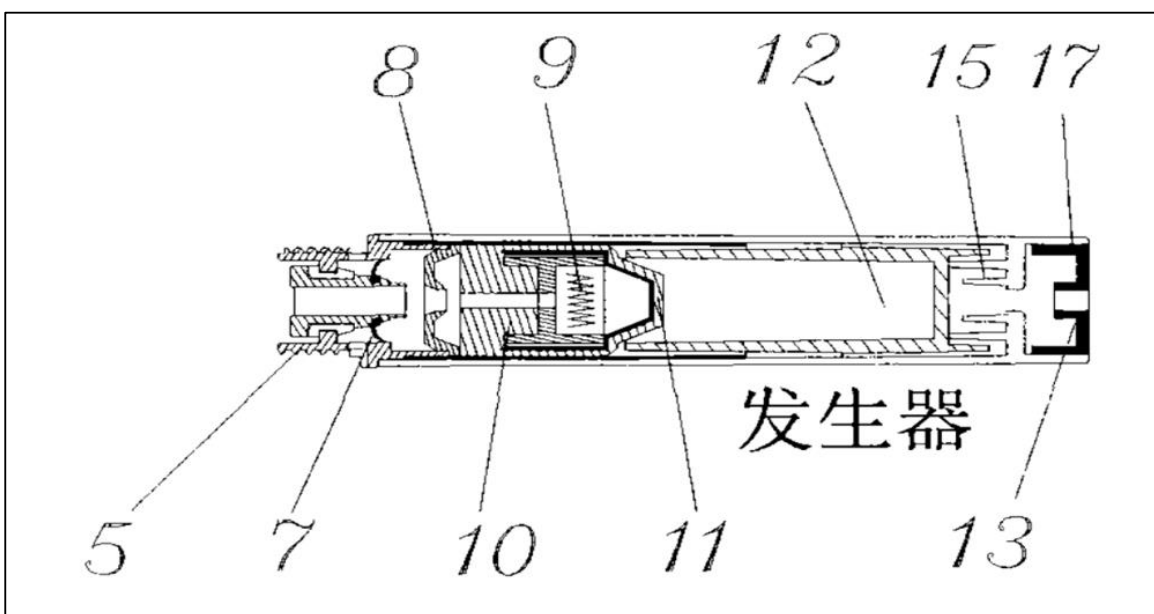
120. Additionally, a POSITA would have had a reasonable expectation of success in making such a modification. Xia already uses this architecture for part of its system, in that secondary liquid storage chamber 10, part of the solution holding medium, is situated between the housing and heater 9 and the portion of the airflow passageway containing the heating element. *See, e.g.,* element 1[h] below. The only modification would be to make that architecture consistent and run along the length of the cartridge. All items would function as they currently do in Xia.

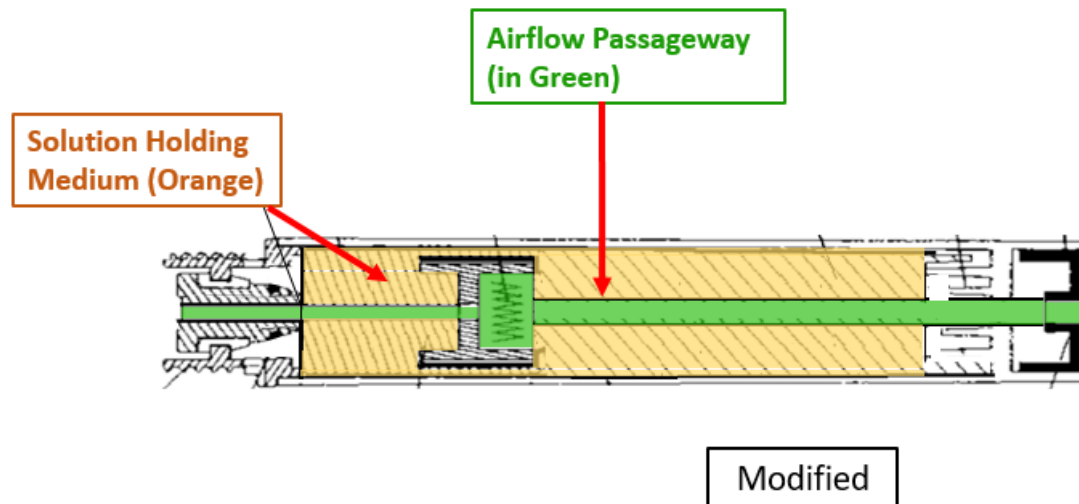
121. A way to achieve the same result would be to change the shape of the liquid storage container 12 to include a central hole through which air can flow, either by using a liquid-impermeable cylinder through the center of the storage container 12, with the existing solution holding medium around it, or by using the solution holding medium of Wang, which has a hole down the middle as explained above and in Ground 2. Xia already discloses that the liquid storage container is not sealed closed, demonstrating that making a through-hole would not require experimentation: “liquid storage chamber 12 is a cylindrical object with one end open.” Ex. 1004, 13. For example, this indicates to a POSITA that the liquid storage

container has a solution retaining medium therein, such as a sponge or the like, that causes the liquid to stay within, despite not being sealed closed. This means that there is not an issue with including a through-hole through it, because its liquid retaining properties were not dependent on it being sealed in the first place.

122. This modification would also simplify the structure of the device, making it (1) have fewer parts, and (2) be more easily manufactured by increasing the use of cylindrical shapes. In doing so, a POSITA would move the portion of the liquid blocking plate 8 that stops the backflow of liquid to the end of the secondary liquid storage chamber. In making such a modification, the secondary storage chamber 10 retains the same properties it has as originally described in Xia (that is, is draws liquid from the storage chamber and causes droplets to become suspended in the air to be vaporized by the heater), other than becoming bigger to hold more liquid. Also, in making the through-hole modification, the storage chamber 12 can additionally have the same impermeable barrier interior it has in Xia's original design, merely extending around the new through hole to prevent liquid droplets from entering into the airflow channel from the storage container. Or using a liquid storage medium like Wang's, with a rolled material within item 12, with a passageway down the middle like in Wang, would be an obvious choice to achieve the obvious benefits of a central airflow passageway the length of the device. Like secondary liquid storage container 10, the liquid storage container 12 is bigger in the

modified design. The liquid blocking plate 8 in Xia also keeps its function, that is, blocking backflow of chemical liquid by having a one-way valve in the path of airflow. See Ex. 1004, 13 (“The liquid-blocking plate 8 may prevent the chemical liquid in the secondary liquid storage chamber 10 from flowing out...”). For example, a side-by-side comparison of the original FIG. 2 and the modified FIG. 2 (showing the airflow passageway in green) illustrates the simplification:



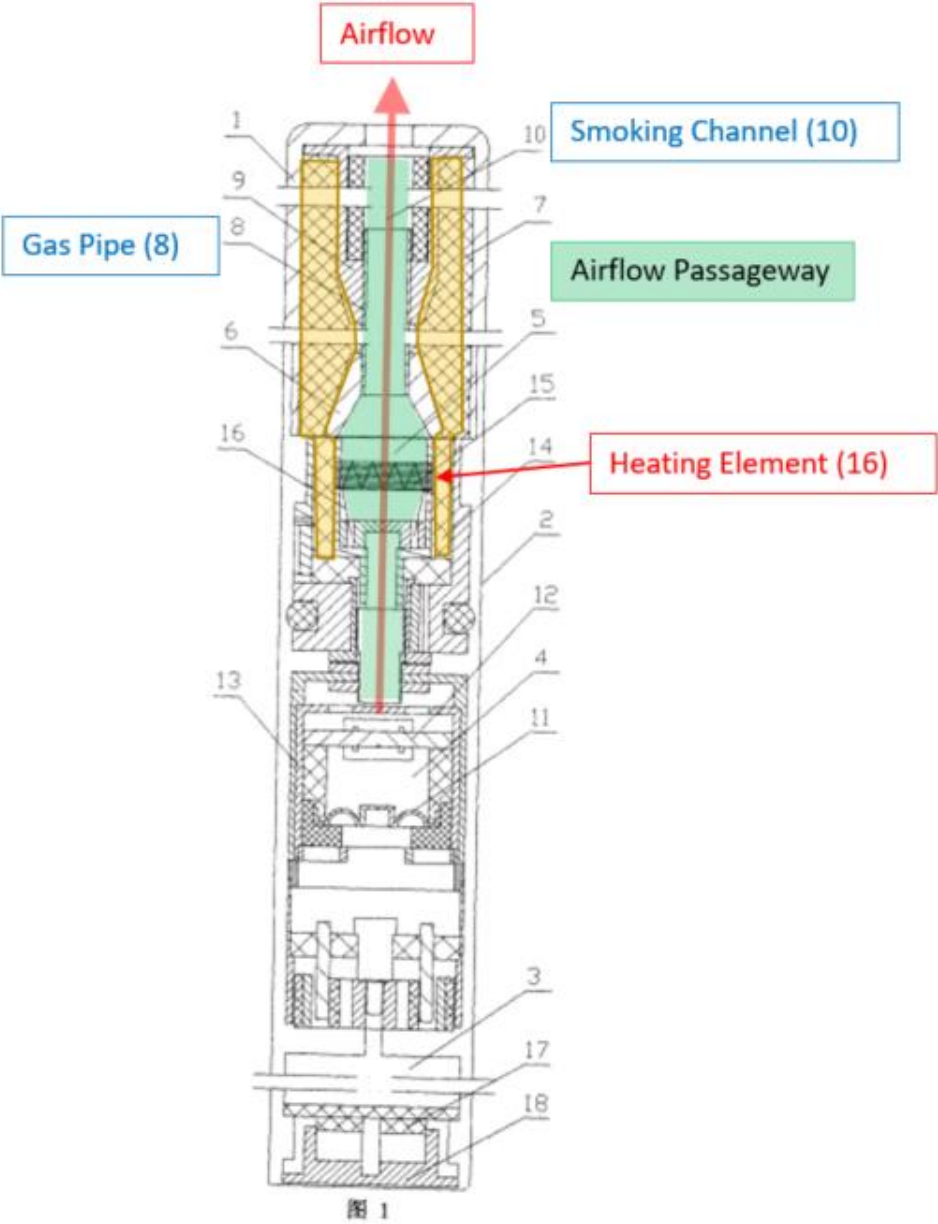


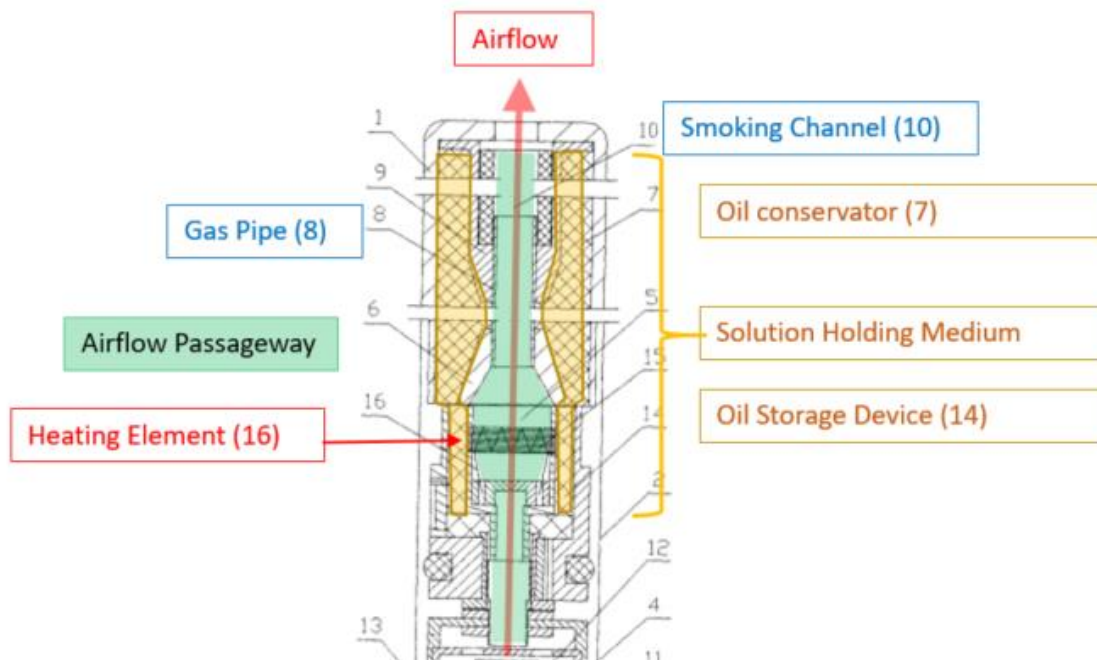
Ex. 1004, FIG. 2 (original); FIG. 2 (modified).

iii. Xia and Wang with Fang

123. In fact, having this sort of structure: a central air tube that extends from the heater and through a cylindrical storage container, on the way to the second central aperture and then to a user's mouth is shown and is obvious further in view of Fang. For example, Fang confirms that in this field, the use of the claimed central and axial airflow passageway was well known. Using Fang's claimed airflow passageway in place of Xia's or Wang's airflow passageway was obvious because, for example, it was the substitution of a known element for another that yields predictable results.

124. Fang's claimed central and axial airflow passageway intermediate a first aperture and a second aperture is illustrated below in green:





125. Fang discloses a “gas pipe (8),” “smoking channel (10),” and other unnumbered hollow portions in the center of the device, indicated in green highlight in the annotated figures, through which air flows directly down the center of the device, which together form an airflow passageway that runs directly through the center of the device and to the tip, where the user places his or her mouth, at the top of the image, where air mixed with vapor exits the device. Ex. 1006 (Fang), 4, 6. The airflow passageway in Fang is surrounded by the solution holding medium, in the form of oil conservator 7 and oil storage device 14, shown in yellow highlight.

126. A POSITA would have been motivated to modify Xia’s or Wang’s cartridge to include this known airflow passageway arrangement of Fang for the reasons discussed above in connection with Wang: it would provide an improved,

smoother air flow without pinch points, better temperature control, and vapor content, as well as being simpler and cheaper to design and manufacture.

127. Use of Fang's airflow passageway arrangement could be easily achieved and would result in predictable results for the same reasons discussed above in connection with Wang. The same is true of using Fang's wick (item 15), which draws liquid to the heating coil (item 16) wrapped around it: a POSITA would know that using either Xia's or Fang's structure for drawing liquid from the sides, where the liquid is stored, toward the heating element located between liquid storage medium components, would function equivalently to allow the heating element to vaporize the liquid, in this modified version in which the air flows entirely down the center of the device.

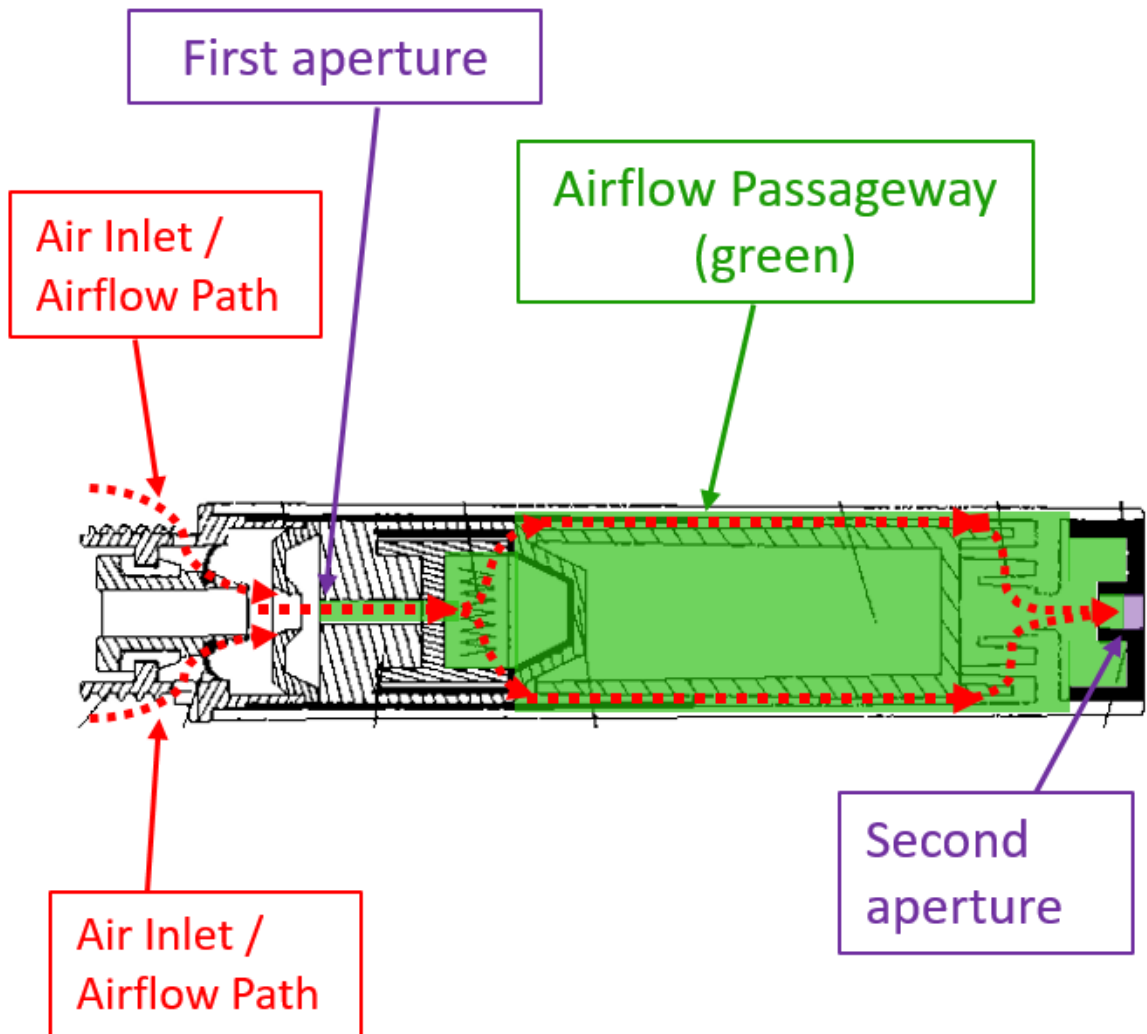
128. The same image as depicted above regarding modification with Wang would result from a POSITA's modification in light of Fang's central airflow passageway and surrounding solution-holding medium.

h. 1[d] wherein the airflow passageway is configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing,

i. Xia

129. Xia alone, or Xia in combination with Wang or Fang discloses an airflow passageway configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing. *See* discussion of claim element

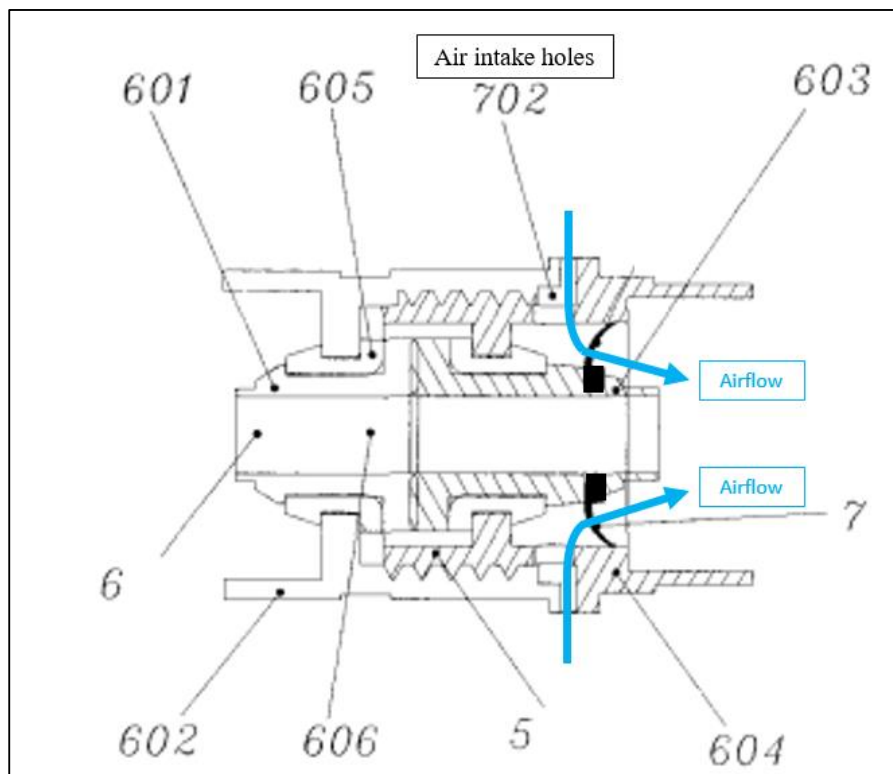
1[c], demonstrating that the airflow passageway is configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing. It is how the air flows from one end of Xia's cartridge to the other.



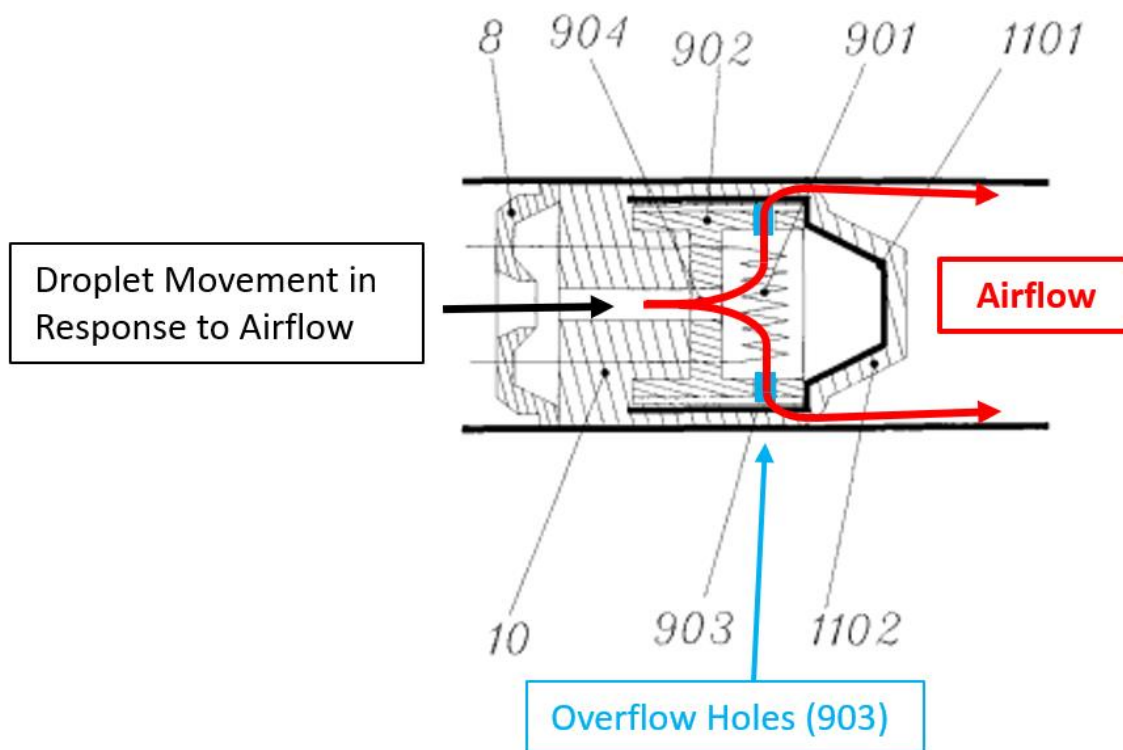
Ex. 1004, annotated Fig. 2 excerpt.

130. For example, Xia explicitly describes the air flow: “when the smoker sucks, the airflow enters from the air inlets 702 to drive the vibrating diaphragm 7 to vibrate” as the air passes by them. Ex. 1004, 7. The airflow then suspends droplets of the e-liquid, and “under the action of airflow, small droplets are sucked into the other side of the heat insulation seat 902 through the spray hole 904 in the heat insulation seat 902” toward heater 901, demonstrating that the airflow follows the same path. Ex. 1004, 8. As described above, Xia’s “spray hole 904” can be the claimed “first aperture.” Then, airflow (and the suspended liquid) passes over all parts of the heating element, where the “liquid is instantly atomized, then flows out of the heater 9 from the overflow holes 903.” Ex. 1004, 13.

131. This flow is illustrated in annotated Figures 3 and 4:

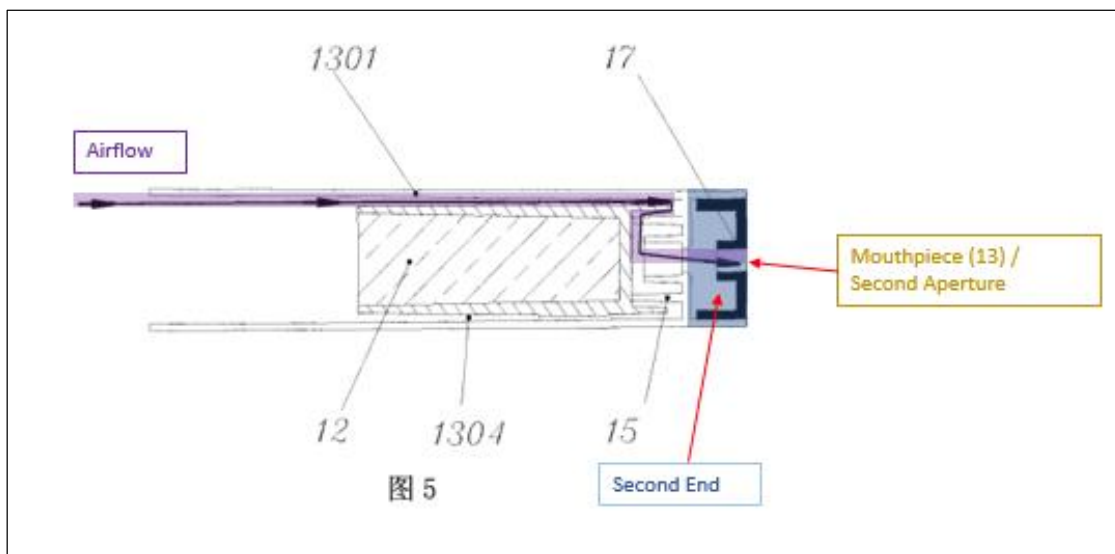


Ex. 1004, Fig. 3 (annotated). After passing through the flaps of the diaphragm as depicted above, the air converges at the opening of item 904 and flows through item 904 toward and over the heater, which vaporizes the liquid in the airflow, and the vaporous air exits:



Ex. 1004, Fig. 4 (annotated).

132. Vaporous airflow then proceeds around liquid storage medium 12 as depicted in Figure 5. The vaporous air “flows to the position of the soft suction nozzle 13 through the gap between the soft suction nozzle and the liquid storage chamber 12 at the airflow channel, and is finally being sucked out through the soft suction nozzle 13,” leaving through the aperture of the mouthpiece 13 (the claimed “second aperture”). Ex. 1004, 13.



Ex. 1004, Fig. 5 (annotated)

133. A POSITA would understand that despite Fig. 5 depicting only one arrow demonstrating airflow, the device in fact has airflow with a cylindrical-shaped cross section, *i.e.*, flowing on all sides between the liquid storage chamber and the housing, flowing between the overflow holes and the soft suction nozzle.

ii. Xia with Wang and/or Fang

134. To the extent that Xia does not disclose this claimed element on its own, Xia in view of Wang discloses this limitation. For example, in addition to disclosing an airflow passageway extending from the first aperture to the second aperture, Wang discloses the airflow passageway is configured to allow an airflow through

the cartridge from the first to the second aperture as claimed. *See* discussion of claim element 1[c]. For example, Wang describes the flow:

a smoking motion causes airflow to enter the interior of the cigarette rod through the air inlet 115 of the cigarette rod ... the airflow reaches the internal gap of the cigarette holder through the air outlet 108 of the cigarette rod and the air inlet 106 of the cigarette holder, and the smoke generated by the tobacco extract 103 instantly heated by the heater 104 is partially sucked out from the air outlet 101 of the cigarette holder.

Ex. 1005, 8.

135. Xia modified in view of Wang would therefore include this element, because both Xia and Wang each disclose it, and because the proposed modification to Xia (including a through-hole in the liquid storage container) does not impede the air flow through the airflow passage (indeed it simplifies it). Xia modified in view of Fang would also meet this limitation, as the modification merely moves the passageway inward away from the walls and moves the solution holding medium 12 outward, as in Fang, still permitting air to flow from the first aperture to the second.

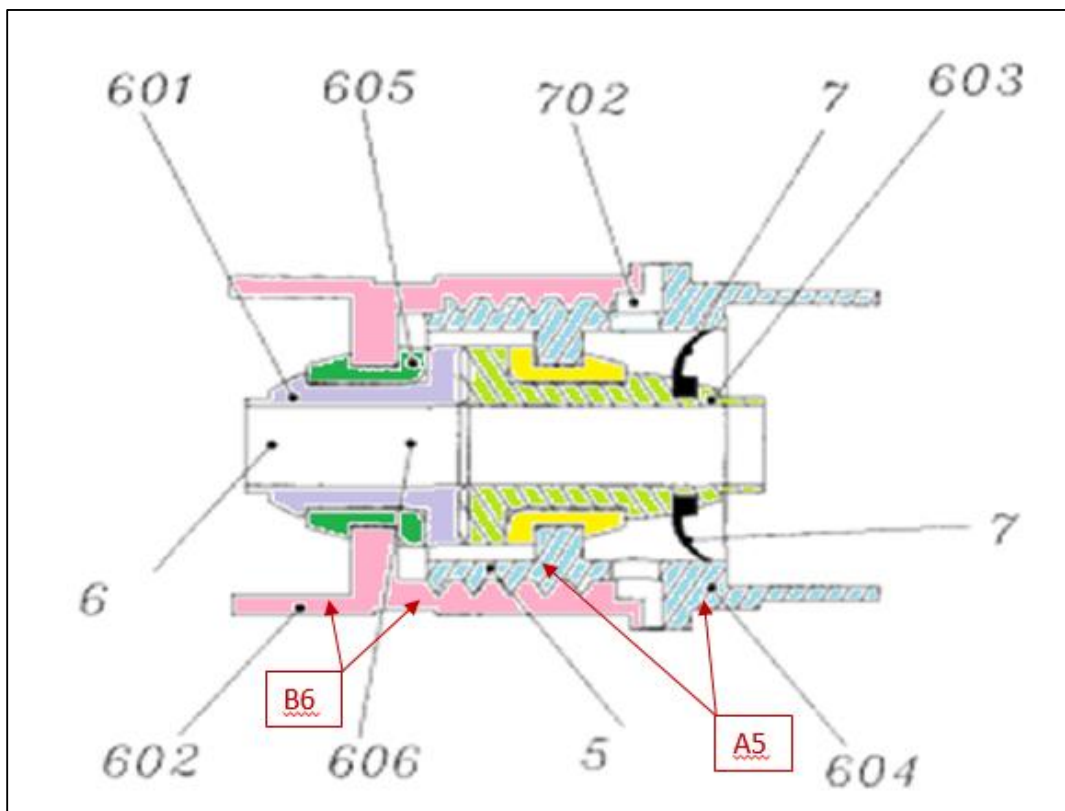
i. **1[e]: wherein the first end of the housing includes an electrically conductive portion that is adapted to mechanically and electrically couple to the electrically conductive portion of the power source,**

i. **Xia**

136. As explained above, in the analysis of claim element 1[a3], Xia discloses an electrically conductive portion of the power source. Further, Xia

discloses that the housing includes its own electrically conductive portion (conductor A 5) that is mechanically and electrically coupled to the conductive portion of the power source (conductor B 6). For example, in Figure 2, conductor B 6 is illustrated as part of the “controller” portion that is or contains the claimed power source, and conductor A5 is illustrated as part of the housing of the generator portion that is the claimed cartridge. Similarly, Figures 1 and 3 illustrate conductor B 6 and conductor A 5 mechanically and electrically coupled to each other. Xia states that “the connecting conductor A 5 and the connecting conductor B 6 form a connecting outer ring through an inner thread 602 and an outer thread 604, respectively” to electrically couple to the battery. Xia also explains the mechanical coupling: the “connecting conductor B6 and the connecting conductor A5 are in threaded connection or clamping groove connection through hollow contact copper caps.” Ex. 1004 at 7. Thus, the housing of the cartridge mechanically and electrically couples on the first end, where A5 is, to the controller, which contains the battery, to create a complete e-cigarette and to power the heating element from the battery. A5 contains electrodes 603 and 604 that conduct electricity and couple to B5, which also has two electrodes, on the controller.

137. Thus, the housing of the cartridge mechanically and electrically couples on the first end, where A5 is, to the controller, which contains the battery, to create a complete e-cigarette and to power the heating element from the battery.



Ex. 1004, Fig. 3 (annotated).

ii. Xia with Wang

138. Xia in combination with Wang or Fang also makes this limitation because the proposed combinations do not alter this aspect of Xia. The modification described in 1[b1] with Wang would result in the aperture either being in the middle of the existing connections in Xia, as described above in this element, or if the modification were to use the connections used in the Wang device to connect the cartridge and power source, such connections also contain, on the cartridge, an electrically conductive portion that is adapted to mechanically and electrically

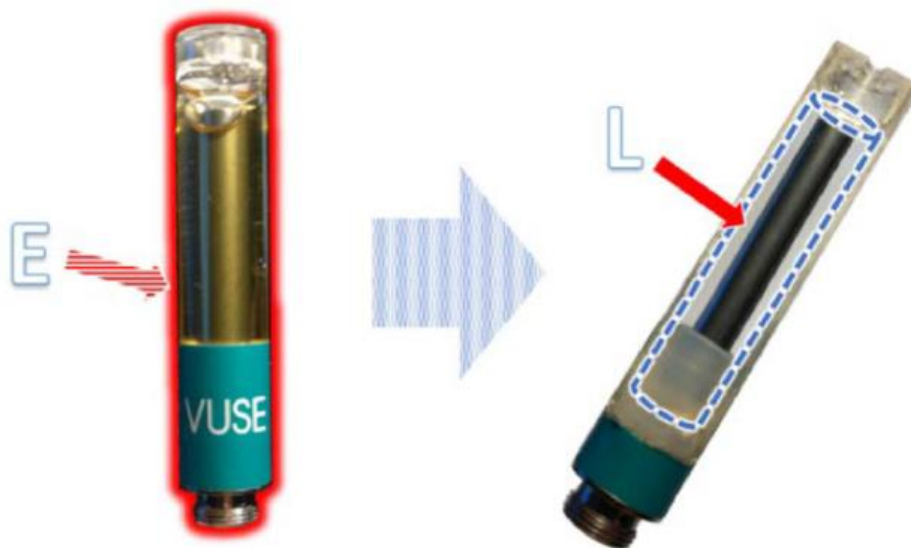
couple to the electrically conductive portion of the power source. Both Wang and Fang describe how the battery ultimately powers the heating element. In Fang, for example, “the electric heating film wire (16) is electrically connected with the battery (3) through the fuming device control switch (4).” Ex. 1006 at 3. In Wang, “[t]he output end 109 of the cigarette rod matches the input end 106 of the cigarette holder, and two poles are isolated by an insulating material, and are connected with the input end 107 of the cigarette holder, respectively, thereby connecting to the electric heater 104 of the cigarette holder.... A resistance value and power of the electric heater 104 of the cigarette holder match with those of the battery 110 of the cigarette rod, which may be realized by a heating wire, a metal coated film, a carbon film and other ways. Two poles of the electric heater 104 are connected with two poles of the input end 106, respectively. Since the motions of the smoker may control the sensor 112, the working time and pause time of the electric heater 104 also change intermittently with the motions of the smoker, thereby atomizing the tobacco extract 103 around it intermittently.” Ex. 1005, at 6-7.

j. 1[f] wherein the housing includes a solution holding medium adapted to hold a solution in the interior of the housing,

i. Xia

139. As discussed above, an RJR device was previously found to infringe the '881 patent and Patent Owner is current asserting that that same RJR device

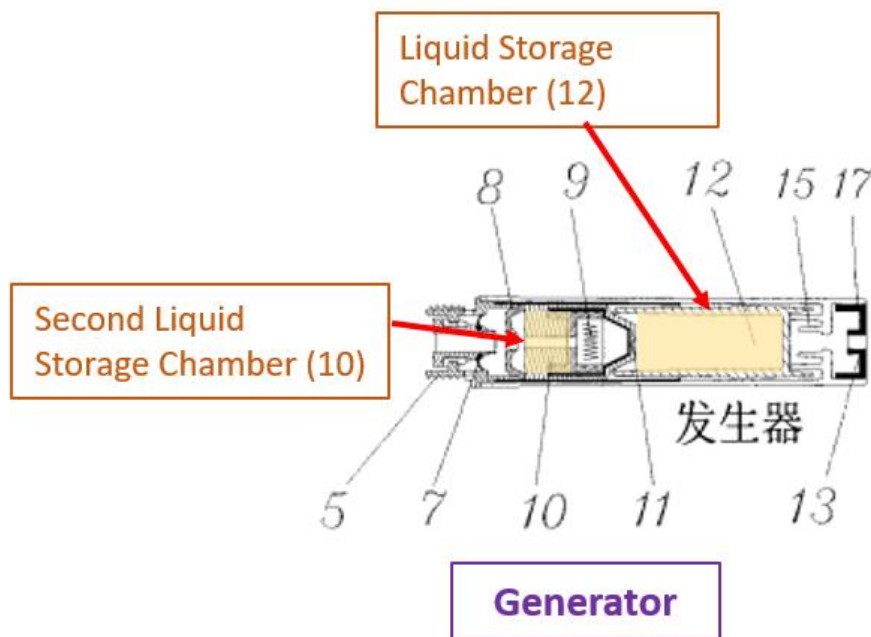
satisfies all of the '881 patent claims. In doing so, Patent Owner is asserting that a chamber (identified below as L) within housing E satisfies the claimed solution holding medium:



Ex. 1032 at 15.

140. Under Patent Owner’s own analysis and admissions, Xia discloses similar chambers and thus discloses or makes obvious this limitation. Xia discloses this limitation. As shown in Figure 2, the cartridge (Xia’s “generator”) has a housing, which has an interior. Ex. 1004, Fig. 2; *id.* at 4 (“stainless steel shells are arranged on an outer surface of the controller and an outer surface of the generator”). Further, Xia’s cartridge housing includes therein a “liquid storage chamber 12,” “liquid-guiding mechanism 11,” and “second liquid storage chamber 10,” for example as

illustrated in in Figures 1, 2, and 4 (which is a close-up view of items 8-11), all of which are solution holding media adapted to hold a solution. Ex. 1004, 3, 6-10:



Ex. 1004, Fig. 2 (partial).

141. For example, Xia states that “secondary liquid storage chamber 10 may temporarily store the chemical liquid,” and that “liquid storage chamber 12 is a cylindrical object with one end open, medicinal cotton fibers are placed in the middle, and then the raw chemical liquid is charged in. Through a capillary action of the liquid-guiding mechanism 11, the chemical liquid stored in the liquid storage chamber 12 is guided into the secondary liquid storage chamber 10.” Ex. 1004, 8.

ii. Xia with Wang and/or Fang

142. Xia modified to include a through hole would still satisfy this limitation because the through hole, whether via an impermeable tube or merely a gap as in Wang, passes through the solution holding medium, which still holds liquid.

143. Xia in view of Wang or Fang also discloses this limitation. For example, the proposed combination involves modifying Xia's liquid storage container, but would not alter the function or location thereof: being adapted to hold a solution in the interior of the housing. For example, Wang's solution holding media are adapted to hold a solution in the interior of the housing. Wang states that "cigarette holder shell 102 is a hollow cylinder" that provides space in the interior of the cylinder for the "tobacco extract 103 and organic fiber 105" where the "tobacco extract 103...is natural tobacco absolute oil, a certain proportion of nicotine is mixed in after the tobacco extract is diluted with alcohols in a certain proportion, and then a mixture quantitatively soaked in the organic fiber 105" and that "the tobacco extract 103 is in a liquid or paste state." Ex. 1005, 4.

k. 1[g]: wherein the housing includes a heating element located in the interior of the housing, wherein the heating element extends transversely across the airflow passageway, wherein the airflow through the passageway passes on both transverse sides of the element,

i. Xia

144. Xia illustrates heating element 9 within the interior of the housing of the generator in Figures 1 and 2.

145. The '881 Patent specification does not use the words “transversely” or “transverse,” and it does not describe what is meant by “transversely across the airflow passageway” or “transverse sides” of the heat element.

146. However, the patent does state the following concerning the claimed orientation of the heating element with respect to the passageway: “[w]hile the heating element 222 is shown as residing solely in the airflow passageway 214, it is to be understood that various other configurations of the heating element 222 with respect to the airflow passageway are contemplated and are **intended to fall under the scope of the hereto-appended claims.**” Ex. 1001, 6:62-67. The patent further provides examples of heating element orientations that fall within the scope of the claims, including a heating element that is “in the airflow passageway,” “on the exterior of the airflow passageway,” “on the exterior or interior of the passageway,” “wrap[ped] around the airflow passageway,” and “the airflow passageway 214 itself.” Ex. 1001, 6:62-7:19. The patent summarized that in the claimed

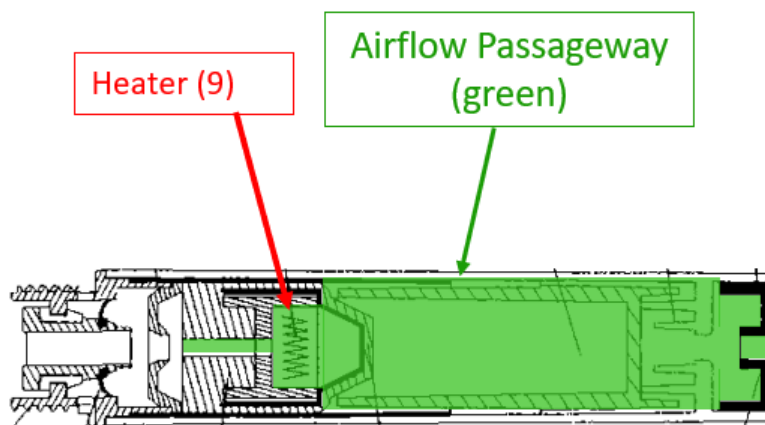
configurations of the heating element in relation to the airflow passageway, “it is readily recognized that airflow may pass directly over the heating element, through a chamber that is proximate to the heating element, or other suitable configuration.”

Id. at 7:17-19.

147. Patent Owner also argues that a device infringes this limitation if air flows over the heating element in the parallel ITC litigation. Ex. 1033 at 6.

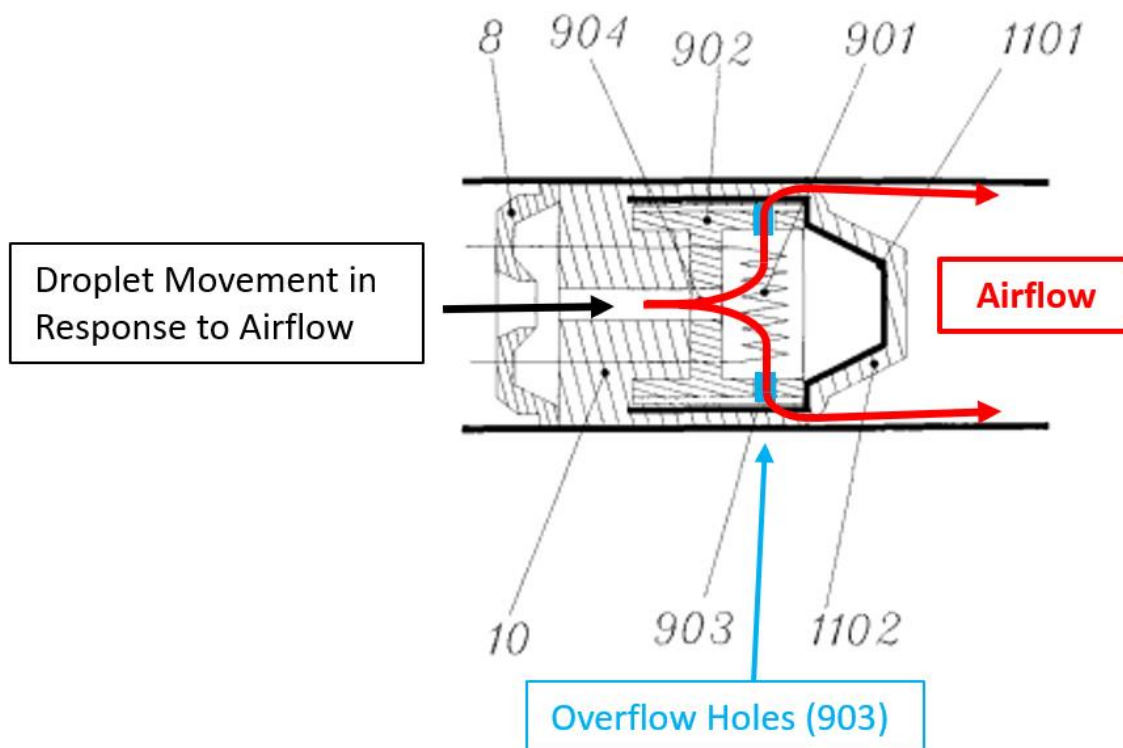
148. Applying this understanding, limitation 1[g] is disclosed and obvious.

149. Heating element 9 of Xia, which is depicted as a coil, is shown oriented transversely “across the airflow passageway” of the Xia cartridge:



Ex. 1004, Fig. 2.

150. The heating element 9 of Xia is displayed in further detail in Figure 4 (below), for which the airflow through the passageway passes all around the heating element 901 (and therefore at least on both transverse sides of the element):



Ex. 1004, Fig. 4.

151. For example, Xia explains that airflow goes around the heater:

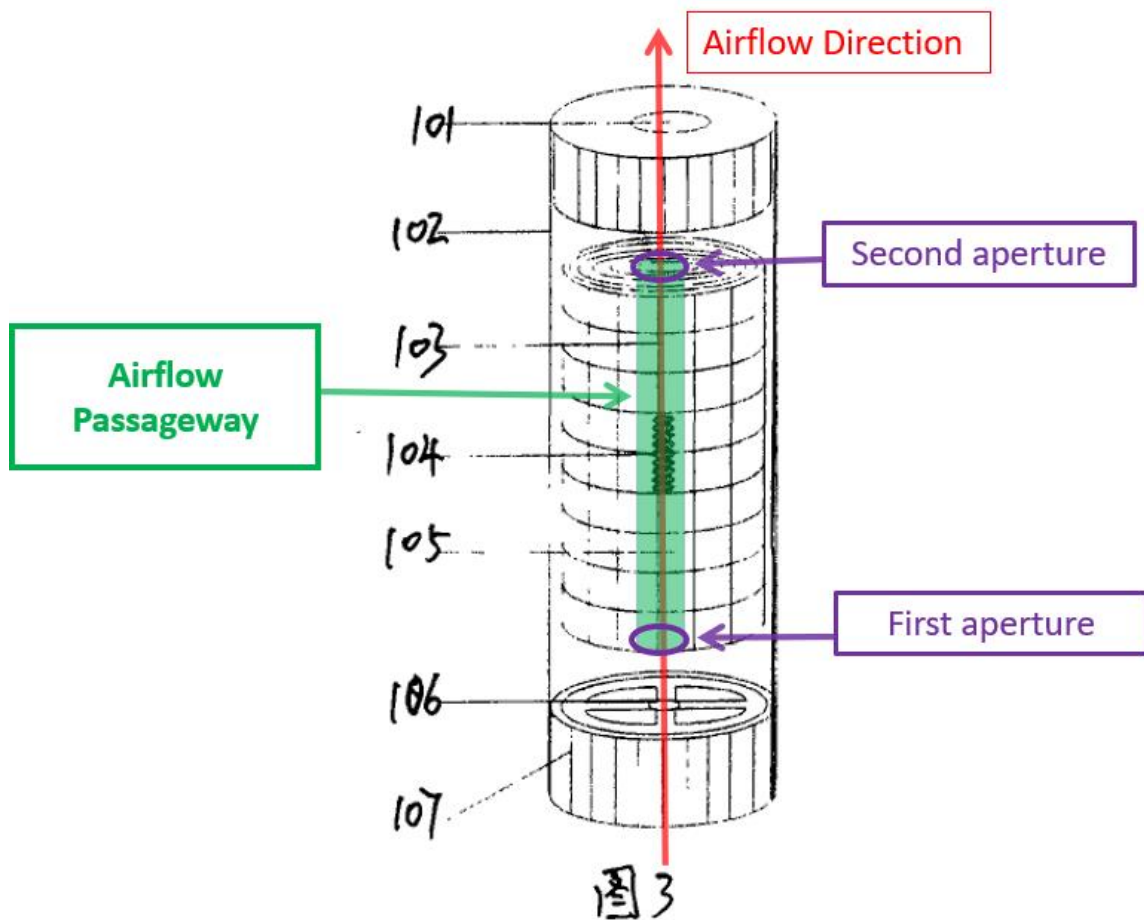
under the action of airflow, small droplets are sucked ...
through the spray hole 904 ... Under the action of the

heating wire 901, the liquid is instantly atomized, then flows out of the heater 9 from the overflow holes 903, then flows to the position of the soft suction nozzle 13 through the gap between the soft suction nozzle and the liquid storage chamber 12 as the airflow channel, and is finally sucked out through the soft suction nozzle 13.

Ex. 1004 at 13.

ii. Xia with Wang and/or Fang

152. As discussed, when substituting Wang's cartridge configuration for Xia's, the resulting heating element 104 is within the airflow passageway and the airflow flows over and around that heater:



153. The same is true if Fang's airway passageway is substituted for Xia's or Wang's because their associated heating elements will still be in the combination's resulting airflow passageway such that airflow may pass directly over it.

- l. 1[h] wherein the solution holding medium surrounds the airflow passageway and the heating element in the interior of the housing and intermediate of the first end and the second end,**

- i. Xia**

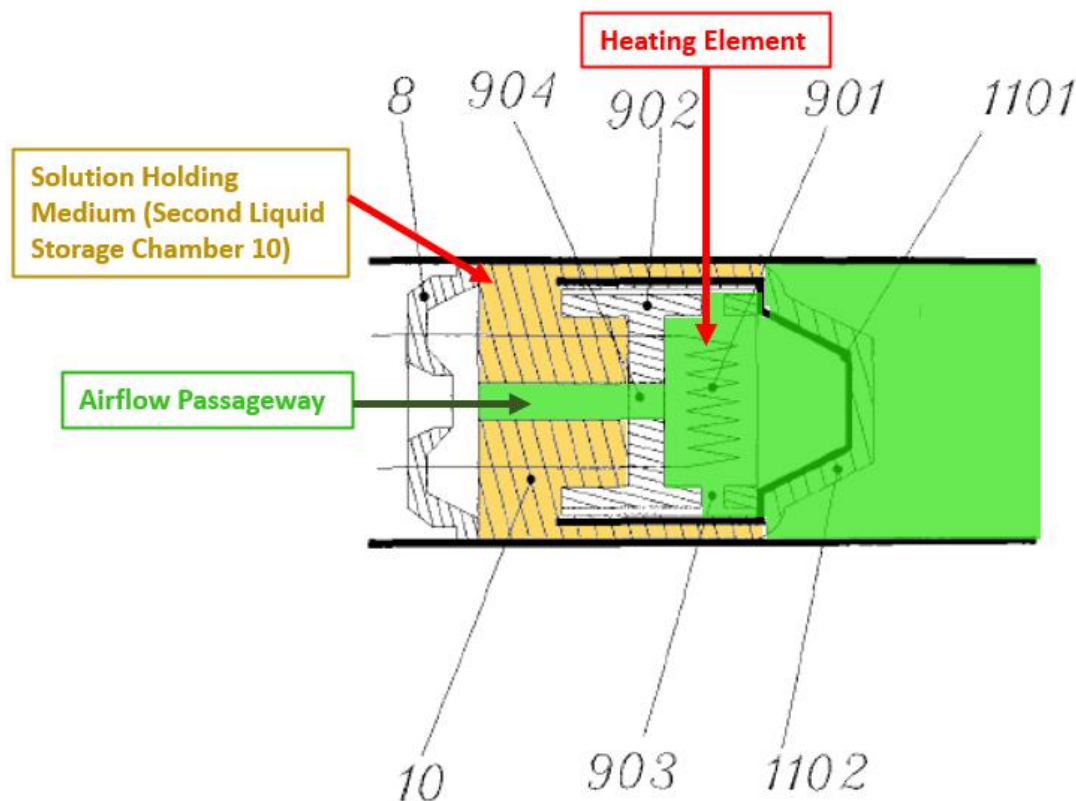
154. I understand that Patent Owner asserts that this limitation is met if the solution holding medium surrounds only a portion of the alleged airflow passageway and not the entire passageway.³ Under Patent Owner's own interpretation, Xia discloses this limitation because, as illustrated below in Figure 4, Xia's solution holding medium 10 surrounds the heating element (heater 9) and at least a portion of the airflow passageway (in green) in the interior of the housing and between the first end and the second ends.⁴

155. Xia's airflow passageway includes the space surrounding the heater as explained above in element 1[c] (and because air flows over the heater). As illustrated in Figure 4 for example, Xia's solution holding medium 10 surrounds that

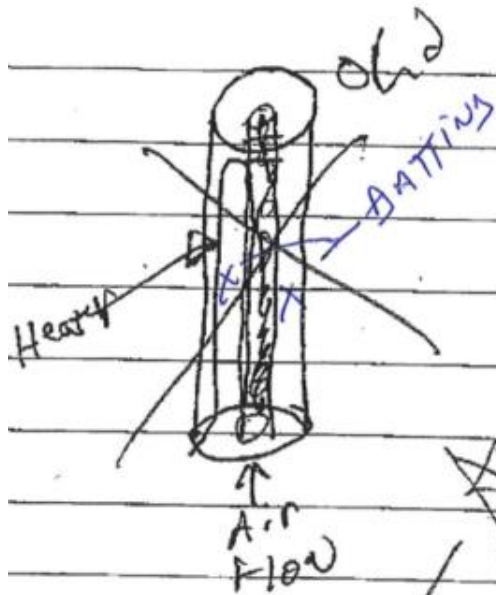
³ My understanding of this claim requirement is based on Patent Owner's infringement allegations in 337-TA-1372, in which Patent Owner asserts infringement of a system in which the accused solution holding medium surrounds only a portion of the alleged airflow passageway and not the entire thing. Ex. 1033 at 7, 2 (showing liquid does not surround alleged passageway on all sides for whole length); Ex. 1032 (337-TA-1372 Initial Domestic Industry Contentions, Ex. 4) at 4-5.

⁴ My application of Patent Owner's apparent construction here or elsewhere in this Petition is not intended to indicate agreement or adoption of such constructions.

airflow passageway and the heating element in the interior of the housing and intermediate of the first end and the second end. For example, not only is the entire solution holding medium 10 intermediate of the first and second ends of the cartridge but the liquid guiding mechanism 11 thereof is also: “chemical liquid flows from the liquid storage chamber 12 into the secondary liquid storage chamber 10 through the liquid-guiding mechanism 11, the heater 9 is wrapped with the liquid-guiding mechanism 11.” Ex. 1004, 5; FIG. 4.



Ex. 1004 at Fig. 4 (modified). First-named inventor, Gregory Conley, also testified multiple prior art e-cigarettes existed in which the solution-holding medium surrounded the airflow passageway, further confirming this was a well-known concept. Ex. 1023 (Conley Dep. Tr.) at 46:19-52:12, 40:12-14, 42:13-19.



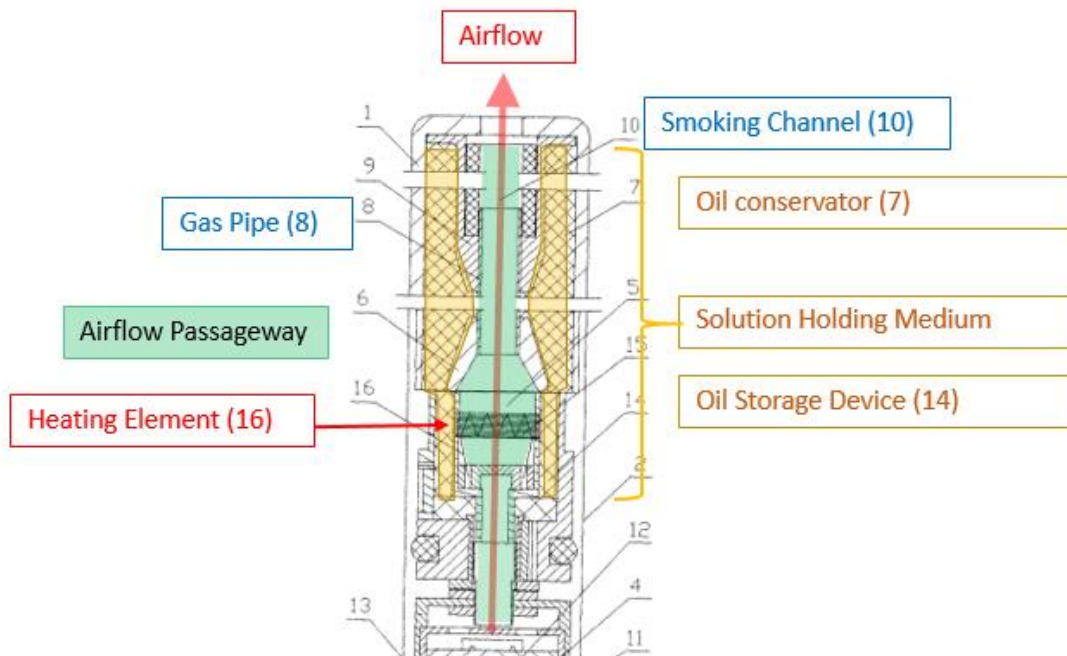
Ex. 1024 (Conley Dep. Tr. Ex. 2A, describing prior art “old” device, with “batting” surrounding airflow passageway).

ii. Xia with Wang

156. Xia in view of Wang and/or Fang also teaches this element. For example, in the combination of Xia and Wang discussed in 1[c] the solution holding medium results in meeting this limitation in either interpretation of its airflow

passageway of Wang as well, as previously described in element 1[c], in which solution holding medium 105 surrounds the entire identified airflow passageway.

157. And if Fang's airflow passageway is used (as described in connection with element 1[c]), this limitation is met even if the entire passageway and heater must be surrounded by the claimed solution holding medium. In that combination, Fang's "Oil Conservator (7)" and "Oil Storage Device (14)" comprise the solution holding medium: "The oil conservator 7, the oil storage device 14 and the temporary oil storage device 15 are made of cotton yarn or sponge materials that can absorb nicotine oil." Ex. 1006 at 6.



Ex. 1006, Fig. 1 (partial) (annotated).

158. As described and depicted in Fang, this solution holding medium (shown in yellow) surrounds both the airflow passageway (shown in green) and heating film wire 16. A POSITA would have been motivated to use this design in modifying Xia in view of Fang because Fang demonstrates it is an acceptable way of having the airflow passageway extend through a through-hole in the solution holding medium. For example, incorporating Fang's solution holding medium/airflow passageway design in Xia would be a straightforward substitution of elements from one reference for another, and would yield predictable results. From an engineering perspective, there is nothing difficult or unpredictable about substituting one known solution holding medium design for another in this context—both Xia and Fang disclose the solution holding medium near a mouthpiece that supplies liquid via capillary action toward a heater element so that it can be vaporized and sucked back past the solution holding medium to the user's mouth. The overall locations of components remain the same within the housing, and this substitution does not require significant redesign of the device. Having the air flow around or through a through-hole in the solution holding medium on its way from the heater to the user's mouth is a matter of design choice—both avenues were known and straightforward to implement. In fact, as I've described, flowing straight through a through-hole has its advantages (including fewer pinch points, etc.).

159. A POSITA would have been motivated to modify Xia in view of Fang because it would be quite obvious that it would benefit the device in that surrounding the airflow passageway with the solution holding medium prevents the heated vapor from contacting the inner wall of the housing, which is very thin. Therefore, the solution holding medium acts as a barrier and insulator, which reduces heat loss and the sensation of the device warming. Therefore, the user will not feel the device being heated, as the solution is vaporized, and also maintains the temperature of the vapor in colder environments.

160. Another benefit is that less material is needed to construct the cartridge, making it easier and less expensive to manufacture. By using the structure of the housing to hold the solution holding in place, with an airflow path down the middle, no additional support is needed for the solution holding medium within the housing.

- m. 1[i]: wherein the heating element is electrically configured to vaporize at least a portion of the solution to be contained in the solution holding medium for oral provision to an individual in an airflow from the second aperture responsive to electrical power received from the battery through the electrically conductive portions of the cartridge and the power source.**

161. Xia alone, Xia in combination with Wang, Xia in combination with Fang, and Xia in combination with Wang and Fang, each alternatively discloses or teaches this limitation. Elements 1[c] and 1[d], for example, describe why Xia and

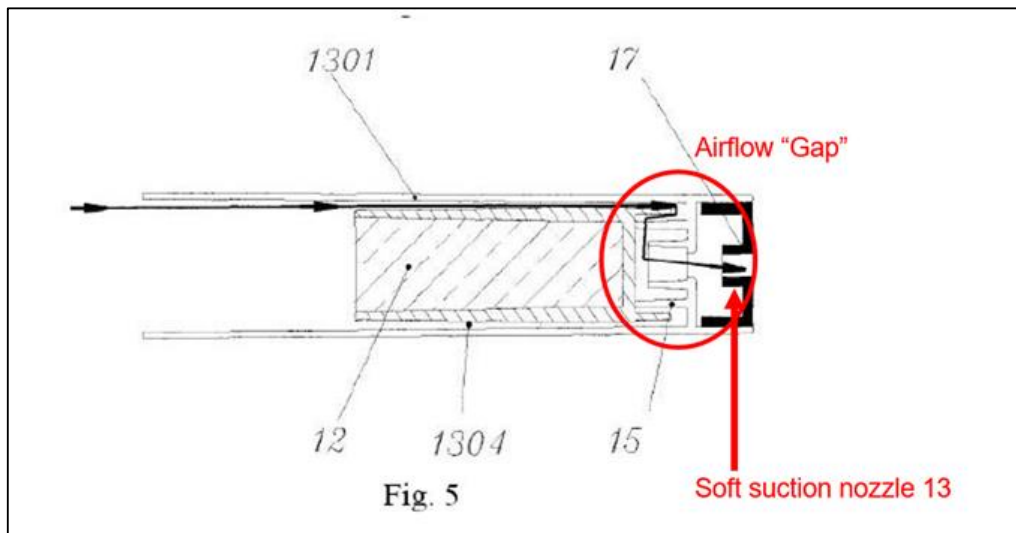
the proposed modifications thereof disclose that the heating element is electrically configured to vaporize at least a portion of the solution to be contained in the solution holding medium for oral provision to an individual in an airflow from the second aperture. *See also* Ex. 1004, 11 (“The smoke generated by smoking is actually water vapor obtained by vaporizing the chemical liquid.”), 10 (“the heater 9 starts working, the chemical liquid is instantly vaporized in an atomizing working room of the heater 9, and the vaporized chemical liquid is sucked out by the smoker from the soft suction nozzle 13.” 14 (airflow is “sucked into the smoker’s mouth”).

162. Elements 1[a1]-1[a3] and 1[e] explain that the heater’s activity is responsive to electrical power received from the battery through the electrically conductive portions of the cartridge and the power source because, for example, “[t]he heater 9 is powered by the rechargeable lithium battery 2 through the connecting conductor A5, the connecting conductor B6, and the integrated circuit board 3.” Ex. 1004, 10.

163. To the extent this element requires mixing of vapor and airflow separately from, or in addition to, air flowing over the heating element, Xia discloses that limitation. For example, in Xia the vapor mixes with existing air in a “gap” before leaving the mouthpiece 13 via inhalation from the user. Xia states that “a gap which is used as an airflow channel is left between the soft suction nozzle 13 and the liquid storage chamber 12” and that the air “flows to the position of the soft suction

nozzle 13 through the gap between the soft suction nozzle and the liquid storage chamber 12 as the airflow channel, and is finally sucked out through the soft suction nozzle 13.” Ex. 1004, 2, 3, 7, 10, 13 14; see FIG. 5.

164. In this configuration, the vapor combines with existing air in the airflow gap before exiting the device.



165. As shown above, the vapor would combine with the existing air in the airflow gap for oral provision to the user. For example, ambient air exists in the airflow gap between the mouthpiece component and the inward extension of the housing, and as the vaporous air flows from the heater toward the user’s mouth, it enters this airflow gap and mixes with the ambient air before being sucked into the user’s mouth. This airflow gap helps the vaporous air to cool before entering a user’s mouth by mixing with ambient temperature air, and allows for improved vapor

distribution within the vaporous air. For example, by mixing with ambient air in the gap, the vapor can be distributed better as a suspension in the air.

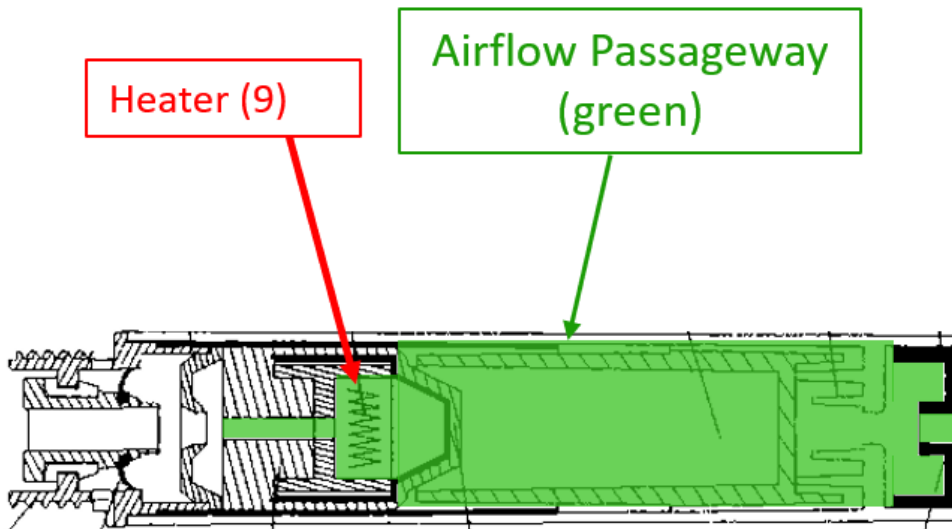
166. The relevant portions of Xia would be unmodified in the combinations with Wang or Fang. For example, the combinations would each include a heater to vaporize a portion of the liquid and have the vaporous air flow for oral provision to a user through the second aperture (including because each reference discloses that), and use an airflow gap because of Xia's disclosure of doing so, and the benefits that a POSITA would recognize of keeping that feature. Even in modifying Xia (alone or in view of Wang or Fang) to have the airflow passageway extend all the way to the second aperture, a POSITA would have good reason to maintain a space for mixing in the second aperture or aperture area, which could for example take the form of Figure 2 of the '881 patent, which is similar to Figure 5 of Xia. Ex. 1001, Fig. 2, 7:6:55-61.

2. Claim 2

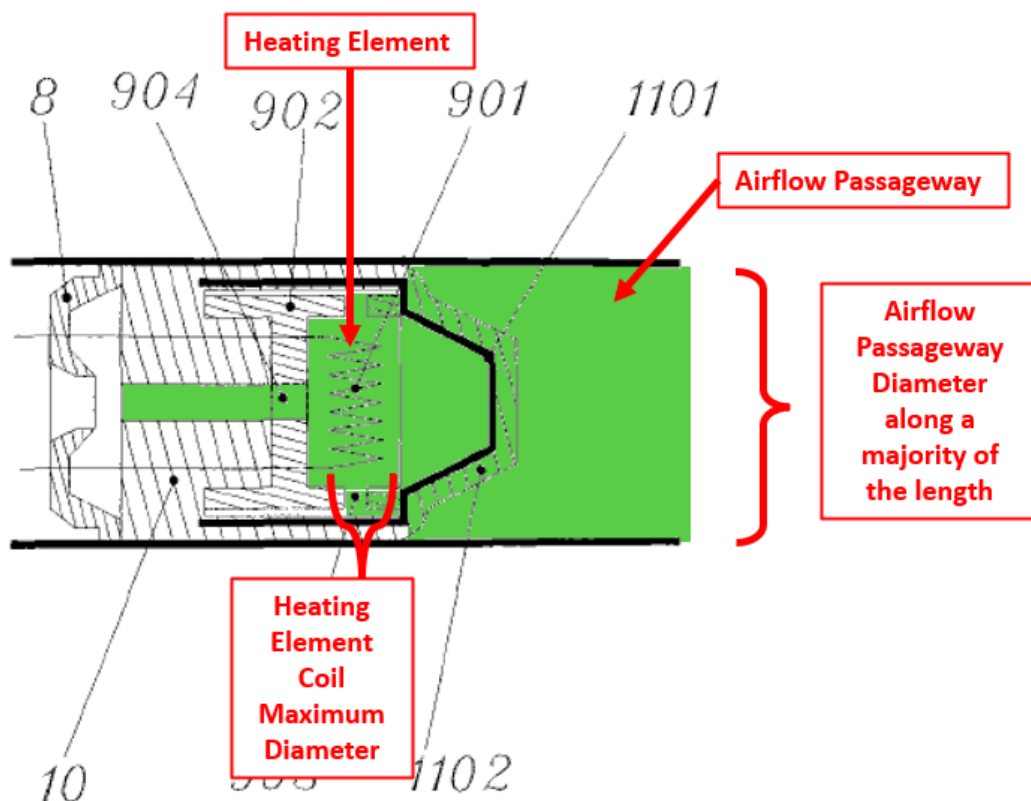
- a. [2]: The cartridge of claim 1, wherein the heating element is a coil having a maximum diameter, the airflow passageway having a length having a circular cross section having a diameter along a majority of the length, the maximum diameter of the coil being smaller than the diameter of the circular cross section of the length of the airflow passageway.

i. Xia

167. Under Patent Owner's own application of the term, Xia discloses this limitation. For example, Xia's figures show that heater 9 and/or heating filament 901 is a coil that has a maximum diameter smaller than the diameter of the circular cross section of the majority of the length of the airflow passageway to the right of the coil:



Ex. 1004, FIG. 2 (annotated).



Ex. 1003, Fig. 4 (partial, annotated); *see also* FIG. 2 (showing length of airflow passageway).

168. In the figures shown above, the internal components (to the right of the heating element) have been removed to show the resulting airflow passageway.

169. A POSITA would understand that, because the figures are cross sections, the body of Xia's generator is cylindrical, meaning the airflow passageway defined therein is a large hollow cylindrical path, and therefore has a circular cross section. For example, Xia discloses that the "liquid storage chamber 12 is a

cylindrical object,” and it is illustrated within and in the same manner as the airflow passageway, indicating that the passageway is cylindrical. Ex. 1004, 10. From the figures above, it is clear that the diameter of the coil is less than that of (the cross section of) the airflow passageway, which has a uniform cross section from the coil to the second aperture, along a majority of its length.

170. A POSITA would also understand that a diameter of a coil is measured with respect to the loops of the coil, as illustrated in the annotated figures above. In general, coils can have different diameters along their length, for example if the coil starts with a small diameter, goes to a bigger diameter, and returns to a small diameter, it would have a generally oval shape. As illustrated in Xia, the heating element is a coil and is generally cylindrical in shape and has a generally uniform diameter along its length, which serves as the maximum diameter of it. From the figures above, it is clear that the diameter of the coil is less than that of (the cross section of) the airflow passageway, which has a uniform cross section from the coil to the second aperture, along a majority of its length.

171. To the extent this element is interpreted to refer to the length of the coil as compared to the cross section of the airflow passageway, in the direction perpendicular to the central longitudinal axis of the housing, because the coil fits in the airflow passageway, that length is less than that of the diameter of the passageway.

172. A POSITA would have also been motivated to modify the heating element in Xia to consist of a coil. A coil was a well-known shape for a heating filament, which had been in production for over a hundred years (for example in a light bulb), and provides increased surface to heat the solution, as opposed to a straight wire. Additionally, a coil is an open shape, allowing air to pass through it, which does not obstruct airflow.

ii. Xia with Wang and/or Fang

173. To the extent this claim requires the airflow passageway have a uniform cross section along the majority of, or entirety of, the length of the passageway, such a simple design for a passageway would have been incredibly obvious, as Xia as modified by Wang or Fang demonstrate, and would have obvious benefits. For example, in the combinations, a POSITA would maintain one of the beneficial features of the airflow passageway: its uniformity. This is because it reduces pinch points in the flow of air and improves functionality of the device. In combining the references to move the passageway within the solution holding medium, the uniformity that's already present in Xia's airflow passageway would continue to exist, at least because there are several obvious benefits to a uniform, cylindrical passageway, *e.g.*, to simplify manufacturing. Generally, making a uniform cylinder is easier and cheaper than making a non-uniform passageway because it requires

fewer bends in a metal sheet, or fewer parts in a compilation, and it would be easier to create within the housing (for example by inserting a straight cylinder instead of having to insert different-sized or non-uniform sized parts. The uniform cylinder could extend from end to end, or at least between the heating element and the second aperture, as a matter of design choice. The length of the passageway between the heater and the second aperture is a majority of the length of the passageway, making even that modification satisfy this claim. Moreover, a POSITA would recognize the obvious benefits of a simple uniform cross section in the airflow passageway, because it would create a more consistent airflow with fewer pinch points, would be simpler to manufacture and repair, and maximizes the storage space for liquid around the passageway. For example, an airflow passage with abrupt changes in diameter would cause an additional pressure drop, reducing airflow to a user. It could also create spots for suspended droplets or vapor condensation to collect, such as in a corner, which could introduce a foul taste or scent to the device after sitting.

174. Xia in view of Wang and/or Fang, also teach this limitation. For example, the coils of the heating elements of Wang and Fang are clearly smaller in cross section than their respective airflow passageways, and the passageway of Xia, as explained in Ground 2, claim 2 for Wang, and as depicted in elements 1[c] and 1[h] above.

175. Moreover, to the extent this claim requires a uniform cross section along the majority of, or entirety of, the length of the passageway, Xia as modified by Wang or Fang, described in 1[c] disclose this limitation. In each, the proposed modification is to maintain the uniformity of the airflow passageway, which already exists in Xia, but to move the passageway to be within the solution holding medium, with the medium being adjusted to surround the passageway. The passageway would be or could be a consistent-diameter cylinder from end to end (a simplifying modification, if anything), or at least between the heating element and the second aperture, which is a length of the passageway that constitutes at least a “majority.”

176. Moreover, as noted above, a POSITA would recognize the benefits of a uniform cross section in the airflow passageway, because it would create a more consistent airflow, be simpler to manufacture, and maximizes the storage space for liquid around the passageway. In manufacturing a tubular, consistent shape is easier to produce and requires less material. Additionally, maintaining a cylindrical passageway along the length of the device allows it to mimic conventional, combustible cigarettes.

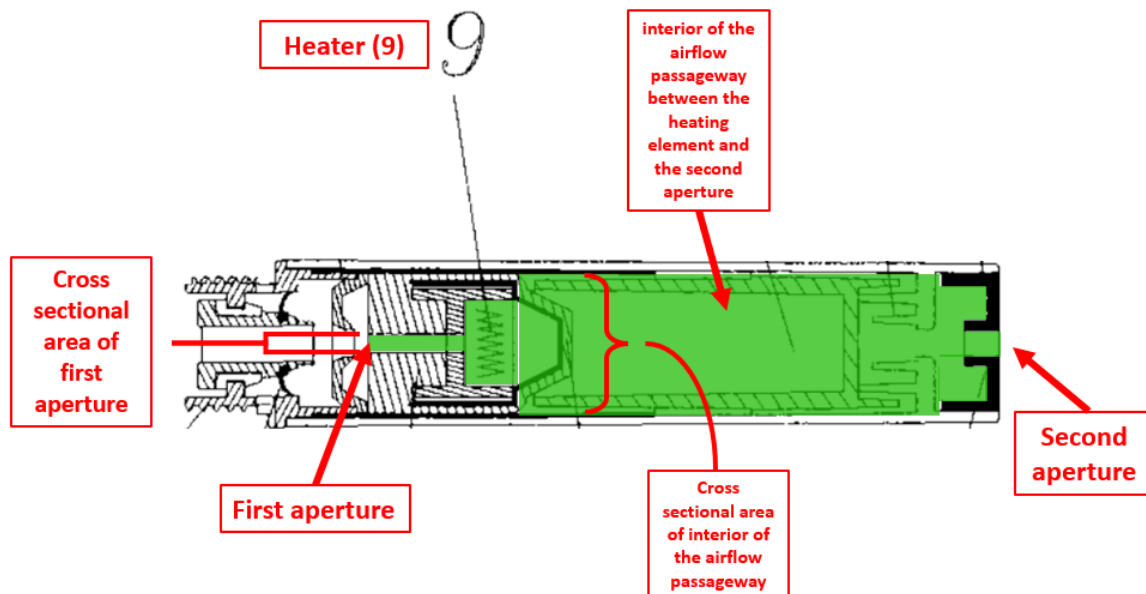
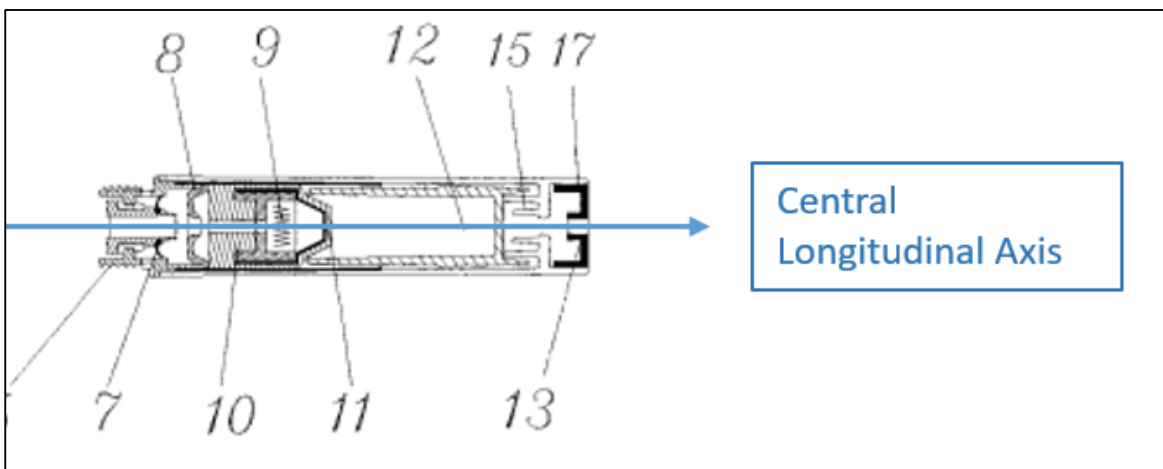
3. Claim 3

- a. [3]: The cartridge of claim 2, wherein the first aperture on the first end is located centrally and axially with respect to the housing, the first aperture having a cross-sectional area measured perpendicular to a central longitudinal axis of the housing, the interior of the airflow passageway between the heating element and the second aperture being no smaller in cross-sectional area than the cross-sectional area of the first aperture.**

177. Xia alone, Xia in combination with Wang, Xia in combination with Fang, and Xia in combination with Wang and Fang, each alternatively discloses or teaches this limitation.

i. Xia

178. As illustrated in the Xia figures below, the interior of Xia's airflow passageway has a cross sectional area larger than the first aperture. As also shown (and described above), the first aperture is located centrally and axially with respect to the housing.



Ex. 1004, Fig. 2 (partial, annotated).

ii. Xia with Wang and/or Fang

179. Xia in view of Wang and/or Fang, also teaches this limitation. The modifications proposed in 1[c] in view of Wang would not change the first aperture's size in relation to the cross-section of the airflow passageway. Moreover, it would

have been obvious to a POSITA to modify them to ensure that the first aperture was equal to or smaller than the diameter of the airflow passageway and second aperture to ensure proper airflow, with the vaporized solution, exiting the device.

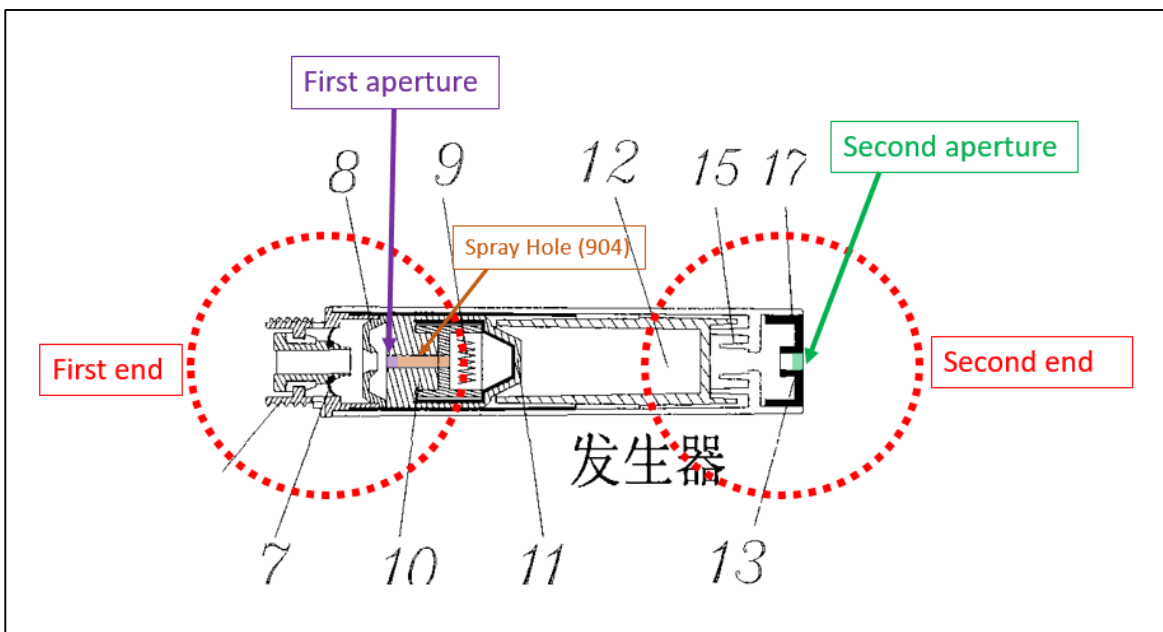
4. Claim 4

- a. [4]: The cartridge of claim 3, wherein the first aperture on the first end is smaller than the second aperture on the second end.**

180. Xia alone, Xia in combination with Wang, Xia in combination with Fang, and Xia in combination with Wang and Fang, each alternatively discloses this limitation.

i. Xia

181. Xia illustrates the first aperture, on the first end, smaller than the second aperture, on the second end:



Ex. 1004, Figs. 1, 2.

ii. Xia Combined with Wang and/or Fang

182. There would be no need or reason to change the foregoing in the proposed combinations of Xia with Wang and/or Fang. Moving Xia's first aperture in view of Wang does not change its size relative to the second aperture, and so this is met for the reasons above.

5. Claim 5

- a. [5]: The cartridge of claim 1, wherein the solution holding medium includes at least one of an absorbent material and a reservoir.

183. Xia discloses at least a solution holding medium including absorbent material. "The liquid storage chamber 12 is a cylindrical object with one end open,

medicinal cotton fibers are placed in the middle, and then raw chemical liquid is charged in.” Ex. 1004, 13. See [8a] regarding reservoir.

6. Claim 6

- a. [6]: The cartridge of claim 1, further comprising a solution in the solution holding medium, the solution comprising one of propylene glycol and nicotine.**

184. Xia alone, Xia in combination with Wang, Xia in combination with Fang, and Xia in combination with Wang and Fang, each alternatively discloses this limitation. For example, Xia states that, as part of heating the liquid from the liquid storage container 10, “the heater works to instantly heat liquid nicotine liquid.” Ex. 1004, 14. Thus, Xia discloses that the liquid storage container contains a solution, and that the solution contains nicotine and discloses this limitation.

185. Moreover, a POSITA would have understood that Xia’s solution likely contained, or could easily be modified to contain propylene glycol. For example, propylene glycol is a well-known, safe for human consumption, and common solvent for organic chemicals, such as nicotine. A POSITA would have known very easily that solutions such as nicotine and tobacco oil (which contains nicotine) would benefit from a solvent because it could then be less viscous and could better flow between the liquid storage chamber 12 and the temporary liquid storage chamber 10 via capillary action (as disclosed in Xia). Additionally, making the solution less viscous can improve the vaporizing properties of the liquid, for example by making

it more easily suspended in air as droplets to be vaporized. Propylene glycol is also in the alcohol family and vaporizes readily, which can contribute to improve vaporizing properties. Designing the device to work with a solution that can have its concentration adjusted (e.g., based on evolving user preferences or regulations, or even flavor additives) is good design practice because the solution concentration can be altered by adjusting the ratio of propylene glycol without having to adjust the mechanical design (and therefore the manufacturing molds/forms/process). Additionally, early e-cigarettes imported into the U.S. contained this exact solution. Ex. 1016 (Tariff Classification) at 1.

186. Moreover, Wang and Fang both describe the solutions to be vaporized as containing nicotine. *See* Ex. 1005, at 7 (“The tobacco extract 103 of the cigarette holder is natural tobacco absolute oil, a certain proportion of nicotine is mixed in after the tobacco extract is diluted with alcohols in a certain proportion[.]”); *see also*, Ex. 1006, at 4 (“nicotine oil is fumed by the nicotine oil fuming device to produce nicotine oil smoke.”).

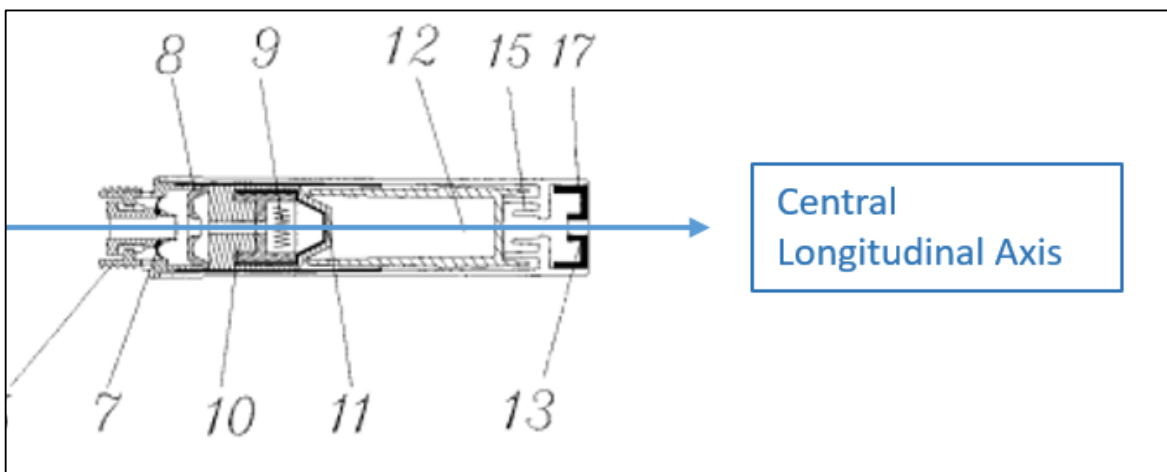
7. Claim 7

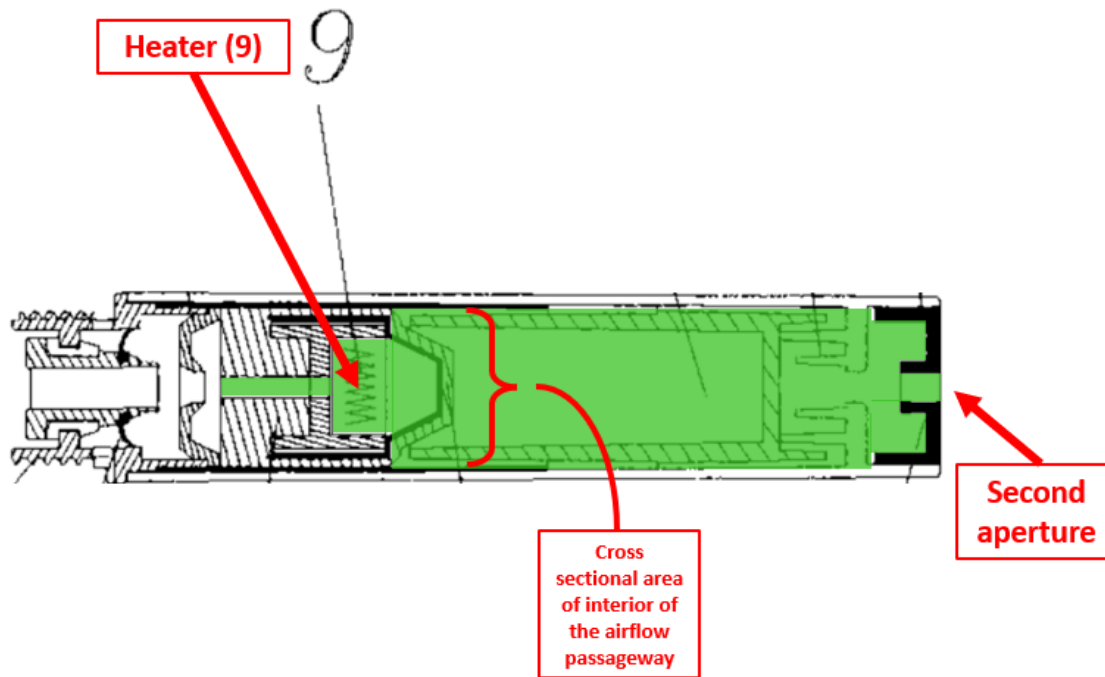
- a. [7]: The cartridge of claim 1, wherein the airflow passageway has a uniform cross-sectional area measured perpendicular to a central longitudinal axis of the housing between the heating element and the second aperture.

187. Xia alone, Xia in combination with Wang, Xia in combination with Fang, and Xia in combination with Wang and Fang, each alternatively discloses this limitation.

i. Xia

188. As depicted below and above, the airflow passageway (highlighted in green) between the heating element and the second aperture has a uniform cross-sectional area measured perpendicular to a central longitudinal axis of the housing between the heating element (9) and the second aperture (13):



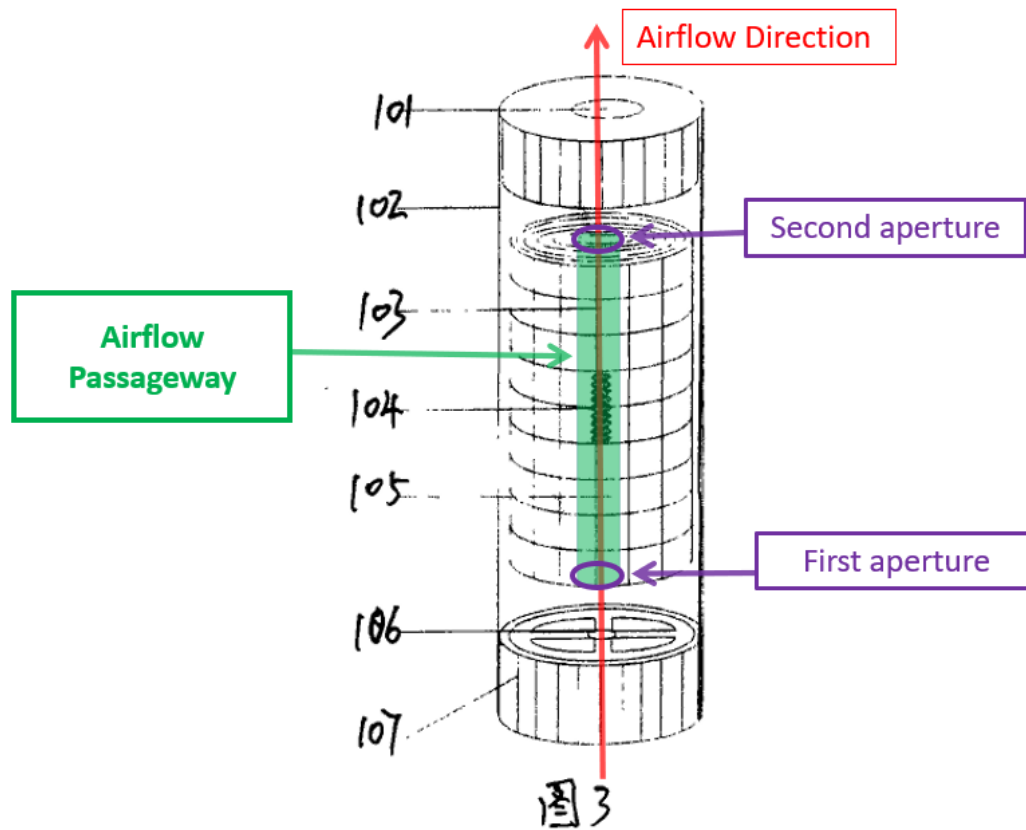


Ex. 1004, Fig. 2 (partial, annotated).

ii. Xia Combined with Wang and/or Fang

189. For the same reasons discussed in claim 2, regarding the resulting discussing uniform cross section, a POSITA would have been motivated to combine Xia with Wang and/or Fang.

190. As established above and depicted below, the airflow passageway in Wang meets this limitation, and Xia modified with Fang would maintain Xia's passageway uniformity:



191. Moreover, to the extent this limitation is not disclosed, a POSITA would have found this to be an obvious variation that is inexpensive and a routine design choice that would be known to obviously be beneficial to the design because it allows for constant, uniform airflow between the heating element and the second aperture where the user draws from.

8. Claim 8

- a. 8[p]: A cartridge configured to mechanically and electrically couple to a power source of an electronic vaporizer, the cartridge comprising:**

192. Xia discloses this limitation for the same reason describes in claim element 1[e].

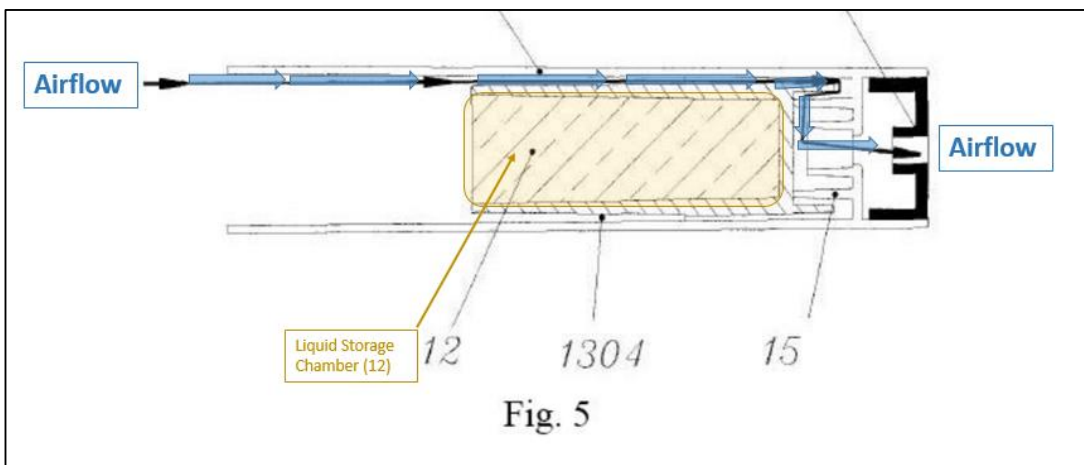
- b. 8[a1]: a housing having an interior and a solution holding medium reservoir adapted to hold a solution,**

193. Xia discloses this limitation for the same reason describes in claim element [1f].

i. Xia

194. Under Patent Owner's own contentions, Xia also discloses a liquid storage chamber that acts as a solution holding medium reservoir. "The liquid storage chamber 12 is a cylindrical object with one end open, medicinal cotton fibers are placed in the middle, and then raw chemical liquid is charged in." Ex. 1004, 10.

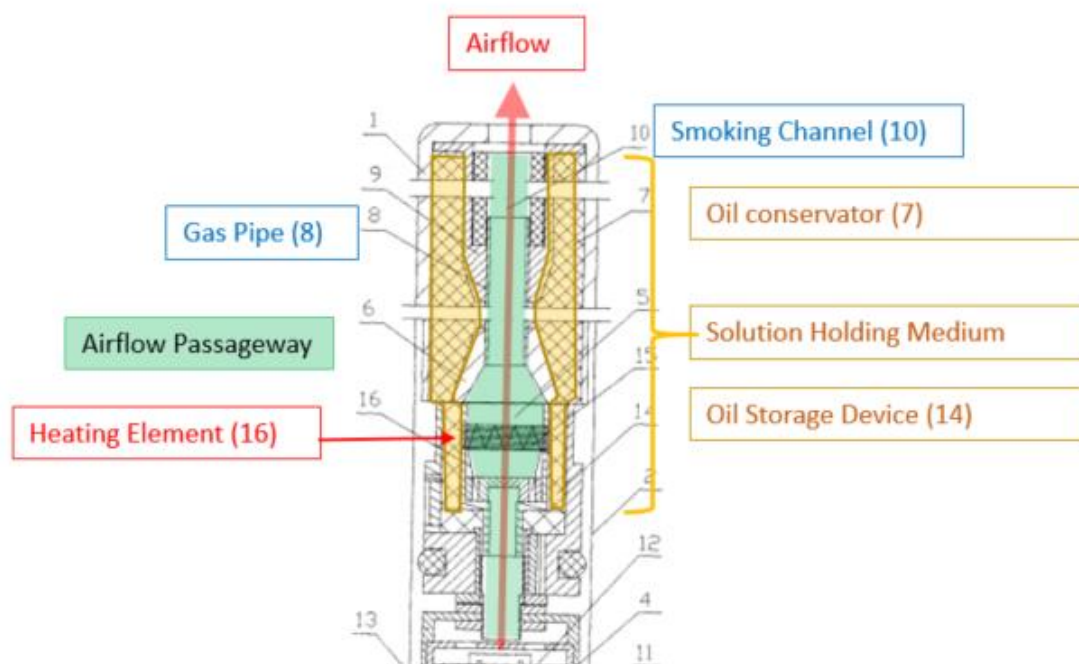
195. A POSITA would know that the "cylindrical object" used to hold the medicinal cotton fibers would be hard and/or impermeable and therefore be a reservoir (to the extent that is a requirement of "reservoir"), including because air flows around liquid storage chamber 12 and not through it.



Ex. 1004, Fig. 5 (annotated).

ii. Xia with Wand and/or Fang

196. Additionally, this limitation is obvious in light of Fang (with or without Wang). Fang’s solution holding medium, comprised of “[t]he oil conservator 7, the oil storage device 14 and the temporary oil storage device 15,” is surrounded on all sides by a hard material from the housing on exterior, as well as, the gas pipe and a “waterproof bellow mouth” on the interior, which “solve[s] the problem that moisture in the nicotine oil smoke is sucked into the user’s mouth.” Ex. 1006, 6.



Ex. 1006 (FANG), Fig. 1 (partial) (annotated).

197. To the extent not all sides are hard material, such a modification would be an obviously beneficial way to store liquid to keep it from leaking out, for example because hard-sided reservoirs have been ubiquitous since antiquity. Surrounding the solution holding medium with hard sides allows the medium to have additional design options, such as for example being a softer and potentially more absorbent material that would not support itself (e.g., a very soft sponge would collapse into the through-hole without a rigid surround). The same would be true of the modification.

198. The same would be true of the modification. Patent Owner has taken the position that Fang has “a liquid reservoir disposed within said housing and sealably separated from said atomizing chamber” in parallel litigation. Ex. 1022 (337-TA-1368 NJOY’s Invalidity Contentions), Ex. A at 134-35 (element 1.G-H)] (citing Fang 044 at Abstract; p.5 ¶¶ 1,3; p.6 ¶¶ 2,4–5; p.7 ¶ 1,3; Figs. 1–2).

199. Therefore, a POSITA would have been motivated to modify Xia’s solution holding medium reservoir with that of Fang’s to include an impermeable material around the outside. This modification serves the dual-purpose of creating an open airflow passageway through the center of the solution holding medium, while preventing the solution from being pulled directly into the airflow, and potentially ingested by the user prior to vaporization.

- c. **8[a2]: the housing having a first end and a second end that is opposite the first end, the housing having a first aperture on the first end and a second aperture on the second end,**

200. For the same reasons described above, in relation to claim element 1[b2], Xia alone or in combination with Wang and/or Fang teaches this limitation.

- d. 8[a3]: the first end of the housing having an electrically conductive portion adapted to mechanically and electrically couple to the electrically conductive portion of the power source;**

201. For the same reasons described above, in relation to claim element 1[e],

Xia alone or in combination with Wang and/or Fang teaches this limitation.

- e. 8[b1]: an airflow passageway in the interior of the housing extending centrally and axially with respect to the housing intermediate of the first aperture on the first end of the housing and the second aperture on the second end of the housing,**

202. For the same reasons described above, in relation to claim element 1[c],

Xia alone or in combination with Wang and/or Fang teaches this limitation.

- f. 8[b2]: the airflow passageway being configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing; and**

203. For the same reasons described above, in relation to claim element 1[d],

Xia alone or in combination with Wang and/or Fang teaches this limitation.

- g. 8[c1]: a heating element located in the interior of the housing, the heating element being located within and extending transversely across the airflow passageway, the airflow through the passageway passing on both transverse sides of the heating element,**

204. For the same reasons described above, in relation to claim element 1[g],

Xia alone or in combination with Wang and/or Fang teaches this limitation.

- h. 8[c2]: both the heating element and the airflow passageway being surrounded by the solution holding medium reservoir,**

205. For the same reasons described above, in relation to claim element 1[h],

Xia alone or in combination with Wang and/or Fang teaches this limitation.

- i. 8[c3]: the heating element being electrically configured to vaporize at least a portion of the solution to be contained in the solution holding medium reservoir for oral provision to an individual in an airflow from the second aperture responsive to electrical power received from the battery through the electrically conductive portions of the cartridge and the power source.**

206. For the same reasons described above, in relation to claim element 1[i],

Xia alone or in combination with Wang and/or Fang teaches this limitation.

9. Claim 9

- a. [9]: The cartridge of claim 8, further in combination with the power source including a battery and the electrically conductive portion, the electrically conductive portion of the power source being mechanically and electrically coupled to the electrically conductive portion of the first end of the housing.**

207. For the same reasons described above, in relation to claim elements 1[a3] (discussion of power source) and 1[e] (for discussion of cartridge), Xia alone or in combination with Wang and/or Fang teaches this limitation.

10. Claim 10

- a. **[10]: The cartridge of claim 9, wherein the heating element is a coil having a maximum diameter, the airflow passageway having a length having a circular cross section having a diameter along a majority of the length, the maximum diameter of the coil being smaller than the diameter of the circular cross section of the length of the airflow passageway.**

208. For the same reasons described above, in relation to claim 2, Xia alone or in combination with Wang and/or Fang teaches this limitation.

11. Claim 11

- a. **[11]: The cartridge of claim 10, wherein the first aperture on the first end is located centrally and axially with respect to the housing, the first aperture having a cross-sectional area measured perpendicular to a central longitudinal axis of the housing, the interior of the airflow passageway between the heating element and the second aperture being no smaller in cross-sectional area than the cross-sectional area of the first aperture.**

209. For the same reasons described above, in relation to claim 3, Xia alone or in combination with Wang and/or Fang teaches this limitation.

12. Claim 12

- a. **[12]: The cartridge of claim 11, wherein the first aperture on the first end is smaller than the second aperture on the second end.**

210. For the same reasons described above, in relation to claim 4, Xia alone or in combination with Wang and/or Fang teaches this limitation.

13. Claim 13

- a. **[13]: The cartridge of claim 8, wherein the solution holding medium reservoir includes an absorbent material.**

211. For the same reasons described above, in relation to claim 5, Xia alone or in combination with Wang and/or Fang teaches this limitation.

14. Claim 14

- a. **[14]: The cartridge of claim 8, further comprising a solution in the solution holding medium reservoir, the solution comprising one of propylene glycol and nicotine.**

212. For the same reasons described above, in relation to claim 6, Xia alone or in combination with Wang and/or Fang teaches this limitation.

15. Claim 15

- a. **[15]: The cartridge of claim 8, wherein the airflow passageway has a uniform cross-sectional area measured perpendicular to a central longitudinal axis of the housing between the heating element and the second aperture.**

213. For the same reasons described above, in relation to claim 8, Xia alone or in combination with Wang and/or Fang teaches this limitation.

16. Claim 16

- a. 16[p]: A cartridge configured to mechanically and electrically couple to a power source of an electronic vaporizer, the cartridge comprising:**

214. For the same reasons described above, in relation to claim element 1[e],

Xia alone or in combination with Wang and/or Fang teaches this limitation.

- b. 16[a1]: a housing having an interior and a solution holding medium adapted to hold a solution in the interior of the housing,**

215. For the same reasons described above, in relation to claim element 1[f],

Xia alone or in combination with Wang and/or Fang teaches this limitation.

- c. 16[a2]: the housing having a first end and a second end that is opposite the first end, the housing having a central longitudinal axis extending through the first end and the second end, the housing having a first aperture on the first end and a second aperture on the second end,**

216. For the same reasons described above, in relation to claim element

1[b2], Xia alone or in combination with Wang and/or Fang teaches this limitation.

Further, all references have a housing with a central longitudinal axis extending through the first end and the second end, as described in the discussion of claim 3.

- d. 16[a3]: the first aperture having a cross-sectional area measured perpendicular to the central longitudinal axis of the housing,**

217. For the same reasons described above, in relation to claim element 1[b1] and claim 3, Xia alone or in combination with Wang and/or Fang teaches this limitation.

- e. 16[a4]: the first end of the housing having an electrically conductive portion adapted to mechanically and electrically couple to an electrically conductive portion of the power source;**

218. For the same reasons described above, in relation to claim element 1[e], Xia alone or in combination with Wang and/or Fang teaches this limitation.

- f. 16[b1]: an airflow passageway in the interior of the housing, the airflow passageway having a length extending centrally and axially with respect to the housing intermediate of the first aperture on the first end of the housing and the second aperture on the second end of the housing,**

219. For the same reasons described above, in relation to claim element 1[c], Xia alone or in combination with Wang and/or Fang teaches this limitation.

- g. 16[b2]: the airflow passageway being configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing,**

220. For the same reasons described above, in relation to claim element 1[d], Xia alone or in combination with Wang and/or Fang teaches this limitation.

h. 16[b3]: the airflow passageway having an exterior adjacent to the solution holding medium along a majority of the length of the airflow passageway,

221. For the same reasons described above, in relation to claim element 1[h], Xia alone or in combination with Wang and/or Fang teaches this limitation.

222. Additionally, under Patent Owner’s own contentions in the parallel ITC investigation, Xia alone and in view of Wang and/or Fang discloses “the airflow passageway having an exterior adjacent to the solution holding medium along a majority of the length of the airflow passageway.”

i. Xia

223. Xia’s airflow passageway has an exterior that is the outermost portion of the interior of item 13, which runs along the length of the device and through which air flows, as explained in 1[c]. That exterior is adjacent to item 12, part of the solution holding medium as explained in claim 1.

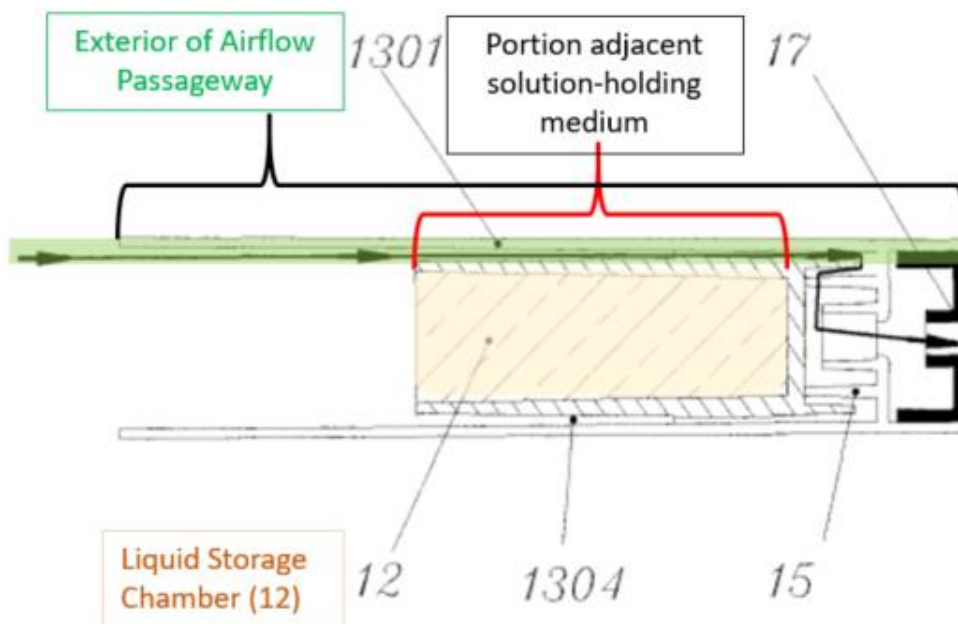
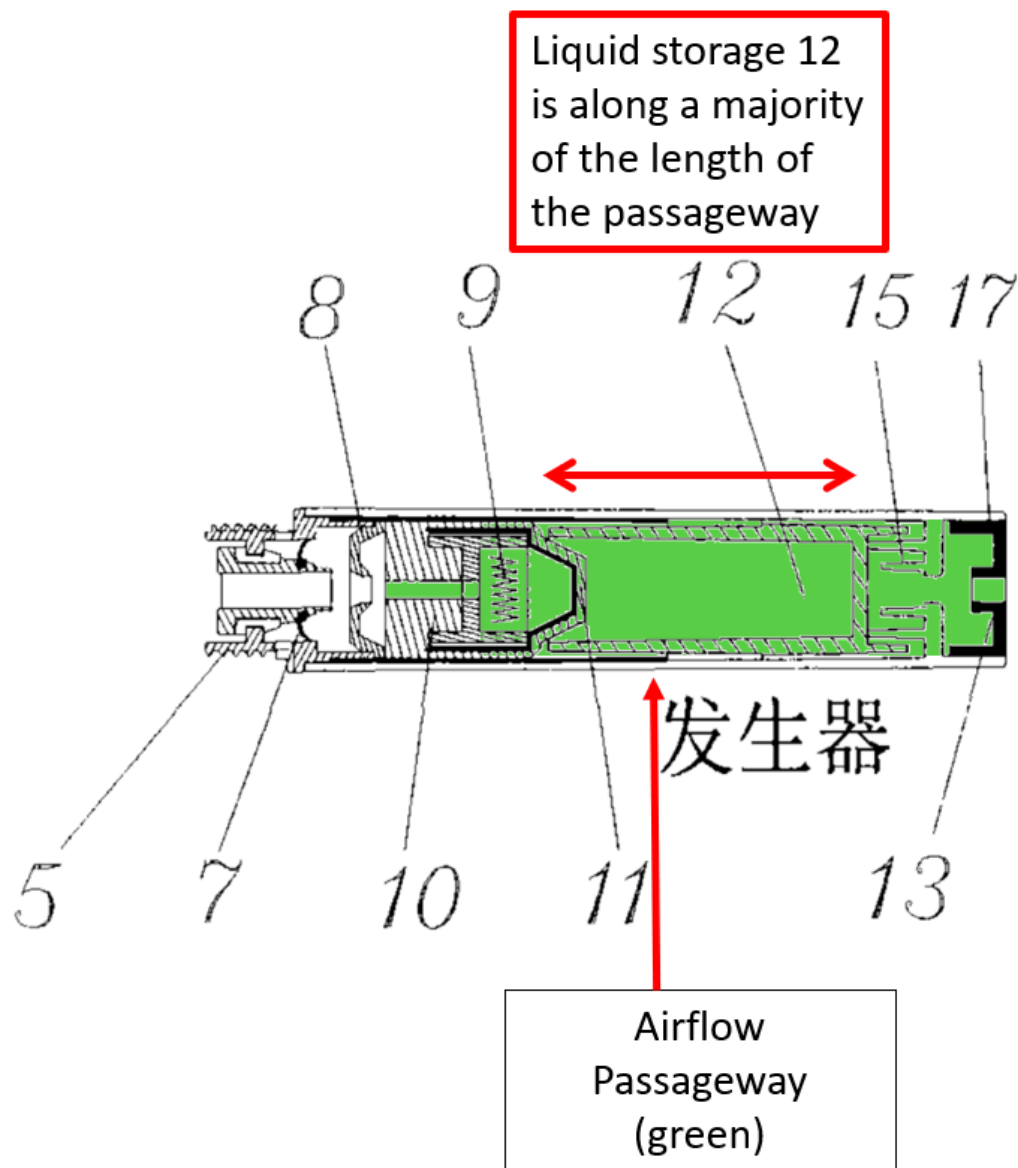


图 5

Ex. 1005, Fig. 5, annotated.

224. That adjacency is along a majority of the length of the airflow passageway, as item 12 runs along a majority of that length: As seen in Xia Figure 2, the majority of the exterior of the airflow passageway is adjacent to solution holding medium 12, as seen in Figure 2, where the airflow passageway is annotated in green:



Ex. 1004, Fig. 2, annotated.

225. To the extent the length of the airflow passageway adjacent to the solution holding medium is not seen as a “majority” of the airflow passageway, a

POSITA would understand that the solution holding medium could be lengthened to meet this limitation. For example, a POSITA would understand that the cartridge portion of Xia's device can be modified to extend as far as desired with the same cross sectional design as the middle region thereof (near the location of the pointer of ref. no. 12 in FIG 2 for example). This would benefit the device by extending the housing and the liquid storage container 12, thereby providing more storage space for solution. *Id.*

226. Additionally, as explained further below, in Xia, the portion of the airflow passageway that extends through item 904 and into the area near the heating element (on the left side of the cartridge), also has an exterior adjacent to a solution holding medium (specifically secondary liquid storage container 10). This adds to the proportion of the solution holding medium in Xia that is adjacent to the airflow passageway, increasing the amount by which it is a "majority" of the airflow passageway as claimed. For example, the part to the left of the heating element plus the part to the right of the heating element is certainly a majority.

227. Additionally, to the extent this limitation is not disclosed in Xia, a POSITA would have found this to be an obvious variation that is inexpensive and a routine design choice. This would be obvious and beneficial because it creates a uniform airflow path between the apertures, which, as described previously, creates better airflow and vapor delivery. Additionally, requiring that "the airflow

passageway hav[e] an interior having a uniform cross-sectional area...and extend[] continuously along a majority of the length of the airflow passageway,” means it can be manufactured as a single tube, which is easier and less expensive. The use of uniform diameters of tubing generally requires fewer steps to manufacture than something with “necking,” “tapering,” or more complex geometry. This is also true for casting, machining, or stamping methods of manufacturing.

ii. Xia combined with Wang and/or Fang

228. As described in the discussion of claim element 1[c] and 1[h], above, each of the proposed modifications of Wang and/or Fang is such that the airflow passageway is surrounded by the solution holding medium at least along the majority of the length of the airflow passageway, which results in the airflow passageway having an exterior adjacent to the solution holding medium along a majority of the length of the airflow passageway.

i. 16[b4]: the airflow passageway having an interior having a uniform cross-sectional area measured perpendicular to the central longitudinal axis of the housing and extending continuously along a majority of the length of the airflow passageway; and

229. For the same reasons described above, in relation to claim 7, Xia alone or in combination with Wang and/or Fang teaches this limitation.

- j. **16[c1]: a heating element located in the interior of the housing and extending transversely across the airflow passageway, the airflow through the passageway passing on both transverse sides of the heating element,**

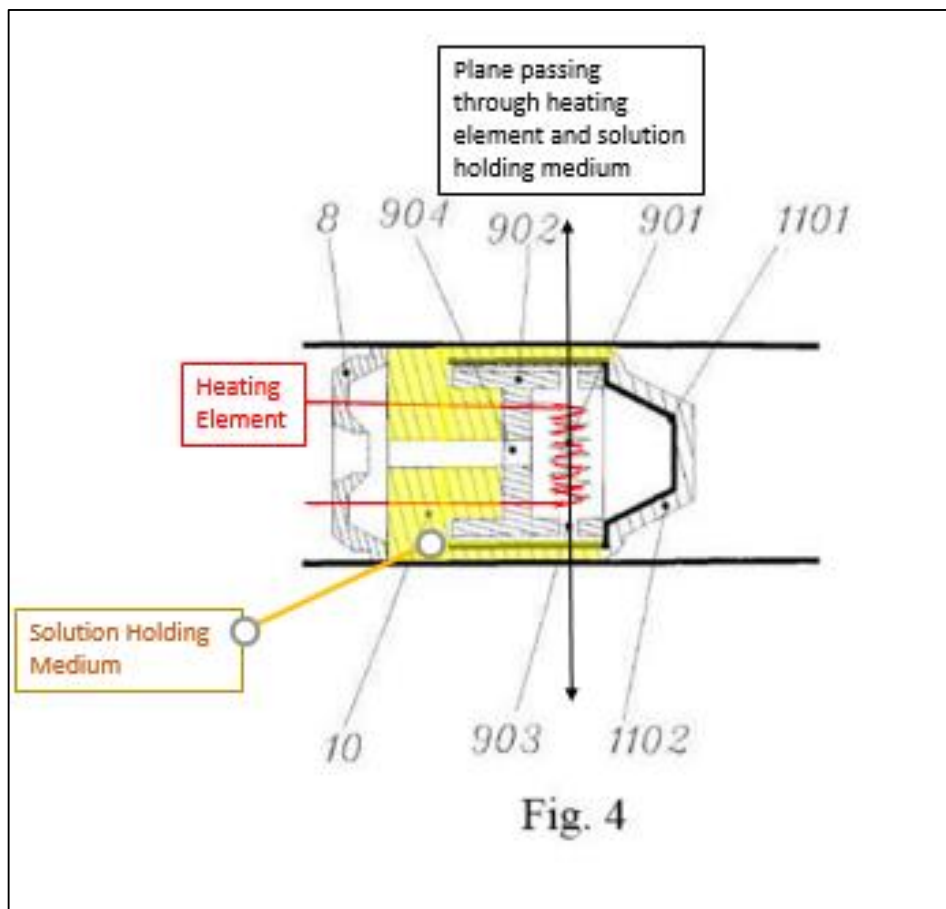
230. For the same reasons described above, in relation to claim element 1[g], Xia alone or in combination with Wang and/or Fang teaches this limitation.

- k. **16[c2]: a plane perpendicular to the central longitudinal axis of the housing passing through the heating element and the solution holding medium,**

231. For the same reasons described above, in relation to claim element 1[h], Xia alone or in combination with Wang and/or Fang teaches this limitation. Xia alone, Xia in combination with Wang, Xia in combination with Fang, and Xia in combination with Wang and Fang, each alternatively discloses the limitation of “a plane perpendicular to the central longitudinal axis of the housing passing through the heating element and the solution holding medium.”

i. Xia

232. Xia discloses a secondary liquid storage chamber (10), part of the solution holding medium, proximate and surrounding the heater 9, comprising heating wire (901). As seen in annotated Figure 4, below, a plane perpendicular to the central longitudinal axis of the housing medium (the axis being left-to-right and centrally vertically) passes through a portion of the solution holding medium and the coiled part of the heating wire element.



Ex. 1004, Figure 4 (annotated)

ii. Xia combined with Wang and/or Fang

233. Xia in view of Wang and/or Fang, also render this limitation obvious. For example, in modifying Xia, with any of the knowledge of a POSITA, Wang, or Fang, Xia's airflow passageway is surrounded by the solution holding medium. In making this modification, a POSITA would not need to modify the heating element location from what is disclosed in Xia, and therefore the modified device meets this

limitation. Additionally, a POSITA could incorporate the heating element locations disclosed in Fang and Wang, both of which meet this claim limitation. For example, as described in Ground 2, element 16[c2], Wang's heating element meets this limitation. *See, e.g.* Wang FIG. 3 (showing the medium surrounding the heating element, meaning a plane perpendicular to the central longitudinal axis of the housing passes through both). *See also* claim 3 regarding the location of the central longitudinal axis in Wang.

234. As described above in claim element 1[h] and claim 3, Fang's heating element also meets this limitation for example because it shows the solution holding medium surrounding the heating element.

l. 16[c3]: the airflow passageway having an interior between the heating element and the second aperture no smaller in cross-sectional area than the cross-sectional area of the first aperture,

235. For the same reasons described above, in relation to claim 3, Xia alone or in combination with Wang and/or Fang teaches this limitation.

m. 16[c4]: the heating element being connected to the electrically conductive portion of the first end of the housing,

236. For the same reasons described above, in relation to claim elements 1[e] and [i], Xia alone or in combination with Wang and/or Fang teaches this limitation.

- n. **16[c5]: the heating element being electrically configured to vaporize at least a portion of the solution to be contained in the solution holding medium for oral provision to an individual in an airflow from the second aperture responsive to electrical power received from the power source through the electrically conductive portion of the cartridge.**

237. For the same reasons described above, in relation to claim element 1[i],

Xia alone or in combination with Wang and/or Fang teaches this limitation.

17. Claim 17

- a. **[17]: The cartridge of claim 16, further in combination with the power source including a battery and the electrically conductive portion, the electrically conductive portion of the power source being mechanically and electrically coupled to the electrically conductive portion of the first end of the housing.**

238. For the same reasons described above, in relation to claim element 1[a3] (for discussion of power source) and 1[e] (for discussion of cartridge), Xia alone or in combination with Wang and/or Fang teaches this limitation.

18. Claim 18

- a. **[18]: The cartridge of claim 16, wherein the heating element is a coil having a maximum diameter and the uniform cross-sectional area of the airflow passageway is a circle having a diameter, the maximum diameter of the coil being smaller than the diameter of the circle of the uniform cross-sectional area of the airflow passageway.**

239. For the same reasons described above, in relation to claim 2, Xia alone or in combination with Wang and/or Fang teaches this limitation. One additional element in claim 18 is the requirement that “uniform cross sectional area of the airflow passageway *is a circle* having a diameter,” rather than “having a circular cross section,” as described in claim 2. For the same reasons described in claim 2, however, Xia also discloses the cross-sectional area of the airflow passageway is a circle.

19. Claim 19

- a. **[19]: The cartridge of claim 18, wherein the first aperture on the first end is located centrally and axially with respect to the housing.**

240. For the same reasons described above, in relation to claim 3, Xia alone or in combination with Wang and/or Fang teaches this limitation.

20. Claim 20

- a. **[20]: The cartridge of claim 19, wherein the first aperture on the first end is smaller than the second aperture on the second end.**

241. For the same reasons described above, in relation to claim 4, Xia alone or in combination with Wang and/or Fang teaches this limitation.

21. Claim 21

- a. **[21]: The cartridge of claim 16, wherein the heating element is a coil having a maximum diameter and the uniform cross-sectional area of the airflow passageway is a circle having a diameter, the maximum diameter of the coil being smaller than the diameter of the circle of the uniform cross-sectional area of the airflow passageway.**

242. For the same reasons described above, in relation to claim 18, Xia alone or in combination with Wang and/or Fang teaches this limitation.

22. Claim 22

- a. **[22]: The cartridge of claim 16, wherein the first aperture on the first end is located centrally and axially with respect to the housing.**

243. For the same reasons described above, in relation to claim 3, Xia alone or in combination with Wang and/or Fang teaches this limitation.

23. Claim 23

- a. **[23]: The cartridge of claim 16, wherein the first aperture on the first end is smaller than the second aperture on the second end.**

244. For the same reasons described above, in relation to claim 4, Xia alone or in combination with Wang and/or Fang teaches this limitation.

24. Claim 24

- a. **[24]: The cartridge of claim 16, wherein the solution holding medium includes at least one of an absorbent material and a reservoir.**

245. For the same reasons described above, in relation to claim 5, Xia alone or in combination with Wang and/or Fang teaches this limitation.

25. Claim 25

- a. **[25]: The cartridge of claim 16, further comprising a solution, wherein the solution comprises one of propylene glycol and nicotine.**

246. For the same reasons described above, in relation to claim 6, Xia alone or in combination with Wang and/or Fang teaches this limitation. One difference in claim 25 is the omission of the solution holding medium described in claim 6. For the same reasons described in claim 6, however, Xia also discloses a solution within the cartridge.

26. Claim 26

- a. **[26]: The cartridge of claim 16, wherein the heating element is in operative connection with a wicking material, and the wicking material is operative to attract a portion of the solution from the solution holding medium located immediately adjacent opposite ends of the heating element toward the heating element.**

247. As explained above in the discussion of claim element 1[h], the solution holding medium surrounds the heating element, and so it is immediately adjacent opposite ends of the heating element. Xia alone, Xia in combination with Wang, Xia in combination with Fang, and Xia in combination with Wang and Fang, each alternatively discloses this limitation.

i. Xia

248. Xia discloses this limitation in two ways. As explained above in claim 1[h], the solution holding medium surrounds the heating element, and so it is immediately adjacent opposite ends of the heating element. Xia's liquid guiding mechanism 11 is a claimed wicking material. For example, Xia discloses that "the chemical liquid flows from the liquid storage chamber 12 into the secondary liquid storage chamber 10 through the liquid-guiding mechanism 11" and "the heater 9 is wrapped with the liquid-guiding mechanism 11." Ex. 1004, 10; *see also* 12-13. Thus liquid-guiding mechanism 11 is a wicking material operable to draw the solution from liquid storage chambers 10 and 12 from opposite sides of the heater "toward

the heating element” as claimed. Xia’s second liquid chamber 10 is also a claimed wicking material because it continues to draw the liquid from liquid-guiding mechanism 11 and item 1102 extending on opposite sides of the heater toward the airflow passageway and toward the heating element.

ii. Xia Combined with Wang and/or Fang

249. Xia in view of Wang (with or without Fang), also discloses this limitation. For example, if Wang is combined with Xia (with or without Fang) as described above, Wang discloses this limitation, stating that the organic fiber 105 is wound around the heating element in conjunction with the tobacco extract 103. Ex. 1005, 7. In this configuration, the organic fiber acts as a wicking element to draw the solution to the heating element from all ends, including those opposite each other. Xia combined with Fang as discussed above also discloses this limitation. Specifically, Fang discloses a wicking element in the form of its temporary oil storage 15 that draws the solution from the oil storage device, located adjacent both ends of the heating element. Ex. 1006, 6 (“due to the action of the capillary tubes, the temporary oil storage device 15 sucks in nicotine oil stored in the nicotine oil storage device 14, when the electric heating film wire 16 is powered on to heat, nicotine oil on the temporary oil storage device 15 is fumed to produce nicotine oil smoke.”). Patent Owner has taken the position that Fang has “a wick in contact with

the liquid in the liquid reservoir” in parallel litigation. Ex. 1022, (337-TA-1368, NJOY’s Invalidity Contentions) Ex. A at 135 (element 1.I)] (citing “Fang 044 at p.5 ¶3; p.6 ¶¶4–5; p.7 ¶1; Figs. 1–2.”).

27. Claim 27

- a. [27]: The cartridge of claim 16, wherein the airflow passageway has a uniform cross-sectional area measured perpendicular to the central longitudinal axis of the housing between the heating element and the second aperture.**

250. For the same reasons described above, in relation to claim 7, Xia alone or in combination with Wang and/or Fang teaches this limitation.

B. Ground 2: Wang alone or in combination with Fang Discloses Claims 1-27

251. In my opinion, claims 1-27 are obvious over Wang alone or in combination with Fang and the knowledge of a POSITA, for the following reasons.

1. Claim 1

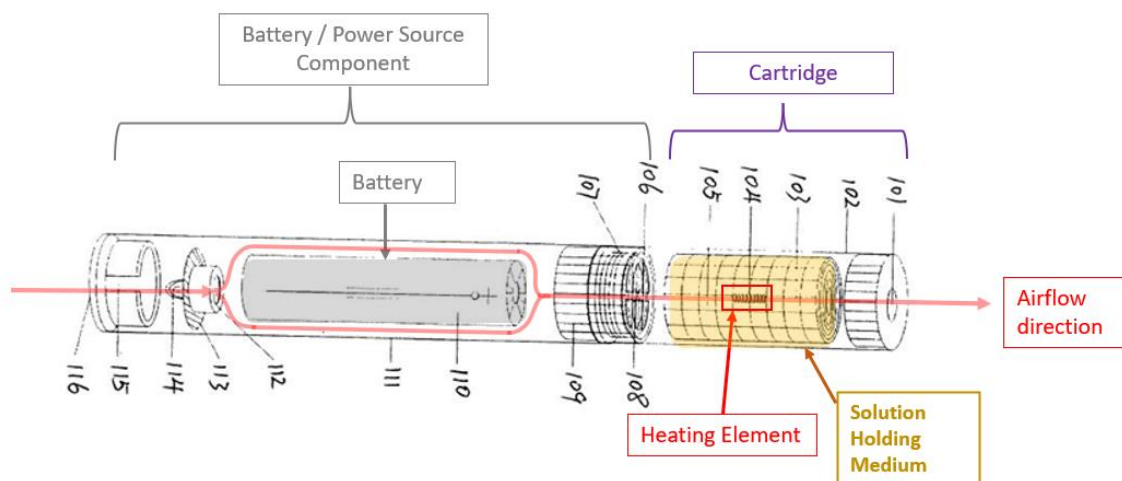
- a. 1[p]: An apparatus comprising:**

252. Wang discloses “An electronic pure cigarette, comprising a cigarette holder part and a cigarette rod part, characterized in that the cigarette rod part consists of a cigarette rod shell, a battery, a sensor, an indicating lamp, a circuit control board, an indicating lamp cover, an air inlet, an air outlet, an output end, and the like, and the cigarette holder part consists of a cigarette holder shell, an electric

heater, a tobacco extract, an organic fiber, an air inlet, an air outlet, an input end, and the like.” Ex. 1005, at Claim 1.

b. 1[a1]: a power source,

253. The device of Wang contains “Battery 110” on the left in Figure 1 below (also Fig. 2), *i.e.*, in “cigarette rod shell 111.” The battery powers the heating element 104 in the cartridge component (“cigarette holder part,” the right of Fig. 1 below, and Fig. 3), through various connections described below: Wang’s device contains “a device that controls a battery to discharge through smoking motions, thereby driving an electric heater to generate heat, and further atomizing a tobacco extract.” Ex. 1005 at 4.



Ex. 1005 (Wang), Fig. 1 (annotated).

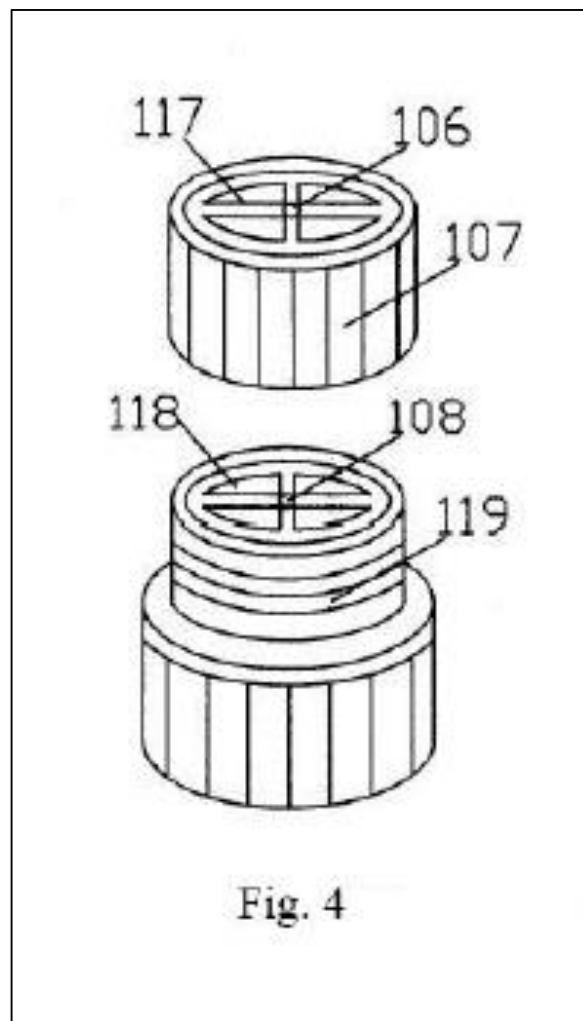
254. The power source may be considered to be the battery itself, the cigarette rod shell 111 on the left above (and in Figure 2) that contains the battery, or the battery plus some other components, such as electrode 119, within 111, as a POSITA would understand any of these would constitute “a power source.”

c. 1[a2]: wherein the power source includes a battery,

255. Wang discloses this limitation for the same reasons described in claim element 1[a1].

d. 1[a3]: wherein the power source includes an electrically conductive portion; and,

256. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation. Figure 4 shows the mechanical and electrical connection (as required by element 1[e] below) of “cigarette rod shell 111” (which contains the battery) and the cartridge, “cigarette holder part” / “cigarette holder shell 102:



Ex. 1005, Fig. 4.

257. Multiple electrically conductive portions within the power source are disclosed. Wang states: “the input end of the cigarette holder matches the output end of the cigarette rod, the two poles are isolated by an insulating material, and are connected with the output end of the cigarette rod, that is, the two poles are connected to the output end, respectively, an electrode 117 is in butt joint with an electrode 107, the electrode 107 is in butt joint with an electrode 119, and the air

inlet 106 and the air outlet 108 are also in butt joint, thereby playing the role of fixing the cigarette holder and the cigarette rod as a whole. The input end of the cigarette holder and the output end of the cigarette rod may be of screw-fit structures, may also be of plug-fit structures.”). Ex. 1005 at 8.

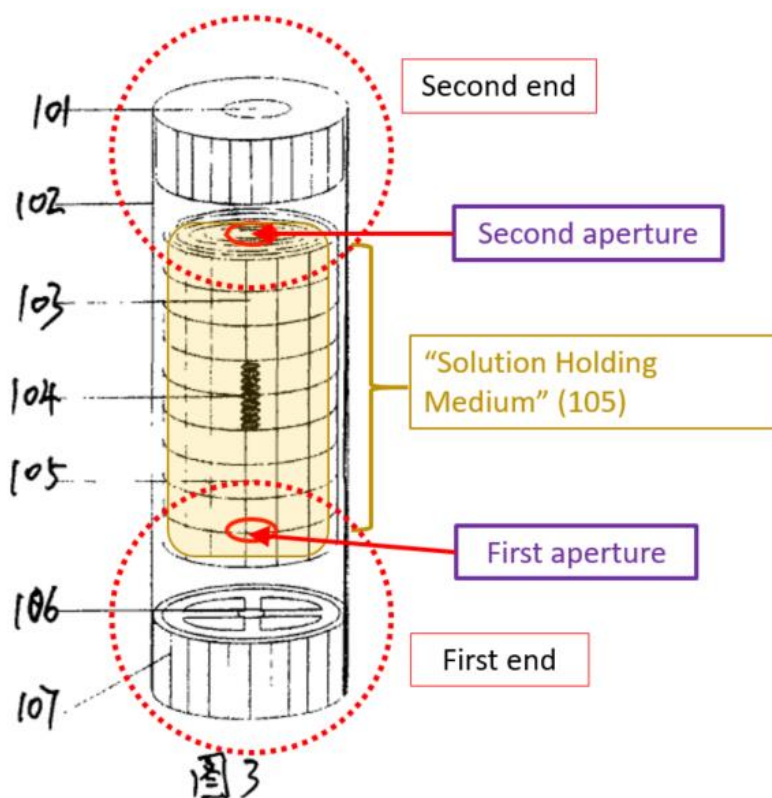
258. Thus, either connecting electrode 119 and/or another un-shown electrical conductive portion is used to connect the battery 110 in 111 to the heating element 104 in cartridge 102 and is both are an electrically conductive portion. The battery itself also contains an electrically conductive portion, as a POSITA would understand.

e. 1[b1]: a cartridge having a housing that comprises an interior,

259. Wang discloses this limitation. As shown in Figure 3, cartridge (“the cigarette holder”), has a housing (“cigarette holder shell 102,” that “is a hollow cylinder”), which has an interior, in which the heating element 104 and solution holding medium 105 are, for example. Ex. 1005, Fig. 3. Wang states that “cigarette holder shell 102 is a hollow cylinder” that “pro-vides a space for smoke produced when the tobacco extract 103 in the organic fiber 105 is heated by the electric heater 104” where the “tobacco extract 103...is natural tobacco absolute oil [that]...is first vaporized into smoke.” Ex. 1005 at 7.

- f. **1[b2]: wherein the housing includes a first end and a second end that is opposite the first end, wherein the housing includes a first aperture on the first end and a second aperture on the second end,**

260. Under Patent Owner's current contentions in the ITC cases and the prior district court analysis, Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation. As shown in Figure 3, cartridge ("the cigarette holder"), has a first end and a second end that is opposite the first end as well as a first aperture on the first end and a second aperture on the second end of the housing:



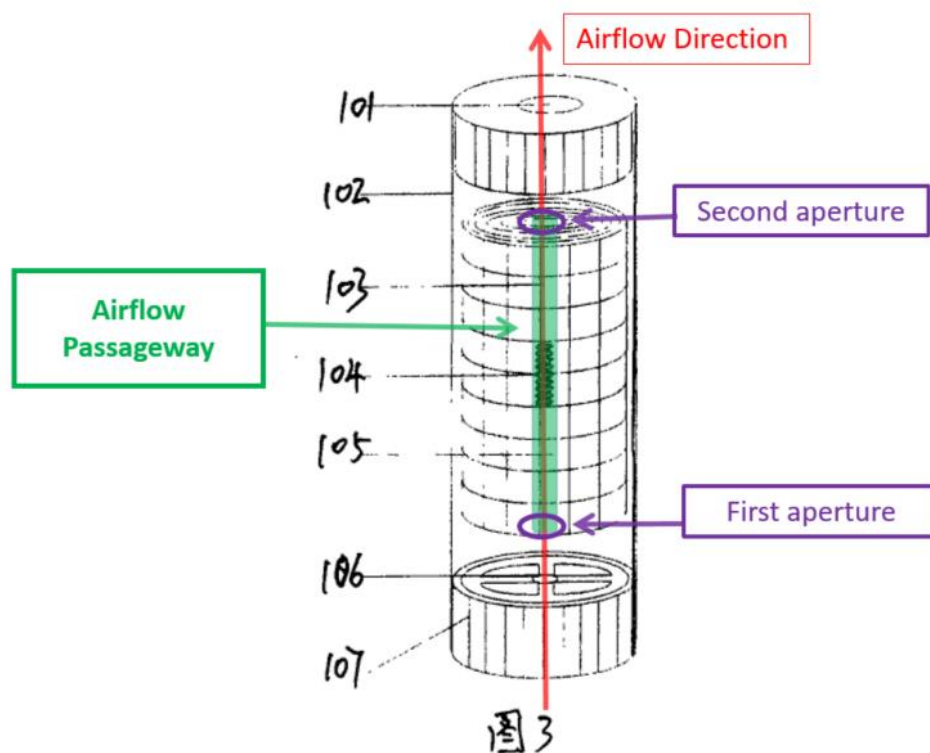
Ex. 1005, Fig. 3 (annotated).

- g. 1[c]: wherein the housing includes an airflow passageway that extends centrally and axially with respect to the housing intermediate of the first aperture on the first end of the housing and the second aperture on the second end of the housing**

261. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation.

- i. Wang**

262. Wang discloses this element for the same reasons as discussed in Ground 1, element 1[c]:



Ex. 1006, Fang, Fig. 3 (annotated).

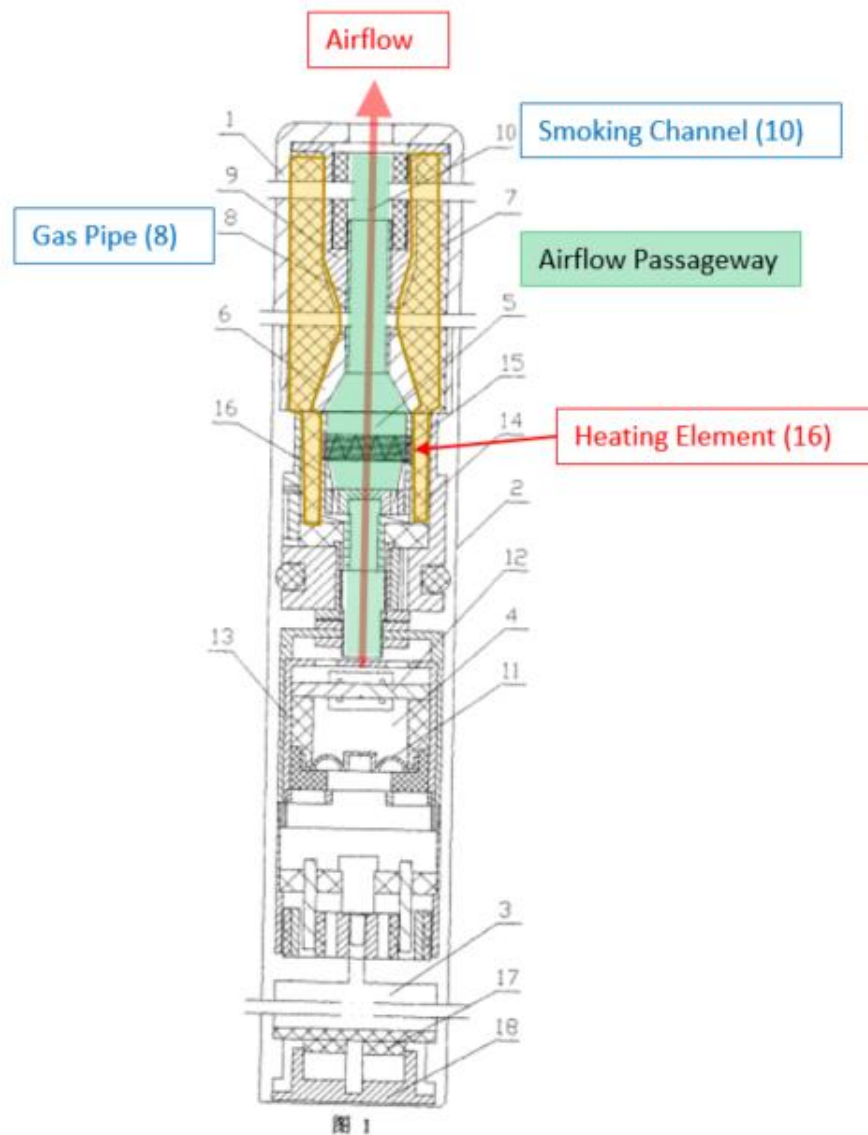
263. A POSITA would also be motivated to modify the image above so that the solution holding medium and the passageway reached to air inlet 106 and air outlet 101, as it would then allow greater volume for the solution-holding medium 105.

264. To the extent solution holding medium 105 does not already have such a separate passageway through the middle, it would be an obvious modification. Instead of requiring the air to flow through the fiber, a more defined central passageway would increase airflow and avoid requiring air that is to be inhaled by a

user directly flowing through fibrous material, which could cause particles to be picked up in the airflow.

ii. Wang with Fang

265. Additionally, and to the extent that Wang's airflow passageway is not seen as central or axial to the housing, this limitation is disclosed by Wang in view of Fang. As explained above—in ground 1 element 1[c] —and seen below, Fang teaches a central and axial airflow passageway.



Ex. 1006, Fig. 1 (annotated).

266. A POSITA would be motivated to modify Wang such that it had a central and axial uniform, cylindrical passageway through the center of the cylinder of the cartridge housing by creating a space, to the extent it is not already disclosed

above in Wang, within the solution holding medium 105 for the passageway and extending the passageway from one aperture to the other, with the solution holding medium around it the entire way to maximize liquid storage.

267. Further, a POSITA would know that to connect the liquid to the heating element, one could use the wicking material in the form of item 15 of Fang, which accomplishes that function in Fang, in the middle of the airflow passageway and connecting to the solution holding medium, and the heating element of Wang or that of Fang wrapped around the wicking material 15.

268. A POSITA would understand the highly obvious benefits of creating an airflow passageway that runs central and along the housing axis, between the two apertures, in creating a uniform, consistent airflow that exists the device at the mouthpiece. For those reasons, a POSITA would have been motivated modify Wang's airflow passageway with Fang's, to create a clear opening down the center, to achieve these simple benefits. *Id.* The resulting device would: (1) maintain Wang's two-piece system and first aperture, as well as, the electrical components described, but; (2) modify Wang's solution holding medium to wrap around the airflow passageway and heating element and orient the heating element horizontally across the airflow, based on the architecture of these elements in Fang.

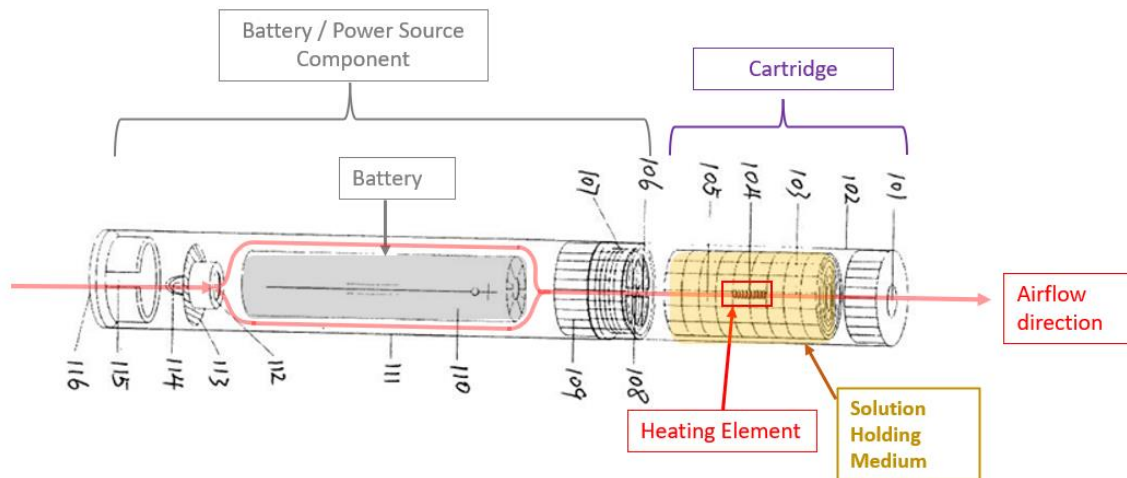
- h. 1[d]: wherein the airflow passageway is configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing,**

269. Wang discloses this limitation for the same reasons discussed for claim element 1[c] above.

i. Wang

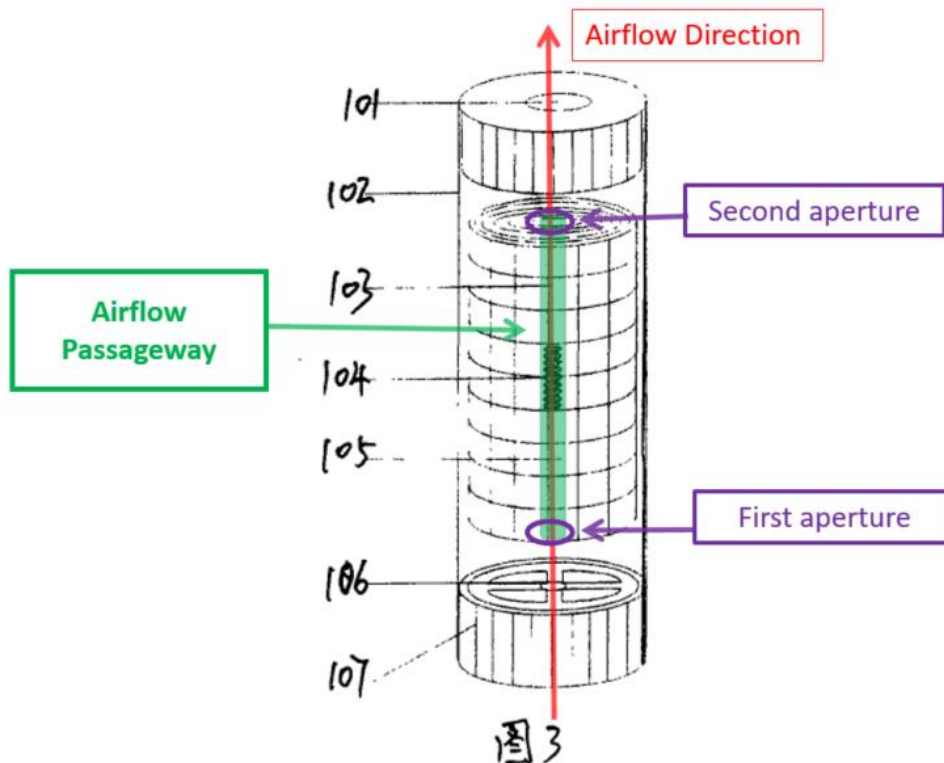
270. Wang discloses that air enters the device through “air inlet 115.” Ex. 1005, 8. Air flow exits “air outlet 108” in the Cigarette rod and crosses into the cigarette holder via “air inlet 106”. Ex. 1005, 8 (“the airflow reaches the internal gap of the cigarette holder through the air outlet 108 of the cigarette rod and the air inlet 106 of the cigarette holder, and the smoke generated by the tobacco extract 103 instantly heated by the heater 104 is partially sucked out from the air outlet 101 of the cigarette holder.”). Air flows into gap in the rolled “organic fiber 105,” which contains “tobacco extract 103,” drawing liquid in toward the heater, flows over the “heater 104,” combines with the vaporized tobacco extract from the heater 104, and exits to the user via “air outlet 101”). Ex. 1005, 8 (“the smoke generated by the tobacco extract 103 instantly heated by the heater 104 is partially sucked out from the air outlet 101”); 7 (“smoke produced when the tobacco extract 103 in the organic fiber 105 is heated by the electric heater 104”); 8 (“air outlet 101...is placed at the other end of the air inlet 106...and is a channel for finally sucking out smoke”). In this configuration, droplets would be pulled into the gap where the heater is. Though

not explicitly described as such in Wang, a POSITA would understand this, as it was disclosed in the art in Xia, for example. *See also* Ex. 1005, 8 (“air inlet 115... an internal gap of the cigarette rod, the air outlet 108... the air inlet 106... an internal gap of the cigarette holder and the air outlet 101 of the cigarette holder form the complete airflow channel... a smoking motion causes airflow to enter the interior of the cigarette rod through the air inlet 115...the sensor 112 is driven to transmit a switching signal to the control circuit board 113, the control circuit board 113 drives the heater 104 connected together through terminals to work, at the same time, the airflow reaches the internal gap of the cigarette holder through the air outlet 108...and the air inlet 106 and the smoke generated by the tobacco extract 103 instantly heated by the heater 104 is partially sucked out from the air outlet 101”).



Ex. 1005, Fig. 1 (annotated).

271. Air enters Wang's cartridge through "air inlet 106." Ex. 1005, 8. Air flows into gap in the rolled "organic fiber 105," flows over the "heater 104," and exits to the user via "air outlet 101"). Ex. 1005, 7-8. In doing so, the air flow passes through the cartridge from the first aperture to the second:



Ex. 1005, 7-8, annotated Figure 3.

ii. Wang with Fang

272. The modification proposed with Fang, wherein the solution holding medium is moved to the exterior part of the interior of the housing and a more

concrete airflow passageway exists down the middle, would permit an airflow through the housing from the first aperture to the second aperture

- i. 1[e]: wherein the first end of the housing includes an electrically conductive portion that is adapted to mechanically and electrically couple to the electrically conductive portion of the power source,**

273. Under Patent Owner's own contentions, Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation.

i. Wang

274. Wang discloses that “the output end 109 of the cigarette rod and the input end 107 of the cigarette holder are connected together,” thus establishing that item 107 within the housing of the cartridge establishes mechanical connection to the cigarette rod portion 111 and the battery contained therein.

275. Item 107 in the cartridge 102 also provides electrical coupling to the power source via, *e.g.*, electrode 117, as explained in element 1[a3] above, *e.g.*: “the input end [107] of the cigarette holder matches the output end of the cigarette rod, the two poles are isolated by an insulating material, and are connected with the output end of the cigarette rod, that is, the two poles are connected to the output end, respectively, an electrode 117 is in butt joint with an electrode 107, the electrode 107 is in butt joint with an electrode 119, and the air inlet 106 and the air outlet 108

are also in butt joint, thereby playing the role of fixing the cigarette holder and the cigarette rod as a whole.”). Ex. 1005 at 8.

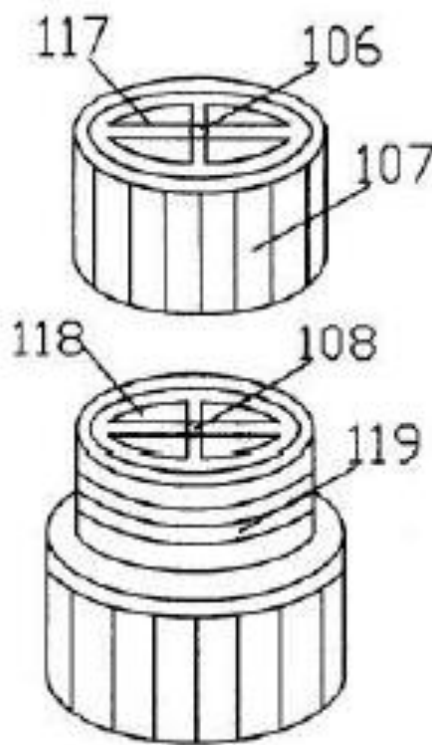


Fig. 4

Id., Fig 4.

276. Thus, Wang makes clear that the “electric heater 104” in the cartridge (“cigarette holder part” containing items 107, 106 and 117 above) is electrically coupled to the “battery 110” in the cigarette rod part, via the “the first end of the housing,” through elements 107 in the cartridge, and 109 in the cigarette holder part

(containing items 108, 118, and 119 above), among others that those contain.

Though not illustrated in Figure 1, below, a POSITA would understand that the heating element (104) is in contact with, and electrically coupled, to the first end of the housing.

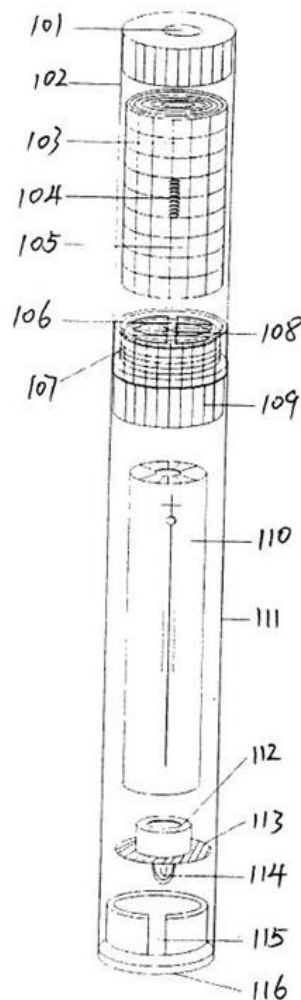


Fig. 1

Ex. 1005, Fig. 1.

ii. Wang with Fang

277. As described above, in element 1[c], the proposed modified device does not alter Wang's two-piece system or its electrical and mechanical connections, and would not impact this element.

j. 1[f]: wherein the housing includes a solution holding medium adapted to hold a solution in the interior of the housing,

278. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation.

i. Wang

279. As shown below above, Wang's cartridge contains a solution holding medium in the form of an absorbent organic fiber 105, which is positioned around that heater 104. *Id.*, 6-7, 8.

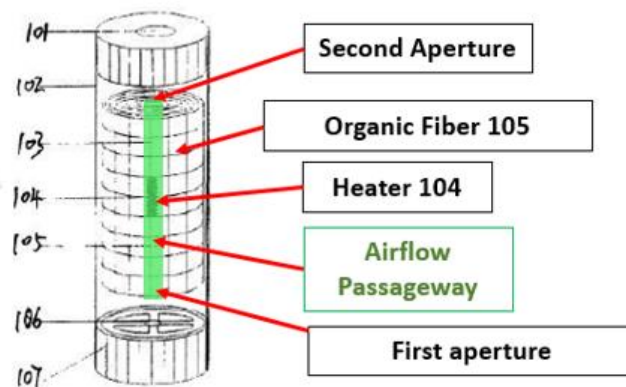


Fig. 3

280. Wang states that “cigarette holder shell 102 is a hollow cylinder” that “provides a space for the electric heater 104 and the tobacco extract 103 and organic fiber 105 wound around it,” where the “tobacco extract 103...is natural tobacco absolute oil, a certain proportion of nicotine is mixed in after the tobacco extract is diluted with alcohols in a certain proportion, and then a mixture quantitatively soaked in the organic fiber 105. Since the tobacco extract 103 is in a liquid or paste state, when heated, the tobacco extract 103 is first vaporized into smoke.” Ex. 1005, 4.

ii. Wang with Fang

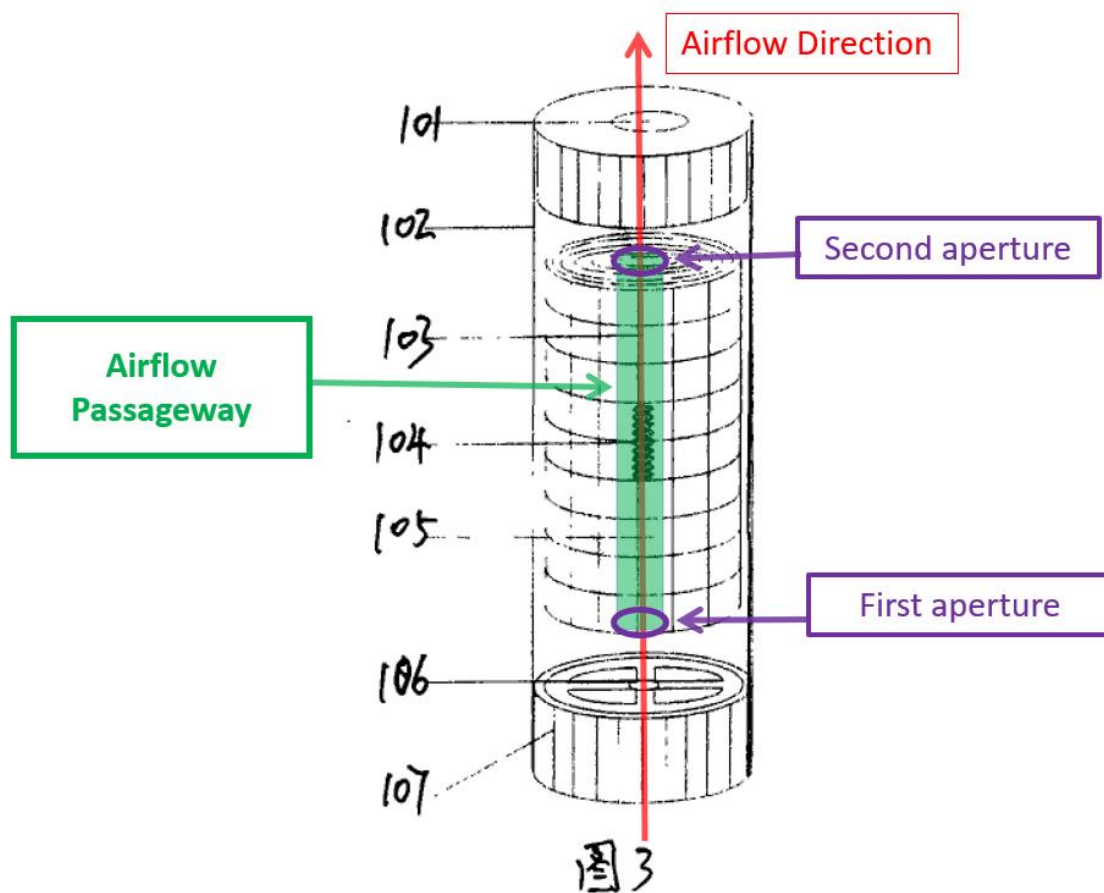
281. The combination with Fang would contain a solution holding medium as disclosed in Wang, or could contain that of Fang.

- k. 1[g]: wherein the housing includes a heating element located in the interior of the housing, wherein the heating element extends transversely across the airflow passageway, wherein the airflow through the passageway passes on both transverse sides of the element,**

282. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation.

i. Wang

283. Wang discloses that heater 104 is within the interior of the housing, as depicted in Fig. 3.



Ex. 1005, Fig. 3.

284. Heater 104 also “extends transversely” across the airflow passageway identified in 1[c] above in Wang, when viewed in light of the '881 specification and Claim 2. Wang’s heating element is consistent with the specification’s description of the heating element claimed in this patent and the configurations covered by the claims as explained in Ground 1, 1[g]. *See, e.g.* Ex. 1001 at 6:62-7:19. Further, claim 2 indicates that the specific orientation of Wang’s heating element with respect to the airflow passageway is contemplated as covered by claim 2, which depends

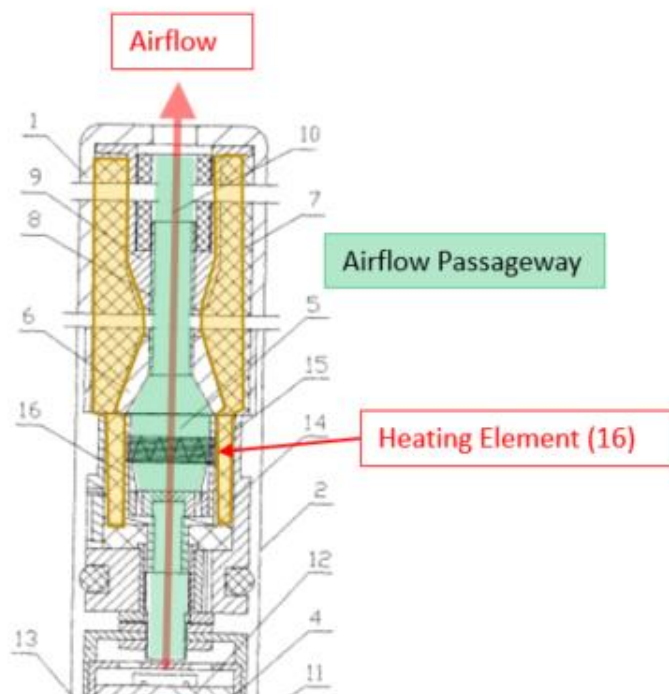
from and is therefore covered by claim 1. Claim 2 restricts claim 1 in that “the maximum diameter of the coil [must be] smaller than the diameter of the circular cross section of the length of the airflow passageway.” Ex. 1001, claim 2.

285. The alignment of the heating element in Wang with respect to the airflow passageway, such that the diameter of the coil and the diameter of the airflow passageway are in the same direction, *i.e.*, a plane perpendicular to a central longitudinal axis, is what a POSITA would recognize is contemplated by claim language comparing diameter size. Figure 3 of the '881 patent illustrates such an embodiment analogous to Figure 3 of Wang, and therefore "intended to fall under the scope of the hereto-appended claims." *See, e.g.* Ex. 1001 at 7:50-52 and 8:20-23. Because they are in the same direction, the comparison of diameter size makes sense, and indeed more sense than if the heating element had its longer edge across the passageway such that its diameter was in a different direction than that of the passageway.

286. Airflow through the passageway passes on both transverse sides of the element, although that term is not explained or defined in the specification, because air flows over the entirety of the heating element 104.

ii. Wang in Combination with Fang

287. To the extent the above does not satisfy the claim language, as explained above in section 1[c], as modified with Fang, the heating element would be oriented perpendicularly as in Fang, which is at a minimum is covered by the claims as depicted in Figure 2 of the '881 patent. *See also* Ground 1, element 1[g]. For example, this would increase the surface area of the heater that comes into contact with the airflow and with the nicotine solution and also provide for a wider airflow passageway between the heater and the mouthpiece while simultaneously helping to reduce the length of the electronic cigarette for increased portability. Moreover, Fang's heating element is oriented perpendicularly to the airflow passageway, as shown in Fang's Figure 1:



288. The design would more evenly distribute the heat applied to the vapor across the longitudinal axis of the electronic cigarette which may limit the maximum heat of the vapor and result in a more pleasant smoking experience. Accordingly, it would have been obvious to a POSITA designing an electronic cigarette to include a heating element that is perpendicular with respect to the housing's central and longitudinal axis. Additionally, designing the heater in this manner is as equally simple of a design as that of Wang, and the choice is not given any particular importance within Wang.

- l. **1[h]: wherein the solution holding medium surrounds the airflow passageway and the heating element in the interior of the housing and intermediate of the first end and the second end,**

289. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation

i. **Wang**

290. As established in Ground 1's 1[h], Wang discloses this limitation regardless of whether the solution holding medium must surround the entire airflow passageway because, as shown below, Wang's solution holding medium 105 surrounds the entire identified airflow passageway and the heating element:

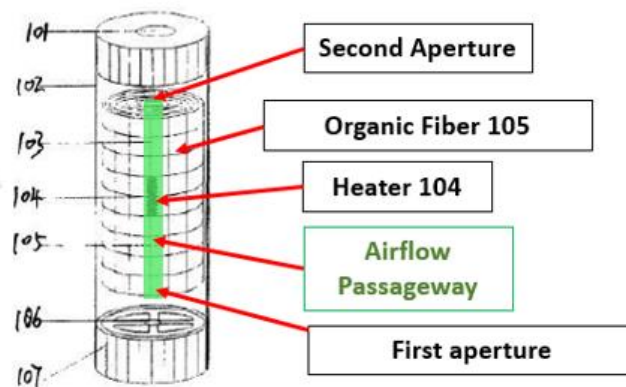


Fig. 3

In the prior litigation, the inventor Mr. Wang confirmed that his invention's absorbent organic fiber 105 “surrounds a complete central air passageway, in which the heater is positioned.” Ex. 1017 (Wang Decl.), 4-5.

ii. Wang in Combination with Fang

291. Wang in view of Fang also discloses this limitation. Fang discloses this limitation as explained above in Ground 1, 1[h]. The modification proposed in 1[c] would result in the solution holding medium surrounding, to the extent it does not already in Wang, the airflow passageway and the heating element. A POSITA would have been motivated to make this modification for the reasons identified above in 1[c] and because changing the solution holding medium and airflow passageway as described would prevent the heated vapor from contacting the inner wall of the housing, which is typically, and is in Wang, very thin.

292. The solution holding medium acts as a barrier and insulator, which reduces heat loss and the sensation of the device warming. Therefore, the user will not feel the device being heated, as the solution is vaporized. Such a solution also maintains the temperature of the vapor in a more predictable and consistent way in colder environments.

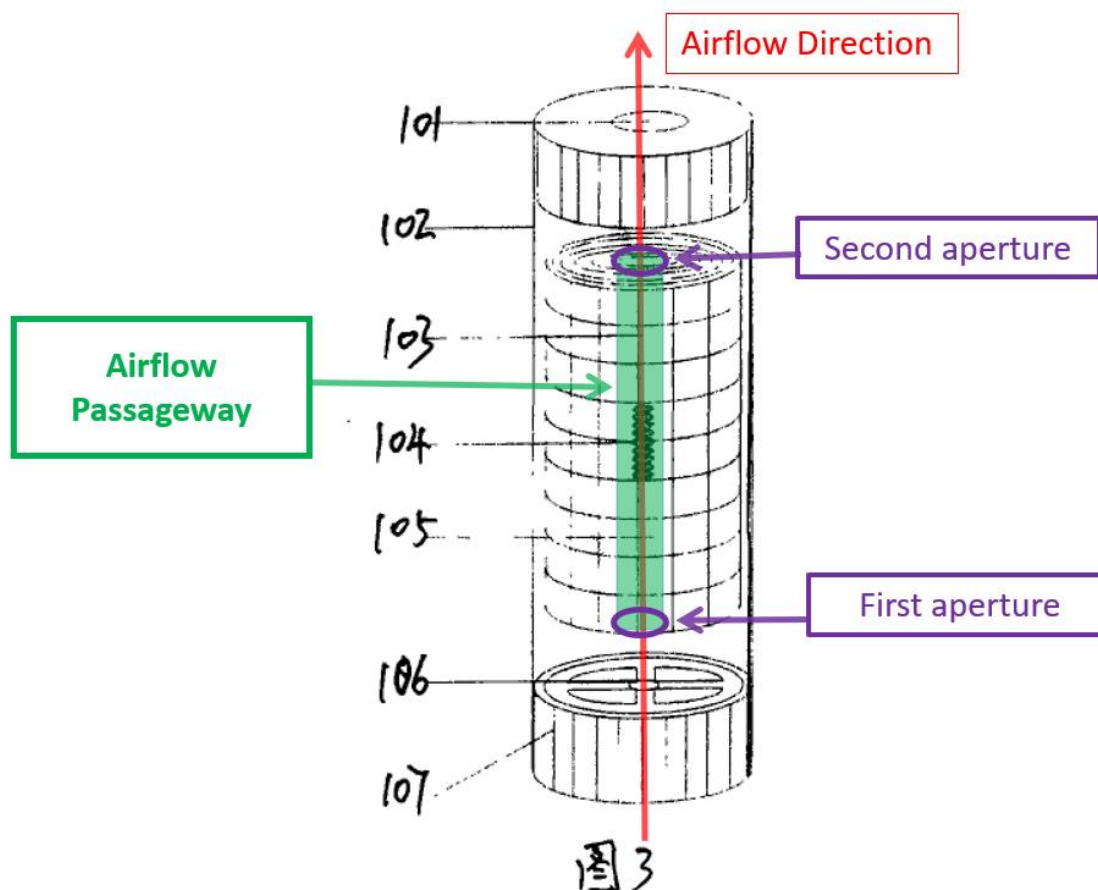
- m. 1[i]: wherein the heating element is electrically configured to vaporize at least a portion of the solution to be contained in the solution holding medium for oral provision to an individual in an airflow from the second aperture responsive to electrical power received from the battery through the electrically conductive portions of the cartridge and the power source.**

293. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation. Wang discloses a cigarette rod shell 111 with a battery 110, that connects to a cartridge (“the cigarette holder”), containing a heating element 104, which is powered by the battery, as described in 1[a1]-1[a3] and 1[e] above. Ex. 1005 at 2-3. Wang also states that “[s]ince the tobacco extract 103 is in a liquid or paste state, when heated, the tobacco extract 103 is first vaporized into smoke.”) Ex. 1005, at 4.

294. The heating of the heating element is “responsive to electrical power received from the battery through the electrically conductive portions of the cartridge and the power source” as explained in 1[a1]-[a3] and 1[e] above.

295. Additionally, Wang discloses that once the tobacco extract is vaporized it is delivered orally to an individual via its second aperture. “[T]he smoke generated by the tobacco extract 103 instantly heated by the heater 104 is partially sucked out from the air outlet 101 of the cigarette holder.” Ex. 1005, 8.

296. To the extent this element requires mixing of vapor and airflow separately from, or in addition to, air flowing over the heating element, Wang discloses that limitation. For example, in Wang the vapor mixes with existing air in an airflow gap that is immediately after the solution holding medium and the second aperture, through which the combined air and vapor exits.



Ex. 1005, Fig. 3 (annotated).

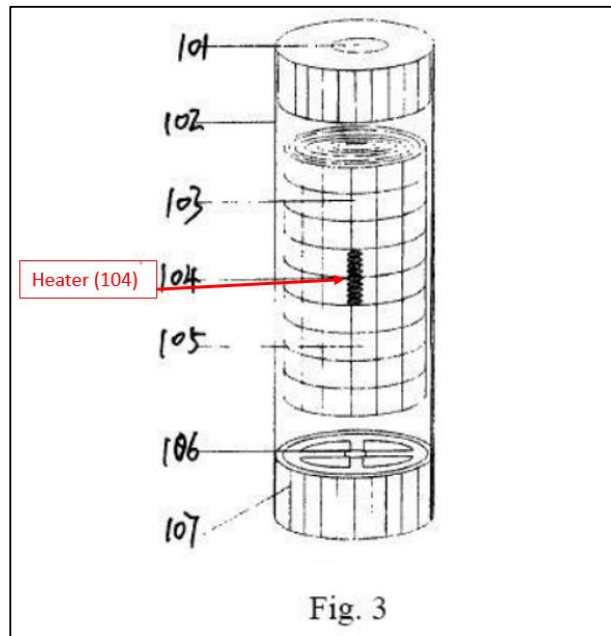
2. Claim 2

- a. [2]: The cartridge of claim 1, wherein the heating element is a coil having a maximum diameter, the airflow passageway having a length having a circular cross section having a diameter along a majority of the length, the maximum diameter of the coil being smaller than the diameter of the circular cross section of the length of the airflow passageway.

297. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation.

i. Wang

298. As depicted in Figure 3, Wang discloses that heating element 104 can be a coil:



Ex. 1005, Fig. 3 (annotated).

299. Moreover, a POSITA would also know that a coil is a very common shape for a heating element, especially within cylindrical shape, such as the electronic cigarette housing of Wang.

300. Additionally, Wang the maximum diameter of heating element is “smaller than the diameter of the circular cross section of the length of the airflow passageway” within which it sits, as depicted above.

301. Furthermore, as described in Ground 1 claims 1[c] and 2, and 1[c] above, the airflow passageway in Wang has a circular cross section having a diameter along a majority of its length. To the extent this claim requires a uniform cross section along the majority of, or entirety of, the length of the passageway, the airflow passageway examples in Wang described in 1[c] and 1[h] meet that requirement, as depicted and explained there.

ii. Wang in Combination with Fang

302. Wang as modified by Fang as described above also meets this requirement. Using the coil orientation of Fang does not change the size of the coil in Wang, and using Fang’s coil also meets the requirement as explained in Ground 1. To the extent the passageway is modified by Fang, the passageway would be uniform and cylindrical in nature, as described above in 1[c] and 1[h].

3. Claim 3

- a. **[3]: The cartridge of claim 2, wherein the first aperture on the first end is located centrally and axially with respect to the housing, the first aperture having a cross-sectional area measured perpendicular to a central longitudinal axis of the housing, the interior of the airflow passageway between the heating element and the second aperture being no smaller in cross-sectional area than the cross-sectional area of the first aperture.**

303. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation.

i. Wang

304. As described in Claim 1 and Ground 1 above, the first aperture is located centrally and axially with respect to the housing. It has a circular cross-sectional area measured perpendicular to a central longitudinal axis (which is along the same line as the airflow direction, *see* 1[d]). *See* Ground 1, claim 3. As shown in 1[c] above and in Ground 1, Wang's airflow passageway and second aperture are equal to or larger than the first aperture.

305. To the extent Wang's airflow passageway interior is not seen as equal to or larger than the area of the first aperture, a POSITA would have found it obvious to modify with Fang to ensure that the cross-sectional area of the airflow passageway is not smaller than that of the first aperture to ensure proper pressure drop and airflow exiting the device.

ii. Wang in Combination with Fang

306. The modification of Wang with Fang, as previously described, would not affect this limitation, as the analysis above would remain true.

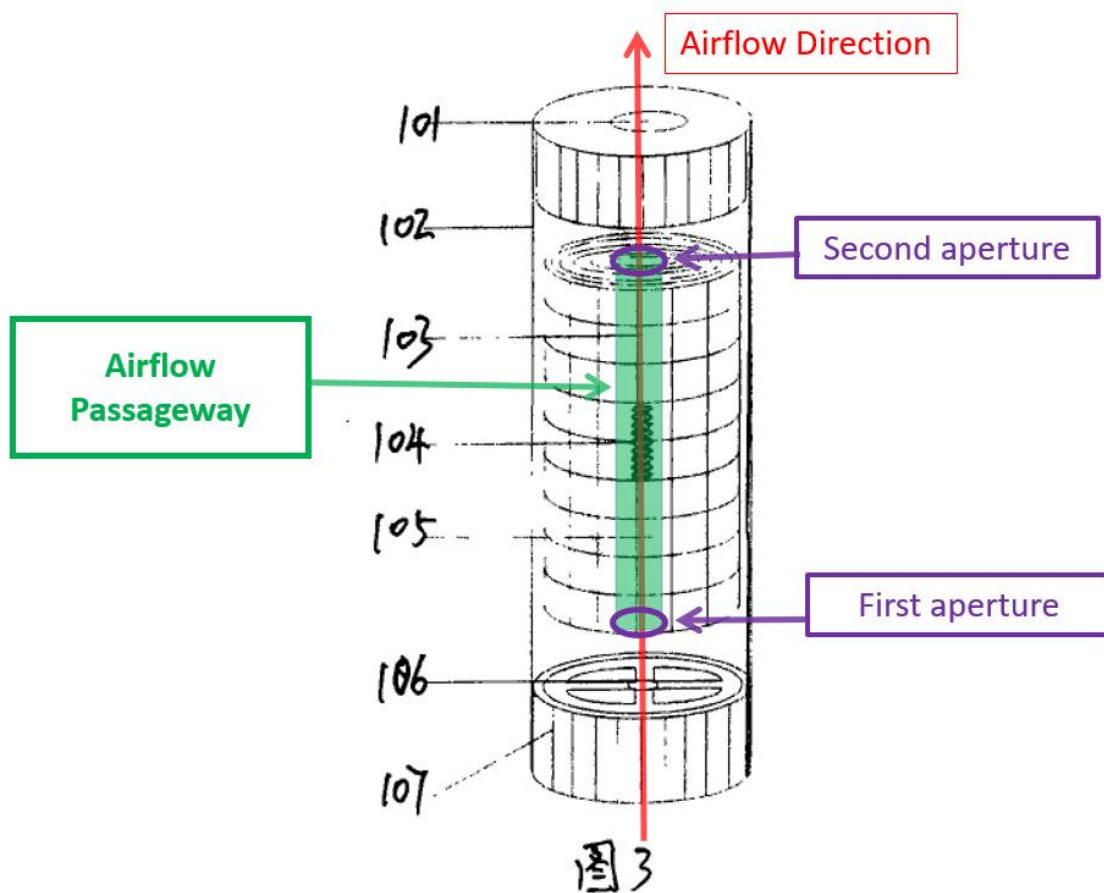
4. Claim 4

- a. [4]: The cartridge of claim 3, wherein the first aperture on the first end is smaller than the second aperture on the second end.**

307. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation.

i. Wang

308. To the extent the first aperture on the first end is not seen as smaller than the second aperture on the second end, in Figure 3 of Wang below, a POSITA would have been motivated to make this change, ensuring that the first aperture was smaller than the second aperture to ensure proper airflow exiting the device.



Ex. 1005, Fig. 3.

ii. Wang in Combination with Fang

309. The modification of Wang with Fang would not affect this limitation, as the analysis above would remain true.

5. Claim 5

- a. [5]: The cartridge of claim 1, wherein the solution holding medium includes at least one of an absorbent material and a reservoir.**

310. Wang discloses at least a solution holding medium including absorbent material. “[A]a certain proportion of nicotine is mixed in after the tobacco extract is diluted with alcohols in a certain proportion, and then a mixture quantitatively soaked in the organic fiber 105.” See [8a] regarding reservoir.

6. Claim 6

- a. [6]: The cartridge of claim 1, further comprising a solution in the solution holding medium, the solution comprising one of propylene glycol and nicotine.**

311. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation. Wang discloses that “The tobacco extract 103 of the cigarette holder is natural tobacco absolute oil, a certain proportion of nicotine is mixed in after the tobacco extract is diluted with alcohols in a certain proportion, and then a mixture quantitatively soaked in the organic fiber 105.” Ex. 1005, 4. Tobacco extract contains nicotine, as would be recognized.

312. Moreover, a POSITA would have understood that Wang’s solution likely contained, or could easily be modified to contain propylene glycol. For example, propylene glycol is a well-known, safe for human consumption, and common solvent for organic chemicals, such as nicotine. Propylene glycol is also in

the alcohol family and vaporizes readily. Additionally, early e-cigarette devices imported into the U.S. contained this exact solution and, thus, it was known in the art. Ex. 1016 (Tariff Classification) at 1.

7. Claim 7

- a. [7]: The cartridge of claim 1, wherein the airflow passageway has a uniform cross-sectional area measured perpendicular to a central longitudinal axis of the housing between the heating element and the second aperture.**

313. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 2.

8. Claim 8

- a. 8[p]: A cartridge configured to mechanically and electrically couple to a power source of an electronic vaporizer, the cartridge comprising:**

314. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1e].

b. 8[a1]: a housing having an interior and a solution holding medium reservoir adapted to hold a solution,

315. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[f].

i. Wang

316. To the extent that the reservoir is required to be made from a hard, impermeable material, A POSITA would have been motivated to modify the solution holding medium of Wang, described as “organic fiber 105,” with Fang’s. Wang would benefit from such a modification because it would provide a place to hold the fiber, allows for replacement of the fiber if it degrades, prevents leakage of liquid from the fiber, and prevents direct inhalation of the liquid before it is vaporized, as described in Fang, and it would which would be an obvious variation for a POSITA.

ii. Wang with Fang

317. As previously described, in the discussion of element 8[a] in Ground 1, Fang’s solution holding medium is flanked on all sides by hard, non-porous material that would hold liquid and satisfy the requirement for a “reservoir.” A POSITA would have been motivated to use a hard tank around Wang’s organic fiber for the reasons described above.

- c. **8[a2]: the housing having a first end and a second end that is opposite the first end, the housing having a first aperture on the first end and a second aperture on the second end,**

318. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[b2].

- d. **8[a3]: the first end of the housing having an electrically conductive portion adapted to mechanically and electrically couple to the electrically conductive portion of the power source;**

319. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[e].

- e. **8[b1]: an airflow passageway in the interior of the housing extending centrally and axially with respect to the housing intermediate of the first aperture on the first end of the housing and the second aperture on the second end of the housing,**

320. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[c].

- f. 8[b2]: the airflow passageway being configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing; and**

321. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[d].

- g. 8[c1]: a heating element located in the interior of the housing, the heating element being located within and extending transversely across the airflow passageway, the airflow through the passageway passing on both transverse sides of the heating element,**

322. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[g].

- h. 8[c2]: both the heating element and the airflow passageway being surrounded by the solution holding medium reservoir,**

323. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[h].

- i. **8[c3]: the heating element being electrically configured to vaporize at least a portion of the solution to be contained in the solution holding medium reservoir for oral provision to an individual in an airflow from the second aperture responsive to electrical power received from the battery through the electrically conductive portions of the cartridge and the power source.**

324. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[i].

9. Claim 9

- a. **[9]: The cartridge of claim 8, further in combination with the power source including a battery and the electrically conductive portion, the electrically conductive portion of the power source being mechanically and electrically coupled to the electrically conductive portion of the first end of the housing.**

325. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim elements [1a3] (for discussion of power source element) and [1e] (for discussion of cartridge element).

10. Claim 10

- a. **[10]: The cartridge of claim 9, wherein the heating element is a coil having a maximum diameter, the airflow passageway having a length having a circular cross section having a diameter along a majority of the length, the maximum diameter of the coil being smaller than the diameter of the circular cross section of the length of the airflow passageway.**

326. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 2.

11. Claim 11

- a. **[11]: The cartridge of claim 10, wherein the first aperture on the first end is located centrally and axially with respect to the housing, the first aperture having a cross-sectional area measured perpendicular to a central longitudinal axis of the housing, the interior of the airflow passageway between the heating element and the second aperture being no smaller in cross-sectional area than the cross-sectional area of the first aperture.**

327. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 3.

12. Claim 12

- a. **[12]: The cartridge of claim 11, wherein the first aperture on the first end is smaller than the second aperture on the second end.**

328. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 4.

13. Claim 13

- a. **[13]: The cartridge of claim 8, wherein the solution holding medium reservoir includes an absorbent material.**

329. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 5.

14. Claim 14

- a. **[14]: The cartridge of claim 8, further comprising a solution in the solution holding medium reservoir, the solution comprising one of propylene glycol and nicotine.**

330. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 6.

15. Claim 15

- a. [15]: The cartridge of claim 8, wherein the airflow passageway has a uniform cross-sectional area measured perpendicular to a central longitudinal axis of the housing between the heating element and the second aperture.**

331. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 7.

16. Claim 16

- a. 16[p]: A cartridge configured to mechanically and electrically couple to a power source of an electronic vaporizer, the cartridge comprising:**

332. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[e].

- b. 16[a1]: a housing having an interior and a solution holding medium adapted to hold a solution in the interior of the housing,**

333. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[f].

- c. **16[a2]: the housing having a first end and a second end that is opposite the first end, the housing having a central longitudinal axis extending through the first end and the second end, the housing having a first aperture on the first end and a second aperture on the second end,**

334. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[b2]. Further, Wang and Fang have a housing with a central longitudinal axis extending through the first end and the second end. *See* claim 3, Ground 1, claim 3.

- d. **16[a3]: the first aperture having a cross-sectional area measured perpendicular to the central longitudinal axis of the housing,**

335. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[b2], claim 2.

- e. **16[a4]: the first end of the housing having an electrically conductive portion adapted to mechanically and electrically couple to an electrically conductive portion of the power source;**

336. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[e].

- f. 16[b1]: an airflow passageway in the interior of the housing, the airflow passageway having a length extending centrally and axially with respect to the housing intermediate of the first aperture on the first end of the housing and the second aperture on the second end of the housing,**

337. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[c].

- g. 16[b2]: the airflow passageway being configured to allow an airflow through the cartridge from the first aperture to the second aperture of the housing,**

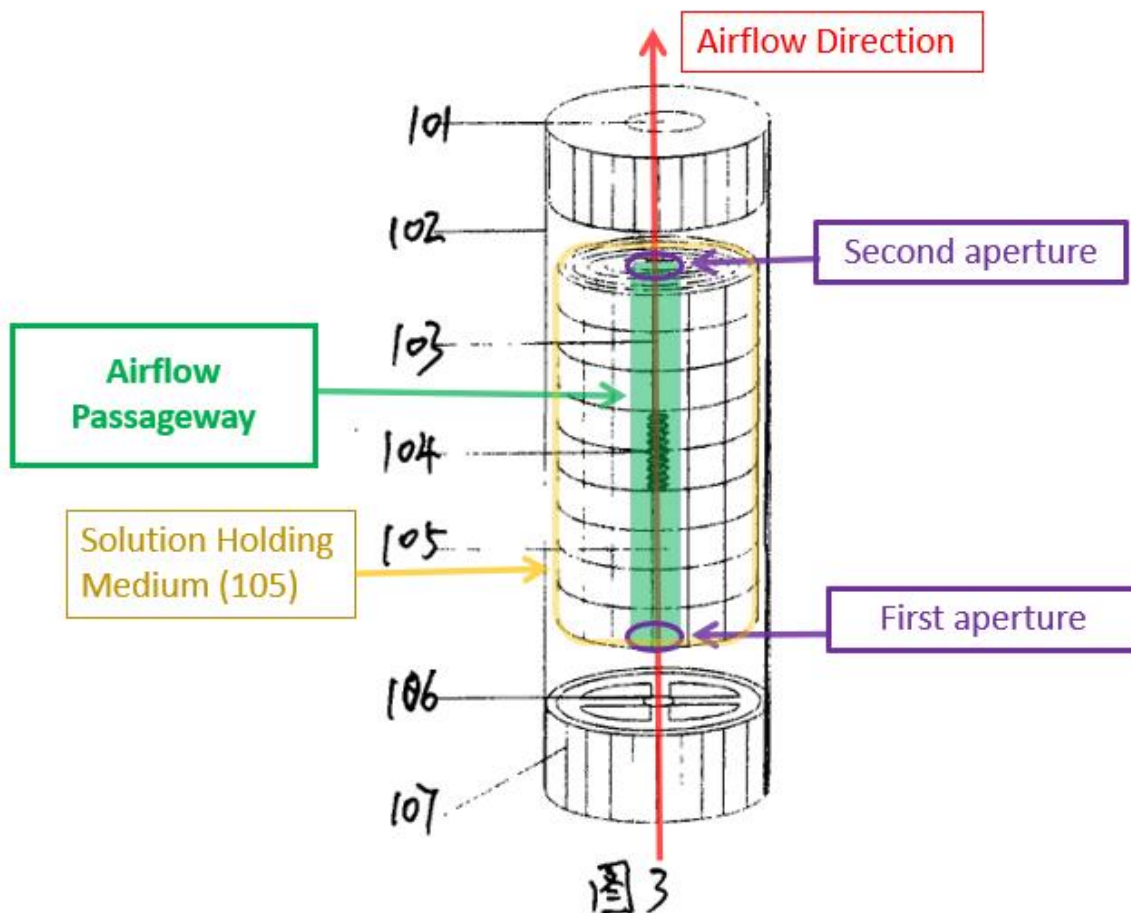
338. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[d].

- h. 16[b3]: the airflow passageway having an exterior adjacent to the solution holding medium along a majority of the length of the airflow passageway,**

339. Under Patent Owner's own contentions in the parallel ITC investigation, Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[h].

i. Wang

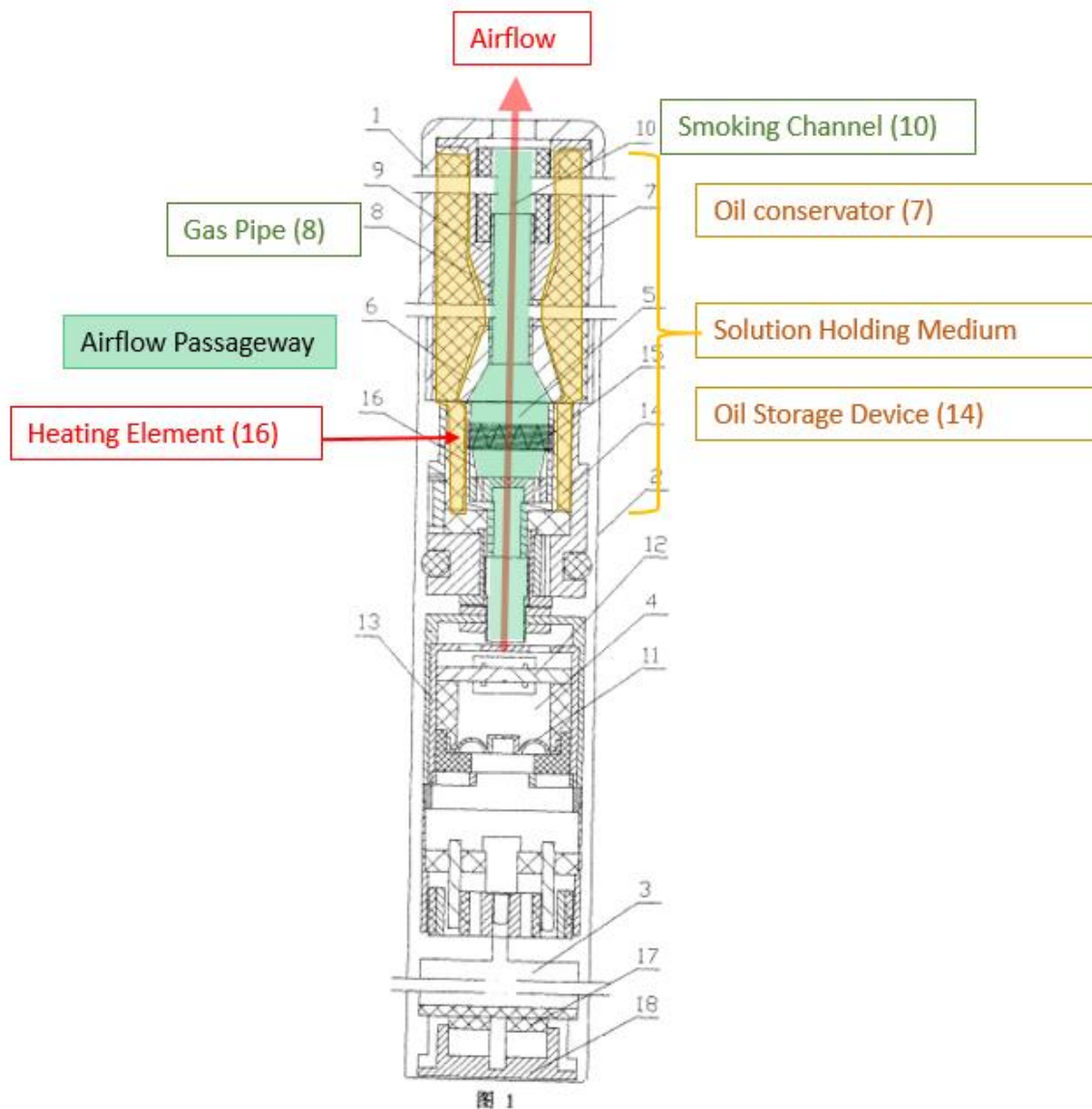
340. In Wang, the solution holding medium surrounds the airflow passageway along a majority of the length of the passageway and thus an exterior of the airflow passageway is adjacent to the solution storage medium along the majority of its length.



Ex. 1005 (Wang) Fig. 3 (annotated).

ii. Wang with Fang

341. Wang as modified with Fang also discloses that the solution holding medium surrounds the airflow passageway along a majority of the length of the passageway, and so meets this claim limitation as well. See 1[h], 1[c].



Ex. 1006 (Fang) Fig. 1 (annotated).

- i. **16[b4]: the airflow passageway having an interior having a uniform cross-sectional area measured perpendicular to the central longitudinal axis of the housing and extending continuously along a majority of the length of the airflow passageway; and**

342. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claims 2 and 7.

- j. **16[c1]: a heating element located in the interior of the housing and extending transversely across the airflow passageway, the airflow through the passageway passing on both transverse sides of the heating element,**

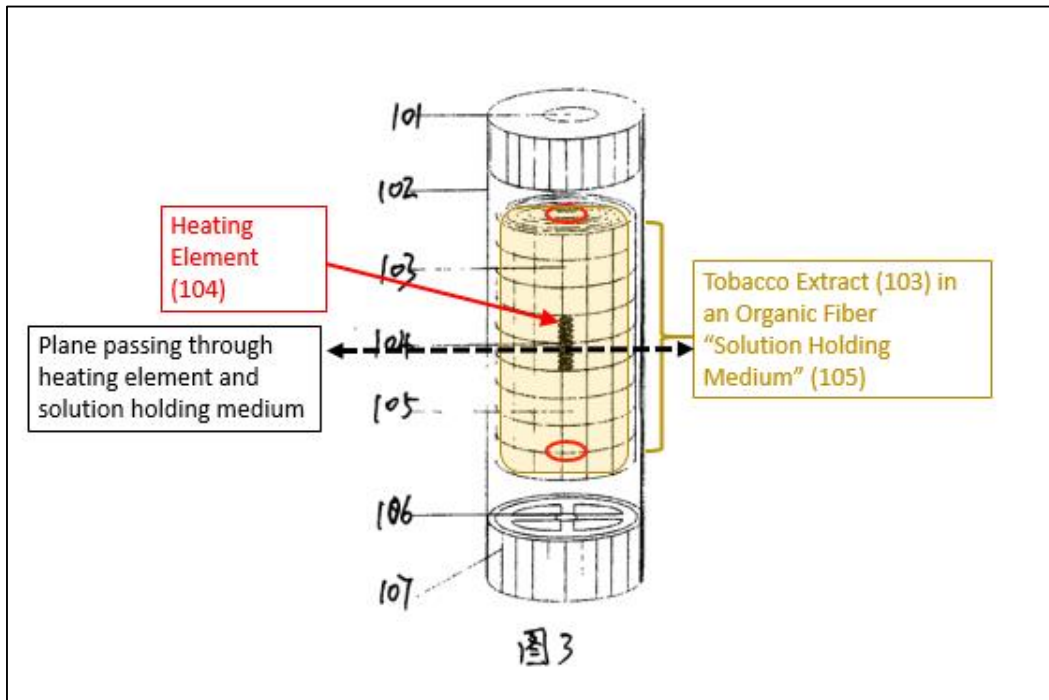
343. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[g].

- k. **16[c2]: a plane perpendicular to the central longitudinal axis of the housing passing through the heating element and the solution holding medium,**

344. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[h]. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation.

i. Wang

345. In Wang, a plane perpendicular through the longitudinal axis passes through both the heating element and solution holding medium.



Ex. 1005, Figure 3 (annotated).

ii. Wang with Fang

346. Wang as modified with Fang discloses this limitation for the same reasons as above, because in the modification, the solution holding medium continues to surround the heating element.

- l. 16[c3]: the airflow passageway having an interior between the heating element and the second aperture no smaller in cross-sectional area than the cross-sectional area of the first aperture,**

347. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 3.

- m. 16[c4]: the heating element being connected to the electrically conductive portion of the first end of the housing,**

348. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim elements 1[e] and [i].

- n. 16[c5]: the heating element being electrically configured to vaporize at least a portion of the solution to be contained in the solution holding medium for oral provision to an individual in an airflow from the second aperture responsive to electrical power received from the power source through the electrically conductive portion of the cartridge.**

349. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[i].

17. Claim 17

- a. **[17]: The cartridge of claim 16, further in combination with the power source including a battery and the electrically conductive portion, the electrically conductive portion of the power source being mechanically and electrically coupled to the electrically conductive portion of the first end of the housing.**

350. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim elements 1[i] (for power source element) and 1[e] (for cartridge element).

18. Claim 18

- a. **[18]: The cartridge of claim 16, wherein the heating element is a coil having a maximum diameter and the uniform cross-sectional area of the airflow passageway is a circle having a diameter, the maximum diameter of the coil being smaller than the diameter of the circle of the uniform cross-sectional area of the airflow passageway.**

351. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 2. Wang alone, and Wang in combination with Fang, each alternatively discloses the additional element recited that “the airflow passageway *is a circle* having a diameter” as described in claim 2 and in Ground 1, claim 2. For the same reasons described in claim 2, Wang also discloses the cross-sectional area of the airflow passageway is a circle.

19. Claim 19

- a. **[19]: The cartridge of claim 18, wherein the first aperture on the first end is located centrally and axially with respect to the housing.**

352. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 3.

20. Claim 20

- a. **[20]: The cartridge of claim 19, wherein the first aperture on the first end is smaller than the second aperture on the second end.**

353. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 4.

21. Claim 21

- a. **[21]: The cartridge of claim 16, wherein the heating element is a coil having a maximum diameter and the uniform cross-sectional area of the airflow passageway is a circle having a diameter, the maximum diameter of the coil being smaller than the diameter of the circle of the uniform cross-sectional area of the airflow passageway.**

354. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 2 and 18.

22. Claim 22

- a. **[22]: The cartridge of claim 16, wherein the first aperture on the first end is located centrally and axially with respect to the housing.**

355. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 3.

23. Claim 23

- a. **[23]: The cartridge of claim 16, wherein the first aperture on the first end is smaller than the second aperture on the second end.**

356. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 4.

24. Claim 24

- a. **[24]: The cartridge of claim 16, wherein the solution holding medium includes at least one of an absorbent material and a reservoir.**

357. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 5.

25. Claim 25

- a. **[25]: The cartridge of claim 16, further comprising a solution, wherein the solution comprises one of propylene glycol and nicotine.**

358. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 6.

26. Claim 26

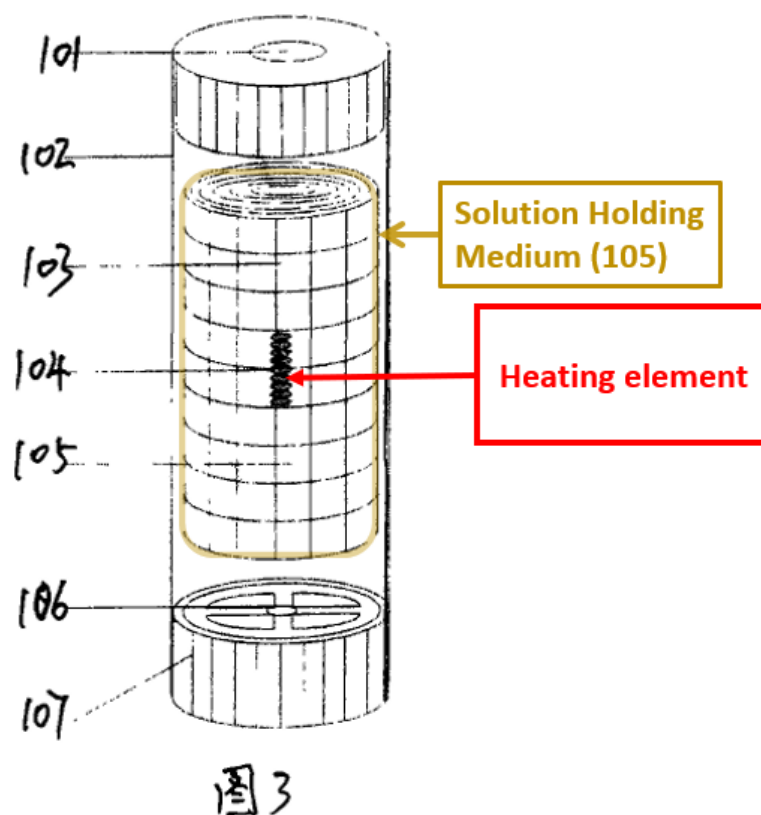
- a. **[26]: The cartridge of claim 16, wherein the heating element is in operative connection with a wicking material, and the wicking material is operative to attract a portion of the solution from the solution holding medium located immediately adjacent opposite ends of the heating element toward the heating element.**

359. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim element 1[h], for solution holding medium limitation.

i. Wang

360. Wang discloses the use of organic fiber, soaked with a solution, to deliver the solution to the heating element. Wang states that the “tobacco extract 103...is natural tobacco absolute oil, a certain proportion of nicotine is mixed in after the tobacco extract is diluted with alcohols in a certain proportion, and then a mixture quantitatively soaked in the organic fiber 105. Since the tobacco extract 103 is in a

liquid or paste state, when heated, the tobacco extract 103 is first vaporized into smoke.”) Ex. 1005, at 4. Thus, a portion of the solution is drawn toward the heating element via element 105, acting as a wicking material, where the portion that holds the solution is located immediately adjacent both opposite ends of the heating element.



ii. Wang in Combination with Fang

361. As described in Ground 1, claim 26, Fang’s “oil storage device (14)” flanks both sides, or opposite ends, of the heating element with a portion that extends

through the ‘heating film wire (16)’ and draws solution to both ends, and thus in the modification in which the heating element and wicking element 15 of Fang is used in Wang, this limitation is met as well.

27. Claim 27

- a. **[27]: The cartridge of claim 16, wherein the airflow passageway has a uniform cross-sectional area measured perpendicular to the central longitudinal axis of the housing between the heating element and the second aperture.**

362. Wang alone, and Wang in combination with Fang, each alternatively discloses this limitation for the same reasons described above, in the discussion of claim 7.

XIV. CONSIDERATIONS OF NON-OBVIOUSNESS

363. I understand that “objective indicia of non-obviousness,” also known as “secondary considerations,” are also to be considered when assessing obviousness of the claims, if such factors are present. These include commercial success of the claimed invention; long felt but unresolved needs; failure of others to solve any “problem” that the inventor solved; unexpected results; copying of the invention by others; and industry recognition or expressions of disbelief by experts in the field of the claimed invention. I also understand that in considering objective indicia of nonobviousness, it is not proper to look beyond the scope of the claimed subject matter.

364. In my opinion, the '881 patent did not resolve any long felt need. Rather, the '881 patent presented known options, as disclosed in Xia, Han, Wang. For the same reasons, I am not aware of any failure of others to solve any “problem” identified by the inventor; any unexpected results resulting from the chosen solution, which was known in the art; or any industry recognition or praise regarding this particular claimed invention. In fact, others succeeded in designing similar e-cigarette devices well before the inventor of the '881 patent.

365. I am also not aware of any other secondary considerations that weigh against the obviousness of the claims, for example, commercial success or copying. Even if evidence of secondary considerations existed, in my opinion, it would be insufficient to overcome the clear obviousness of the challenged claims of the '881 patent, as explained above.

XV. CONCLUSION

366. In signing this declaration, I recognize that it will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place in the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

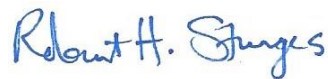
367. The statements and opinions in this declaration comprise and are based upon my review, analysis and understanding of the source materials that I have reviewed as discussed herein, based on the disclosure and statements made within such source materials.

368. I reserve the right to supplement my opinions in the future to respond to any arguments that the Patent Owner raises and to take into account new information as it becomes available to me.

369. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Dated: November 8, 2023

Respectfully Submitted,



Dr. Robert H. Sturges



ROBERT H. STURGES, JR., Ph.D., P.E.

GENERAL:

Education:

S.B.-S.M. Mechanical Engineering (combined degree), M. I. T., June, 1969

Ph.D. Mechanical Engineering, Carnegie Mellon University, December, 1986

Positions Held:

- 1969-1974 Staff Engineer, Charles Stark Draper Laboratories, Cambridge, MA 01239
Mechanical/electrical system design and analysis for the Apollo project

- 1974-1977 Lead Engineer, Westinghouse Electric, R&D Center (R&D), Churchill, PA 15238
Kinematic/mechanical/electrical system design and analysis for product and
process applications.

- 1977-1984 Senior Engineer, Westinghouse R&D
Robotics/teleoperator system design for nuclear fuels and reactor maintenance;
flexible manufacturing system development for industrial applications.

- 1984-1985 Residency year; research in dexterity.

- 1985-1986 Principal Engineer, Westinghouse Productivity and Quality Center (PQC),
Oakdale, PA 15230
Development of design for assembly methods; teaching design for producibility
and statistical process control.

- 1986-1987 Fellow Engineer, Westinghouse PQC
Teaching design for producibility and statistical process control methods, Value
Engineering facilitator.

- 1987-1992 Assistant Professor, Carnegie Mellon University, Department of Mechanical
Engineering

- 1992-1997 Associate Professor, Carnegie Mellon University, Department of Mechanical
Engineering

- 1997-2001 Associate Professor, Virginia Tech, Departments of Mechanical Engineering and
Industrial & Systems Engineering

2001-2017	Professor, Virginia Tech, Departments of Mechanical Engineering and Industrial & Systems Engineering, Director of Robotics and Automation Laboratory
2017---	Professor Emeritus, Virginia Tech, Department of Industrial & Systems Engineering, Adjunct Professor, Department of Mechanical Engineering

TEACHING AND EDUCATION

A. Undergraduate Student Projects:

M. Burke, "Foot-Operated Mouse" 1988
 J. Kalvan, "Balancing Machine" 1988
 J. Kalvan, "Weaving Machine" 1989
 R. Saulnier, "Quincunx" 1990
 M. Pogozielski, "Probability Machine" 1990
 P. Downey, "Review of Design for Assembly Methods," 1990
 C. Wivell, "3-D Displays of Functions" 1991
 A.-C. Kopp, "Generalized 3-D Displays" 1991
 M. Darcy, "Modular Quincunx" 1991
 C. Tesluk, "Hydrofoil Stabilizer for Sailboats" 1991
 A. R. Abid, "Ball Mill Stabilizer," 1991 SURG awardee.
 K. Pogany, "CAD/CAM System" 1992
 S. Radney, "VuMan Shell" 1993
 S. Crouse, "Prototype Flexible Wiring" 1993
 J. Steven, "FMS Programming System" 1993
 D. Fontaine, "Conceptual Design System" 1993
 C. Tesluk, "Variable Attack Wind Turbine," 1993 SURG awardee.
 J. R. Kasperik, "Adjustable Sheetmetal Gripper" 1993
 M. T. Angus, "Bending Press Flexibility Modelling" 1993
 M. Sigrist, "Design of a Table Top NC Mill" 1993
 A. Rose, "Ultra-light Weight Steering System" 1994
 W. Ouyang, "APT Translator for NC Mill" 1994
 P. Klabnik, "Drives and Control for NC Mill" 1994
 K. F. Moser, "Surgical Teleoperator Hand Control" 1994
 T. Bruce, "An Adjustable Gripper for Sheet Metal Handling" 1994
 R. Fenza, "Analysis and Simulation of a Robotic Gripper" 1995
 S. Radney, "Convertible Child Seat" 1995
 R. Sullivan, "Laser-Based DME for Medical Imaging" 1995
 T. Okimoto, "Magnetic Structure for Haptic Interface" 1996
 E. Augustin, "Fuel Injection for Formula Racing Engine" 1997
 M. Abali, "Braking System Design for Formula Racecar" 1998
 D. C. Reubush, "Optimization of Tires for Formula Racecar" 1999
 J. Ballenger, "CAD Modeling of Formula Racecar" 2000
 J. R. Batman, "Directional Drilling" 2003

B. MS Projects Completed:

P. Rao, "Engineered Compliances for Non-symmetric Insertion Tasks," Spring 1990
J.-T. Yang, "Orientation Feature Analysis for Assembly," Fall 1991
N. Pektas, "Stabilization of Nonlinear Computation Circuits" Fall 1992
Omid Rezaia, "Assembly Process Synthesis," May 94.
Dongwon Lee "Design for Disassembly," May 94.
M. DeGuire "Operational Software for Control of Student CNC Milling Machine" Jan 1995
Chris Reider "Robotic Wire Termination," May 1996
H. Bauer, "Massively Parallel Micro Assembly" 1999

C. ME Theses Completed: (please note that at CMU, the terms ME and MS are reversed. Thus, the following works through 1996 are the equivalent of an MS Thesis at VT.)

W. Wang, "Understanding Machineese," 1989
S. Laowatanna, "Physics of Endoscopes," 1990
E. Y. Hershkowitz, "Analog Matrix Inversion," 1991
K. O'Shaughnessy, "Functional Decomposition in Design," 1991
J. H.-W. Wong, "Design for Assembly of Large Components," 1991
M. I. Kilani, "Design for Assembly Reasoning System," 1991
C.-H. Wang, "2D and 3D Models of Bending Processes," 1992
R. G. Reed, "Performance-Intelligent Design Advisors" 1993
D. O. Hunt, "Application of Design for Assembly Theory to Assembly Workstation Design" 1993
C.-S. Chien "Optimization of Bending Processes" 1994
Gita Krishnaswamy "Control for Planetary Rover," 1994
André Butler "Design for Disassembly," 1995
Hong Dao "Reasoning with Functions in Design," 1995
(Winner of the "Bennet Prize" for best ME Project)
Anne-Claire Kopp "Design of Passive Assembly Devices," 1996

MS Theses Completed:

B. Wells, "Control of Multi-unit Tracked Vehicles" 6/99
J. Marehalli, "Optimization of Handling & Gripper Design" 9/99
A. Kanarat, "Modeling & Simulation of Multi-unit Tracked Vehicles" 9/99
V. Aishwarya, "A Software Based Hierarchical Real Time Control System for Rapid Development of Mobile Robot Prototypes", 4/00
S. Wiedmann, "Kinematic Analysis Of Threaded Fastener Assembly In 3 Dimensions", 2/00
Y. Wongwanich, "Fitt's Law Model for Large and Heavy Plates", 9/01
M. Abbott, "Compliance Model for a 6-Dof Robot", 4/02
S. Moutran, "Workspace Analysis for Fiber Placement", 5/02

D. Ph.D. Theses Completed:

S. Laowatanna, "Physics of Rapid Assembly" 6/94
K. Elkins, "Precision Sheet Metal Processes" 8/94

G. Roston, "Genetic Design Methodology for Configuration" 12/94
 K. Sathirakul, "Geometric Modeling of Assembly" 9/97
 V. Ayyadevara, "Algorithmic Planning of the Part Stacking Process" 12/99
 A. Kanarat, "Control of Multi-unit Tracked Vehicles" 5/04
 M. Lee, "Non-Autoclave Processing of Composites" 5/04
 R. Anderson, "A New Approach to Materiel Movement Modeling" 4/06
 J. Choi, "Workspace Modeling for Fiber Placement" 4/06
 G. Chaudhari, "Optimization of Factory Processes"

E. Course Development:

Fall 1988: Developed 7 weeks of new material and introduced 10 "Take Home" Lab Problems for "Manufacturing Sciences" 24-208.

Spring 1990: Introduced "Design for Manufacture" 24-268

Fall 1991: Co-developed "Fundamentals of Mechanical Engineering" 24-101, with Prof. C. Amon
 Featured in *Mechanical Engineering*, Aug, 92

Fall 1992: Started the "24-101 Live Steam Challenge" a distance competition for Freshman with student-designed pint-sized steam powered vehicles.

Fall 1997: Developed 6 weeks of new material and introduced 8 "Take Home" Lab Problems for "Manufacturing Processes" ISE-2204.

Summer 1998: Revised ISE-2204 for "Green Engineering Processes" emphasis, converted course material to web-based format.

Summer 2000: Introduced "Design and Manufacturing Integration" ME/I&SE 5984

Spring 2002: In ME 4524 and ECE 4704: Developed new course pack covering robotics theory and mathematical principles. Developed set of 6 new application lab projects using an industrial robot to build/assemble a working mobile robot.

Fall 2002: In ISE2204: Developed new approach to interactive learning in which all student work is presented orally in lieu of paper-based grading. Indeed, there are no grades at all during the semester, just "competent" or "quality" evaluations, and each student must complete each assignment before proceeding to the next one. The result was gratifying: all students who passed are competent in this subject, and many achieved a depth of understanding that indicates a quality learning experience.

RESEARCH-BASED PUBLICATIONS

A. *Books*: Sturges, Robert H., Jr., 2015, Practical Field Robotics, John Wiley, 1st edition, ISBN 978-1-118-94114-0.

B. *Critically Reviewed Papers*:

Published & Accepted Journal Papers:

j1. Sturges, R.H. 1988. "Analog Matrix Inversion," *IEEE Journal of Robotics and Automation*, Vol 4, No. 2. pp 157-162.

j2. Sturges, R.H. 1988. "A Three Dimensional Assembly Task Quantification with Application to Machine Dexterity," *International Journal of Robotics Research*, Vol 7, No. 4. pp 34-78.

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c75. Junghun Choi, and Robert H. Sturges, "Preliminary Element Design and Analysis of a Smart Endoscope", Flexible Automation & Intelligent Manufacturing, Toronto, Canada, July 12-14, 2004.

c76. Junghun Choi, and Robert H. Sturges, "Design and Simulation of a Smart Endoscope", Intelligent Manipulation and Grasping, Genoa, Italy, July 1-2, 2004.

c77. Junghun Choi, and Robert H. Sturges, "Design and Simulation of a Smart Endoscope: Part 2", ASME International Mechanical Engineering Congress and RD&D Expo ,Anaheim, California, Nov. 13-19, 2004.

c78. Sturges, R. H. , Loos, A, and Viehland, D., "Processing of Composites" Proceedings International Conference On Composites/Nano Engineering , ICCE-10, July 20-26, 2003 New Orelans, LA

c79. Munki Lee, Junghun Choi, and Robert H. Sturges, "Modeling Contact Heat Transfer for Composite Fiber Placement ", Japan-USA Symposium on Flexible Automation, July 19-21, 2004. Denver, CO, *Awarded "Best Paper"*.

c80. Munki Lee, J. Choi, and Robert H. Sturges, "Process Design for Composite Fiber Placement with a Solid Contact Heat Source ", Flexible Automation & Intelligent Manufacturing, Toronto, Canada, July 12-14, 2004.

c81. Anderson, R. and Sturges, R. H., "The Use of Behavior in the Design of Complex Systems" CAD' 04 International CAD Conferences and Exhibitions, May 24-28, 2004. Pattaya, Thailand

- c82. Anderson, R. and Sturges, R. H., "Inherent Behavior in Complex Systems", Japan-USA Symposium on Flexible Automation, Denver, CO, July 19-21, 2004.
- c83. Babiceanu, R. F., F. F. Chen, and R. H. Sturges "The influence of material handling operations on the schedule makespan in manufacturing cell environments" NAMRC 33. 24-27 May 2005, Columbia University, New York
- c84. Musa, R, Sturges, R.H., & Chen F.F. "Process Capability Allocation in the Extended Enterprise Environment" NAMRC 34 (Marquette University, May 23-26, 2006)
- c85. Anderson, R. and Sturges, R. H., "Quantified Behavior as an Optimization Algorithm" CAD'06 International CAD Conferences and Exhibitions, Jun 19-23, 2006. Phuket, Thailand
- c86. Anderson, R. And Sturges, R. H., "Characterization Of Performance, Robustness, And Behavior Relationships In Adaptable Systems", Int'l Symposium On Flexible Automation, Osaka, Japan, July 10-12, 2006.
- c87. Musa, R, Sturges, R.H., & Chen F.F. "Dynamic Variation Reduction Technique in Assembly Lines after Batch Inspection", Int'l Symposium On Flexible Automation, Osaka, Japan, July 10-12, 2006.
- c88. Musa, R. and Sturges, R. H., "Agile Inspection Planning Based on CAD-Data" CAD'06 International CAD Conferences and Exhibitions, Jun 19-23, 2006. Phuket, Thailand
- c89. Sturges, R. H., "A CAD Approach to Upper-Bound Solutions" CAD'06 International CAD Conferences and Exhibitions, Jun 19-23, 2006. Phuket, Thailand
- c90. Musa, R, Sturges, R.H., & Chen F.F. "Comprehensive Inspection Planning for Newly Launched Products in Assembly Lines Using CAD Data" IERC 2006 Orlando, FL, May 20-24, 2006)
- c91. Chaudhari, G.S., Sturges, R.H, Sandu, C., "On the underlying structure of system dynamics models", Proceedings of the 27th International Conference of the System Dynamics Society, Albuquerque, NM (2009).

C. Other Conference Papers (not peer reviewed, or reviewed by abstract):

- a1. Sturges, R.H., 1982. "A Sheet Metal FMS Simulation System," *FABTECH Proceedings*, Chicago, IL, February.
- a2. Sturges, R.H., 1984. "A Wire Harness Flexible Manufacturing System," *Autofact 6 Proceedings*, Anaheim CA, October.
- a3. Sturges, R.H., 1987. "The Design for Assembly Calculator," *EMACTECH Proceedings*, Pittsburgh, PA, May.

- a4. Sturges, R.H., 1989. "Toward Achieving Dexterity in Flexible Assembly Systems," *16th NSF Conf. on Manufacturing Systems*, Arizona State University, Jan 1990.
- a5. Sturges, R.H., 1991. "A Kinematic Approach to Teleoperator Safety," *17th NSF Conf. on Manufacturing Systems*, University of Texas at Austin, Jan 1991.
- a6. Sturges, R.H., 1991. "Workholding and Design for Manufacture," *17th NSF Conf. on Manufacturing Systems*, University of Texas at Austin, Jan 1991.
- a7. Wong, J. H.-W., and Sturges, R.H., 1992. "An Extension of Design for Assembly Methods for Large and Heavy Parts" *18th NSF Conf. on Manufacturing Systems*, Georgia Institute of Technology, Jan 1992.
- a8. Kilani, M. I., and Sturges, R.H., 1992. "Detection and Evaluation of Orientation Features for CAD Part Models" *18th NSF Conf. on Manufacturing Systems*, Georgia Institute of Technology, Jan 1992.
- a9. Sturges, R.H., and Laowattana, S., 1992. "Virtual Wedging in Three Dimensions," *18th NSF Conf. on Manufacturing Systems*, Georgia Institute of Technology, Jan 1992, pub. by SME, NY, NY.
- a10. Sturges, R.H., and Kilani, M. I., 1993. "A Computer-Aided Function Logic Sketchpad," *19th NSF Conf. on Manufacturing Systems*, North Carolina State University, Jan 1993, pub. by SME, NY, NY.
- a11. O'Shaughnessy, K., and Sturges, R.H., 1993. "A Systematic Approach to Conceptual Design," *19th NSF Conf. on Manufacturing Systems*, North Carolina State University, Jan 1993, pub. by SME, NY, NY.
- a12. Sturges, R.H., 1993. "A Computational Model for Conceptual Design," *19th NSF Conf. on Manufacturing Systems*, North Carolina State University, Jan 1993, pub. by SME, NY, NY.
- a13. Sturges, R.H., and Hunt, D., 1993. "Application of DfA Theory to Optimal Assembly Workstation Design," *19th NSF Conf. on Manufacturing Systems*, North Carolina State University, Jan 1993, pub. by SME, NY, NY.
- a14. Sturges, R.H., and Laowattana, S., 1993. "Representations of Rotational and Translational Freedom with Extended Screw Theory," *19th NSF Conf. on Manufacturing Systems*, North Carolina State University, Jan 1993, pub. by SME, NY, NY.
- a15. Sturges, R.H., and Laowattana, S., 1993. "A Voice-Controlled Flexible Device for Endoscopy," *Forum on Medical Robotics and Computer Assisted Surgery*, June 12, 1993, Pittsburgh, PA,
- a16. Wang, C-H., & Sturges, R.H., 1994. "Concurrent Product/Process Design with Multiple Representations of Parts," *20th NSF Conf. on Manufacturing Systems*, MIT, Jan 1994, pub. by SME, NY, NY.

- a17. Sturges, R.H., 1994. "The Function of Value Engineering," *20th NSF Conf. on Manufacturing Systems*, MIT, Jan 1994, pub. by SME, NY, NY.
- a18. Reed, R.G., & Sturges, R.H., 1994. "A Model for Performance-Intelligent Design Advisors," *20th NSF Conf. on Manufacturing Systems*, MIT, Jan 1994, pub. by SME, NY, NY.
- a19. Sturges, R.H., and Laowattana, S., 1994. "A Spatial RCC for Non-Axisymmetric Passive Assembly," *20th NSF Conf. on Manufacturing Systems*, MIT, Jan 1994, pub. by SME, NY, NY.
- a20. Dao, H. & Sturges, R.H., 1995. "Functional Representations of Conceptual and Preliminary Design" *21st NSF Conf. on Manufacturing Systems*, UCSD, Jan 1995, pub. by SME, NY, NY.
- a21. Sturges, R.H., and Hunt, D., 1995. "Detection and Evaluation of Planes of Partial Symmetry in CAD Models," *21st NSF Conf. on Manufacturing Systems*, UCSD, Jan 1995, pub. by SME, NY, NY.
- a22. Sturges, R.H. & Hunt, D.O., 1995. "Reduction of Acquisition Time through New Design for Assembly Heuristics," *21st NSF Conf. on Manufacturing Systems*, UCSD, Jan 1995, pub. by SME, NY, NY.
- a23. Kopp, A.-C., Sturges, R.H., Kalra, A., & Kekre, S., 1996. "Value Implications of Green Design: A Preliminary Progress Report," *22nd NSF Design & Manufacturing Grantees Conf.*, Albuquerque, NM, Jan 1996, pub. by SME, Dearborn, MI.
- a24. Kopp, A.-C., & Sturges, R.H., 1996. "An All-Shear Pad Spatial Remote Center Compliance Design," *22nd NSF Design & Manufacturing Grantees Conf.*, Albuquerque, NM, Jan 1996, pub. by SME, Dearborn, MI.
- a25. Sturges, R.H., & Ayyadevara, V., 1996. "Analysis of Stability of Sheet Metal Parts," *22nd NSF Design & Manufacturing Grantees Conf.*, Albuquerque, NM, Jan 1996, pub. by SME, Dearborn, MI.
- a26. Kopp, A.-C., & Sturges, R.H., 1996. "Prismatic Peg and Hole Assembly Time Tests," *22nd NSF Design & Manufacturing Grantees Conf.*, Albuquerque, NM, Jan 1996, pub. by SME, Dearborn, MI.
- a27. Sturges, R.H., & Sathirakul, K., 1996. "Modelling Multiple Peg and Hole Insertion Tasks," *22nd NSF Design & Manufacturing Grantees Conf.*, Albuquerque, NM, Jan 1996, pub. by SME, Dearborn, MI.
- a28. Sturges, R.H., & Sathirakul, K., 1996. "Compliance Mechanism Design Methodolgy for Passive Assembly," *22nd NSF Design & Manufacturing Grantees Conf.*, Albuquerque, NM, Jan 1996, pub. by SME, Dearborn, MI.
- a29. Sturges, R.H., & Ayyadevara, V., 1997. "Analysis of Stability of Sheet Metal Parts for Automated Part Handling," *Proc. 1997 NSF Design & Manufacturing Grantees Conf.*, Seattle, WA, Jan 7-10, 1997, pub. by SME, Dearborn, MI.

a30. Sturges, R.H., & Sathirakul, K, 1997. "An Analysis of Pen-in-Hole Insertion Tasks: Beyond Chamfer-Crossing," *Proc. 1997 NSF Design & Manufacturing Grantees Conf.*, Seattle, WA, Jan 7-10, 1997, pub. by SME, Dearborn, MI.

a31. Sturges, R.H., & Ayyadevara, V., 1998. "Automated Planning for Stacking of Polyhedral Sheet Metal Parts," *Proc. 1998 NSF Design & Manufacturing Grantees Conf.*, Monterrey, Mexico, Jan 5-7, pub. by SME, Dearborn, MI.

a32. Sturges, R.H., & Sathirakul, K, 1998. "Passive Assembly Approach To Off-Axis Peg-in-Hole Insertion," *Proc. 1998 NSF Design & Manufacturing Grantees Conf.*, Monterrey, Mexico, Jan 5-7, pub. by SME, Dearborn, MI.

a33. Wiedmann, S. & Sturges, R.H., 1999. "Screw Insertion by Passive Assembly," *Proc. 1999 NSF Design & Manufacturing Grantees Conf.*, Los Angeles, CA, Jan 4-6, pub. by SME, Dearborn, MI.

a34. Sainani, M. & Sturges, R.H., 1999. "Review of Robotic Manipulability Measures," *Proc. 1999 NSF Design & Manufacturing Grantees Conf.*, Los Angeles, CA, Jan 4-6, pub. by SME, Dearborn, MI.

a35. Jayavardhan, M., & Sturges, R.H., 1999. "Sensor-Free Robotic Assembly" *Proc. 1999 NSF Design & Manufacturing Grantees Conf.*, Los Angeles, CA, Jan 4-6, pub. by SME, Dearborn, MI.

a36-a49. Fourteen (14) Technical Reports delivered as part of our Phase One activities for ONR, Panama City, FL.

D. Sections or Chapters:

1. Sturges, R.H., 1992. "Reliability and Safety in Teleoperation," book chapter in *Safety, Reliability and Human Factors in Robotic Systems*, James H. Graham, editor, Van Nostrand-Reinhold, January 1992.

2. Sturges, R.H., and Laowattana, S., 1996. "A Voice-Actuated Tendon-Controlled Device for Endoscopy," book chapter in *Computer Integrated Surgery*, R.H. Taylor, ed. MIT Press, pp. 603-617.

E. Abstracts, Reviews: None

F. Other Writings:

Theses:

Sturges, R.H., 1969. "Design Modifications of the ME Braille," SB-SM Thesis, MIT.

Sturges, R.H., 1986. "On Dexterity," Ph.D. Dissertation, Carnegie Mellon University.

Industrial Course Notes:

Dorman, J.G., Sturges, R.H., and Brecker, J.N., 1986. "Design for Producibility,"
©Westinghouse Electric Corp, Westinghouse Productivity and Quality Center, 1986.

Trade Journals:

Sturges, R.H., 1983. "Double the Apple II's Color Choices," *BYTE Magazine*, November, 1983.

CMU Publications:

Sturges, R.H., "Moving Body and Mind: From Industry to University," *CIT*, Summer 1991.

Sturges, R.H., in "Motivating Students," *University Teaching Center Newsletter*, Vol. 1, No. 2,
S. Ambrose, Ed.

Selected Research Report Titles from Westinghouse Electric Corporation:

Please Note: The majority of the author's work between April 1974 and October 1987 is proprietary to the Westinghouse Electric Company and remain in their library. The selection below is representative of these works. Corporate departmental policy regarding listing of author's names on research reports varied. Those titles without named authors for which the candidate is the sole or senior author are denoted with an asterisk.

w1. *"Nuclear Fuel Pellet Inspection Gaging System," MRDD Report 76-8G8-HANFO-R1,
156pp., May 1977.

w2. *"Coupler Hand-Offs in Plug Weld Repair System," 7J41-PLUGR-05C, 13pp, June, 1977

w3. *"Steam Generator Service Arm and Master Manipulator Design Report," 7J42-FOLLO,
36pp, July 1977

w4. *"M/STI SAM Coupler Design Program," 7J42-PRDES, 50pp, Sept 1977.

w5. *"Steam Generator M/STI SAM Coupler System," 7J42-CPLTO, 19pp, Sept 1977.

w6. Sturges, R.H., 1978. "The Structurally-Efficient Manipulator," Westinghouse R&D Center
report 1J43-INHOS-R1.

w7. "Human Factors Assessment of the M/STI SAM Telerobot System" 1J43-FATIG, 70pp,
January 1978.

w8. *"M/STI SAM Design Upgrading Program," 7J43-UPGRA, 80pp, February 1978.

w9. Sturges, R.H., 1980. "Tubesheet Identification and Mapping," Westinghouse R&D Center
report 1J43-TIDMA-R1.

w10. Sturges, R.H., and Gerkey, K.S., 1980. "The Analytical, Experimental, and Design Studies
of General Robotic Manipulators," Westinghouse R&D Center report 1J43-KNUCL-R1.

w11. **“Automated Gaging System Study,”* DQ-153, 35pp, June 1982.

w12. **“Wire Harness FMS Operator's Guide,”* WPQC, 125pp, Sept 1987.

Research Memoranda from C. S. Draper Laboratories:

d1. Sturges, R.H., 1971. *“Teleoperator Arm Design Program Principles of Operation,”* MAT-33, 17 pp, Nov 1971.

d2. Sturges, R.H., 1972. *“Teleoperator Arm Design Progress,”* MAT-53, 11 pp, June 1972.

d3. Sturges, R.H., 1972. *“On the Moving Base Problem,”* MAT-54, 3pp, July 1972.

d4. Sturges, R.H., 1973. *“Singularities and Redundancies of the PaR-3000 Jacobian,”* MAT-80, 5 pp, January 1973.

d5. Sturges, R.H., 1973. *“Six Degree of Freedom End-Effector Design,”* MAT-113, 4 pp, March, 1973.

d6. Sturges, R.H., 1973. *“Work Volume of a Revolute Arm,”* MAT-133, 3pp, May, 1973.

d7. Sturges, R.H., 1973. *“Optimization of Robot Link Parameters for Engine Assembly,”* MAT-145, 5 pp, June 1973.

d8. Sturges, R.H., 1973. *“Wrist Force Sensor Elasticity Analysis,”* MAT-186, 4 pp, Dec, 1973.

d9. Sturges, R.H., 1974. *“Wrist Force Sensor Mechanical Parameters,”* MAT-211, 2 pp, March, 1974.

Research Reports from C. S. Draper Laboratories:

d10. Woodin, A.E., et al. 1972. *“Annual Progress Report for the Development of Multi-Moded Remote Manipulator Systems No. 1,”* C-3901, 146pp, January, 1972.

d11. Woodin, A.E., et al. 1973. *“Annual Progress Report for the Development of Multi-Moded Remote Manipulator Systems No. 2,”* C-3790, 174pp, January, 1973.

d12. Sturges, R.H., 1973. *“Teleoperator Arm Design,”* C. S. Draper Laboratories Report E-2746.

d13. Nevins, J.L., et al., 1974. *“Exploratory Research in Industrial Modular Assembly,”* R-800, 200pp, March, 1974.

d14. Nevins, J.L., et al., 1974. *“A Scientific Approach to the Design of Computer Controlled Manipulators,”* R-837, 180pp, August, 1974.

Other Reports:

- o1. Sturges, R.H., & Nehring, R., 2008. "Process Mapping the LCS-1 IETM," 14 pp., Jan 2008.
- o2. Sturges, R.H., Nehring, R., & Steeneck, D., 2008. "Work Measurement for the LCS-1 IETM," 110 pp., April 2008.
- o3. Sturges, R.H., & Nehring, R., 2009. "Part Mating Science for the LCS-1," 14 pp., May 2009.
- o4. Sturges, R.H., Nehring, R., & Steeneck, D., 2009. "Simple Task Analysis for the LCS-1," 8 pp., June 2009.
- o5. Sturges, R.H., Nehring, R., & Steeneck, D., 2009. "Pareto Analysis for the LCS-1," 15 pp., April 2009.
- o6. Sturges, R.H., & Steeneck, D., 2009. "Simple Task Analysis for the LCS-1," 15 pp., April 2009.
- o7. Sturges, R.H., & Butler, K., 2009. "Materials Handling Analysis for the LCS-1," 14 pp., June 2009.
- o8. Sturges, R.H., & Mayer, B., 2009. "Materials Handling Workshop Results," 18 pp., September 2009.
- o9. Sturges, R.H., & Mead, P., 2009. "Sea State Simulation Theory," 3 pp., November 2009.
- o10. Sturges, R.H., & Steeneck, D., 2009. "Cost-Time Profiling for the LCS-1," 13 pp., September 2009.
- o11. Sturges, R.H., & Showalter, M., 2009. "Sea-State Simulator Design and Control," 66 pp., September 2009.

G. *Discussions:*

"Research Opportunities in Flexible Assembly," Panelist, ASME Design Technical Conferences, 14 Sept, 1992, Scottsdale, AZ

H. *Patents Awarded:*

Title	Number	Date
1. Remote Access Manipulator	4,168,782	09-25-79
2. Photoelectric Docking Device	4,295,740	10-20-81
3. Electromech. Display Apparatus	4,316,189	02-16-82

4. Pellet Inspection Apparatus	4,349,112	09-14-82
5. Surface Flaw Detection	4,377,238	03-22-83
6. Apparatus and method for classifying fuel pellets for nuclear reactor	4,448,680	04-15-84
7. Fuel Transfer Manipulator	4,485,067	11-27-84
8. Vernier Press Brake Die Set	4,489,587	12-25-84
9. Apparatus for Mapping...an Element within a Field of Elements	4,503,506	03-05-85
10. Manipulator ... for Decontaminating Nuclear Steam Generators	4,521,844	06-04-85
11. Wire Routing & Terminating Device	4,862,927	09-04-89
12. Apparatus for Assembly of Axisymmetric and Non-Axisymmetric Rigid Parts	5,396,714	03-14-95
13. Flexible Steerable Device for Exploratory Procedures	5,759,151	09-03-97
14. Method and apparatuses for control of bending operations	5,761,940	06-09-98
15. Method and apparatuses for control of bending operations	6,292,716	09-18-01
16. Automated continuous haulage system	7,076,346	07-11-06

GRANTS AND CONTRACTS

A. Awarded to Date

1. Analog Matrix Inversion, CMU Faculty Grant, \$4,800, 1988-1990, Principal Investigator.
2. Design for Assembly Evaluation, Engineering Design Research Center. NSF Support: \$243,000 from 1988 through 1994. Principal Investigator
3. Development of Smart Endoscopes, Center for Entrepreneurial Development, \$15,000 in-kind; Pittsburgh Roboscope Co., PA, \$17,000 in-kind; Advanced Technology Center of Western PA, \$48,000; and, AT&T Foundation, \$30,000, 1988-1989. Principal Investigator
4. Representation of Aircraft Design Data for Supportability, Operability, and Producibility Evaluations, Boeing Helicopter Company, \$58,000, June 1989 - December 1989. Principal Investigator

5. The Teaching Factory, DARPA, General Motors, \$35,000, 1988-1989. Co-Principal Investigator with Duane Adams (Computer Science), et al.
6. "1990 George Talman Ladd Award," Carnegie Mellon University, \$3,000, 1990.
7. Design for Manufacture of the CMT, U.S. Post Office, Mellon Institute, \$35,000, 1989-1990. Role: Principal Investigator
8. Intelligent Manufacturing Workcell, DARPA, CMU-RI. This co-PI granted \$35,000. Co-Principal Investigator with David Bourne (Robotics)
9. Toward Achieving Dexterity in Flexible Assembly Systems, NSF Research Initiation, \$60,000, September 1989 - August 1990. Principal Investigator
10. Function Logic Models of Design, AT&T Grant to EDRC, \$12,500, 1990-1991. Principal Investigator
11. Research in Rapid Assembly and Part Design, NSF PYI, \$312,500, August 1990 - July 1995. Principal Investigator
12. Design for Manufacture of the CMT, U.S. Post Office, Mellon Institute, \$21,000, 1990. Principal Investigator
13. Mail Flow Analysis, U.S. Post Office, Mellon Institute, \$10,000, 1990. Principal Investigator
14. An Intelligent Bending Workstation, U.S. Amada Corp, \$55,000/year, July 1991 through June 1995. Co-Principal Investigator with D. Bourne (Robotics) and P. Khosla (ECE)
15. Devices for Advanced Laparoscopic Surgery, Mercy Hospital Foundation, \$15,000, September 1991. (Awarded, but withdrawn due to change of personnel at Mercy Hospital.) Principal Investigator
16. Development of Smart Endoscopes, CMU Faculty Development, \$2,000, August 1992. Principal Investigator
17. Value Chain Implications for Green Design, NSF Management of Technological Innovation Program, \$200,000, October 1994 - September 1997. Co-Principal Investigator with S. Kekre and K. Srinivasan (GSIA)
18. Planning Assembly of Sheet Metal Products, U.S. Amada Corp., \$75,000/year, January 1995 through May 1997. Co-Principal Investigator with D. Bourne (Robotics)
19. Grant for research in Design for Manufacture, Westinghouse Electric Corp, \$21,000, December 1994. Principal Investigator
20. Total Passive Automatic Assembly, NSF DMII, May 1995 - April 1998, \$260,000. Principal Investigator

21. Contact State Space: Automatic Generation, Reasoning and Search, NSF CISE/IRI: Robotics and Machine Intelligence, Sept. 1997-Aug 1999, Grant No. GPG/NSF 95-27, \$225,000. Co-PI (\$78,000) with Dr. Jing Xiao, PI, of UNC-Charlotte.
22. Mobile Bridge Carrier Guidance, Long-Airdox Corp. and Virginia CIT, Aug 1998-July 1999. \$200,000. Principal Investigator
23. Green Engineering Curriculum Development, VT, Aug 1998-May 1999. \$5,000. Principal Investigator
24. Environmentally Conscious Manufacturing, VT ReachOUT, Oct 1998-June 1999. \$7,500. Principal Investigator
25. Continuous Miner and Battery Haulage Design, Long-Airdox Corp. and Virginia CIT, Aug 1999-July 2000. \$200,000. Principal Investigator
26. Continuous Haulage and Battery Haulage Analysis & Manufacturing, Long-Airdox Corp. and Virginia CIT, Aug 2000-July 2001. \$80,000. Principal Investigator
27. Non-Autoclave Composite Materials and Structures, NASA, through UNO/NCAM program, June 2001-March 2002. \$389,000. Co-PI (\$122,530)
28. Pre-Fabricated Steel Building Analysis, Future Steel Ltd., Ont. Canada, \$27,900. Principal Investigator
29. Center for High Performance Manufacturing, Virginia CTRF, July 2001-2004. \$4.35 million, one of 12 co-PI's (\$77,161)
30. Advanced Weapons Elevator, Newport News Shipbuilding, March 2002-December 2002. \$370,000. Co-PI with Virginia Consortium for Material Handling and logistics, (\$50,000)
31. Non-Autoclave Composite Materials and Structures, NASA, through UNO/NCAM program, June 2002-March 2003. \$200,000. Co-PI (\$65,000)
32. Continuous Haulage and Battery Haulage Analysis & Manufacturing, DBT America, Jan 2002-May 2003. \$12,500. Principal Investigator
33. Nat'l Center for Advanced Manufacturing/NASA, "Non-Autoclave Processing And Manufacture Of Large Reusable Aerospace Structures", co-PI with Al Loos, et al. (VT ESM), This co-PI responsible for \$65,300 in Year 3 (July 03-March 04) due to cut-back in the program from original levels.
34. Center for High Performance Manufacturing, Virginia CTRF, July 2001-2004. \$4.35 million, one of 12 co-PI's (\$77,161)
35. CHPM Company Project: Bristol Compressor, PI, \$49,875. (Aug 03-Feb 04)
36. CHPM Company Project: DBT Hillsville, PI, Aug 25 '03, \$25,025. (Aug 03-Dec 03)

37. CHPM Company Project: Federal-Mogul, co-PI 25%, \$27,975 + \$12,102 cost sharing. (July 03-Dec 03)

38. DBT America, Pulaski Division, "Control of REACH System Vehicles," 2 projects initiated. 15 Aug 03, PI, \$24,180; and 1 Jan 04, PI, \$30,677. (Aug 03-Jun 04)

39. International Technologies of Pittsburgh, two gifts of \$10,000 each, in December, 2003, and in April '04 "to support Professor Robert H. Sturges's research and laboratory work in Engineering Design and Manufacturing Processes."

40. CHPM Center Project: PI, \$48,736 "Process Mapping and Cost-Time Profiling in Support of Lean Manufacturing". (July 04-July 05)

41. Titan Corp. PI, \$110,000 "Designing and Defending Against Swarming Behavior", (Aug 04-May 05)

42. NSF, "Embodiment Awareness" Sub Fund \$45,000; supporting Francis Quek, PI

43. CHPM Project "Strain Model" \$8,000, PI, for Metalsa Corp.

44. Nat'l Center for Advanced Manufacturing/NASA, "Non-Autoclave Processing And Manufacture Of Large Reusable Aerospace Structures", co-PI with Romesh Batra, et al. (VT ESM), responsible for \$22,000 in Year 5 (July 05-March 06).

45. Concoa, Inc., "New Product Design & Development", PI, \$48,812 from Concoa, \$26,765 State match, total = \$75,487.

46. ONR, "Meeting Mandated Manning Requirements Through Effort Leveling", PI, \$1,577,418; co-PI's Thurmon Lockhart and Roger Anderson; responsible for \$981,318. (Jan 08-May 09)

47. ONR, "Meeting Mandated Manning Requirements Through Effort Leveling: Phase 2", PI, \$745,404; co-PI Thurmon Lockhart; responsible for \$372,702. (Jan 10-May 11)

48. TEMCI, "New Product and Process Development for SVI", PI, \$80,000; responsible for \$80,000. (June 2011, May 2012)

49. TEMCI, "Second Product and Process Development for SVI", PI, \$80,000; responsible for \$80,000. (June 2012, May 2013)

Total as PI: \$4,556,069; Total in Research Projects \$8,216,822 (Nov 1987 - present)

B. Proposals Pending total requested in FY 2011 = \$880,000.

PROFESSIONAL ACTIVITIES

A. Short Courses:

1. "Design for Quality in Manufacturing," for the Carnegie Bosch Institute, Advanced Program for Technical Managers, 8 class contact hours: August 1991.
2. "Manufacturing Concerns in Design," for the Carnegie Bosch Institute, Advanced Program for Technical Managers, 12 class contact hours: August 1992.
3. "Design for Manufacture," for the Carnegie Bosch Institute, Advanced Program for Technical Managers, 12 class contact hours: August 1993.
4. "TQM and Design for Manufacture," for the Korean/GSIA Management Institute, Program for Technical Managers, 9 class contact hours: August 1995.
5. "Excellence in Manufacturing," for the Executive Education Network (EXEN) with CMU Graduate School of Industrial Administration, 3 class hours by direct satellite, with 2-way audio interaction. February 1996.
6. "Management of Technological Information," for the Executive Education Network (EXEN) with CMU Graduate School of Industrial Administration, 3 class hours by direct satellite, with 2-way audio interaction. March 1996.
7. "Excellence in Manufacturing," for the Executive Education Network (EXEN) with CMU Graduate School of Industrial Administration, 3 class hours by direct satellite, with 2-way audio interaction. April 1997.
8. "Design For Assembly Workshop: Theory and Practice," for Long-Airdox Company, one day session, Blacksburg, Virginia, June, 1999
9. "Value Analysis Workshop: 8-16 UniHauler," for Long-Airdox Company, eight weekly 4-hour sessions, Blacksburg, Virginia, Aug.-Sept., 2000
10. "Design for Manufacture and Assembly," for ABB, Ltd. one day sessions presented at Pine Tops, NC; Brno, Czech Rep.; Ratingen, Germany; Nashik, India; Cairo, Egypt; Sao Paulo, Brasil. 2004 - 2005

Seminars:

1. "Design for Assembly Methods," CMU Robotics Institute Colloquium, August, 1985.
2. "Robotic Dexterity," Ben Franklin Institute, May, 1986.
3. "Human and Machine Dexterity," CMU Mechanical Engineering Department Graduate Seminar, October, 1986.
4. "Design for Producibility." METAC Symposium, January, 1989.
5. "Dexterity for Automated Assembly," Ohio State University Mechanical Engineering Graduate Seminar Series, invited speaker, Nov 1989.

6. "Workholding and Design for Manufacture," CMU Robotics Institute, April, 1990.
7. "Design For Assembly: Theory and Practice," Ohio State University Mechanical Engineering Graduate Seminar Series, invited speaker, May 1990.
8. "Design for Manufacture," Lord Corporation, Erie, PA, November, 1990.
9. "A Flexible Tendon-Controlled Device for Endoscopy," CMU Robotics Institute, March, 1991.
10. "Functional Process Planning for DfM," CMU Robotics Institute, October, 1991.
11. "Information Content in Design for Manufacture," CMU Engineering Design Research Center Seminar Series, November, 1991.
12. "Design for SMED in Sheet Metal Fabrication," CMU Engineering Design Research Center Seminar Series, March 5, 1992.
13. "Design for Manufacture," CMU Post College Professional Education Program for Technical Managers, March 20, 1992.
14. "Single-Minute Bending Set-Ups with a Vernier Punch and Die Set," CMU Robotics Institute, March 31, 1992.
15. "Design for Manufacture: Is There Any Other Way?" CMU College of Fine Arts Seminar Series, April 20, 1992.
16. "Applications of Symmetry to Sheet Metal Part Design and Manufacture," CMU Robotics Institute, June 23, 1992.
17. "Getting the Design Process Started," CMU Engineering Design Research Center Seminar Series, June 24, 1992.
18. "Flexible Assembly Systems," for the EC Researchers, EC/US Collaboration on Advanced Manufacturing, at EDRC, October 27, 1992.
19. "An Advisor for Designing a Process and a Process for Designing an Advisor," CMU Engineering Design Research Center Seminar Series, DfM Lab, 9 Feb 1993.
20. "Passive Assembly," CMU Mechanical Engineering Department Graduate Seminar, November, 1993.
21. "Design For Assembly: Product and Process," Ohio State University Mechanical Engineering Graduate Seminar Series, invited speaker, April 1994.
22. "Automating the Planning of Sheet Metal Products," CMU Robotics Institute, May 23, 1994.

23. "Assembly Strategy 2000," EARN Program Speaker, 25 May, 1994. Also presented at the Production Engineering Research Labs of Hitachi, Ltd., Himeji, Japan, 18 July 1994.
24. "Design for Manufacture: Myths and Realities," CMU Mechanical Engineering Department Graduate Seminar, April, 1995.
25. "Passive Assembly," University of Pittsburgh Mechanical Engineering Department Graduate Seminar, October, 1995.
26. "Getting it All Together: Modern Manual and Machine Assembly Measurement," SPQA, Virginia Forum for Excellence, Workshop 6, April 29, 1998, Richmond, VA.
27. "Modern Optimization Methods in Design," invited seminars at KMIT, Thonburi, and KMUT, Ladkrabang, Bangkok, Thailand, 2006.
28. "Collaborative Automotive Design" for International Co-op program with IESTM, Monterrey Mexico, Fall 2007.
29. "Robotic Safety Considerations" for ASSE, Roanoke, VA, 5 March 2010.
30. "The Next Killer App" for ISE Department, VT, 21 October 2011.

Videotape Productions:

- "Design for Manufacture," 10:00, June 1986.
- "Design for Assembly Calculator," 16:15, July 1986.
- "Voice-controlled Flexible Endoscope," 2:35, June 1989.
- "Smart Endoscope Development at CMU," 4:25, Feb 1991.
- "Model Mail Culler Demonstration," 3:32, April, 1991.
- "24-101 Introduction," 11:00, August, 1991.
- "24-101 Lecture Series," approx 6 hours, April 1992.
- "Spatial Remote Center Compliance," 4:10, September 1992.
- "24-101 Live Steam Challenge," Part I, 4:02, October 1992.
- "24-101 Live Steam Challenge '92," Part II, 3:50, December 1992.
- "Passive Assembly," 10:30, November, 1993.
- "Flexible Gripper for Sheetmetal Handling," 2:50, December, 1994.
- "Rational VHS Cassette Design," 5:00, April 1995.
- "Passive Assembly of Multiple Pegs and Screws," 4:00, July, 1996.
- "This is ISE Manufacturing," 35:20, August, 2000
- "Shop Hobbing," 18:10, September 2008
- "Sea-State Simulator Platform" 4:00, October 2010
- "TruTrac Model Operation" 18:00, February 2012

B. Government Committees:

1. "NSF Workshop on Computer Assisted Surgery," 28 Feb - 2 Mar 1993, Wash. DC, Plenary Session Speaker.
2. NSF DDM Proposal Review Panel, April 27-28, 1993, Wash. DC.

3. NSF DMII Proposal Review Panel, April 25-26, 1995, Wash. DC.
4. NSF IIS Proposal Review Panel, September 1998, remote.

C. Memberships:

Sigma Xi, Member.

ASME, Member

IIE, Member

Westinghouse Engineer's Society, President 1978.

D. Editorial Roles:

Reviewed Papers for:

Advances in Engineering Software

AI EDAM

ASME Design Theory & Methodology Conferences

ASME Japan-USA Conf. on Flexible Automation

ASME Journal of Engineering for Industry

ASME Journal of Engineering Materials and Technology

ASME Journal of Mechanical Design

ASME Manufacturing Review

Computing Systems in Engineering

FAIM Transactions

IEEE Control Systems Society

IEEE Expert

IEEE International Robotics and Automation Conferences

IEEE Trans. on Control Systems Technology

International Journal of Robotics Research

Journal of Computer Aided Design

Mechatronics

International Journal of Solids and Structures

Journal of Engineering Design

E. Professional Awards:

Professional Engineer, Commonwealth of Pennsylvania, certificate number PE-041434-E, Jan 1991.

"1990 George Talman Ladd Award," recognizing excellence in research for a young faculty member, Carnegie Mellon University.

"1990 Presidential Young Investigator," National Science Foundation.

"B.G. Lamme Fellowship," Westinghouse Electric Corp., 1984.

"Silver Signature Award," Westinghouse Electric Corp., 1983, for the development of the Wire Harness Flexible Manufacturing System.

“Engineering Achievement Award,” Westinghouse Productivity and Quality Center, Oakdale, PA, 1982, for the development of the Mobile Interactive Terminal.

“Dean’s Teaching Excellence Award,” Virginia Tech, April 2005.

F. Service/Committees:

CMU:

- Manufacturing Strategy Task Force (1988-91)
- Xerox CMU Challenge TQM Program (June 1992)
- Interdisciplinary Design MS Program Planning Committee (1992)
- Faculty Development Committee (1992-93)
- MSMEM Degree Program Development (1992-93)
- Multidisciplinary MS Design Program Development (1992)
- ESL Oral Examinations Workshop (1994)

Carnegie Institute of Technology, Mechanical Engineering:

- Departmental Undergraduate Committee (1988-89)
- Departmental Seminar Program Coordinator (1988-89)
- Departmental Graduate Committee, Graduate Applications Coordinator (1989-90), Design Curriculum Subcommittee Coordinator (1990, 1991), Qualifying Exam Coord (93)
- Departmental Faculty Search Committee (1989-90, etc.)
- Departmental Freshman Course Committee (1990-91, 94-95)
- Departmental Undergraduate Committee (1993-95)

VPI&SU, Industrial & Systems Engineering:

- Awards Committee (1997-2004)
- Undergraduate Honor Board Panelist (2000-2008)
- Graduate Honor Board Panelist (2007-2008)
- AdHoc P&T Committee (2004-2005)

VPI&SU, Mechanical Engineering:

- Formula SAE Team Advisor (1998-2000)
- Graduate Program Committee (1999-2001)

VPI&SU, College/University:

- Engineering Faculty Organization, member (1998-present)
- Engineering Faculty Organization, Chair (2001-present)
- College of Engineering Commencement Committee, General Marshall
- College of Engineering Green Engineering Program Steering Committee
- College of Engineering Undergraduate Curriculum Committee
- Commission on Undergraduate Curriculum
- Commission on Undergraduate Studies And Policies
- Intellectual Property Committee

IEEE: Session Chair “Integration and CAD/CAM,” *Third Int’l Conf. on Computer Integrated Manufacturing*, RPI, Troy, NY, May 1992.

ASME:

1. Session Chair, "Machining and Manufacturing Processes," *ASME 18th Design Automation Conference*, Scottsdale, AZ, Sept. 15, 1992
 2. Panelist, "Research Opportunities in Flexible Assembly," *ASME 18th Design Automation Conference*, Scottsdale, AZ, Sept. 14, 1992
 3. Session Chair, "Concurrent Engineering," *ASME 19th Design Automation Conference*, Albuquerque, NM, Sept. 20, 1993
 4. Program Committee, *Japan-USA Symposium on Flexible Automation*, Boston, MA, July, 1996.
 5. ASME Student Design Contest Committee, 1997-2000.
 6. Program Committee, and Session Chair, *3rd ASME-DFM Conference*, Atlanta, GA, Sept. 13-16, 1998.
 7. Conference Chair, *4th ASME-DFM Conference*, Las Vegas, NV, Sept. 12-14, 1999.
 8. Program Committee, and Session Chair, *5th ASME-DFM Conference*, Baltimore, MD, Sept. 11-13, 2000.
 9. ASME DFM Committee, Vice Chair, 1999-2001
 10. Program Committee, *Japan-USA Symposium on Flexible Automation*, Denver CO., July, 2004.
 11. Session Chair CAD' 04 International CAD Conferences and Exhibitions, May 24-28, 2004. Pattaya, Thailand
 12. Session Chair CAD' 06 International CAD Conferences and Exhibitions, Jun 19-23, 2006. Phuket, Thailand
- SME: Student Section Advisor, 2007-2009, 2009,-2011

Other:

"NSF Workshop on Computer Assisted Surgery," 28 Feb - 2 Mar 1993, Wash., DC.
Plenary Session Speaker.

"First Int'l Symposium on Medical Robotics and Computer Assisted Surgery,"
Pittsburgh, PA, 22-24 Sept 1994, Program Committee.

Mentor in "The LiNC Project": a joint research effort on behalf of the National Science Foundation Networking Infrastructure for Education program between Virginia Tech and Montgomery County Public Schools, Spring 1999.

Mentor for International Co-op program with IESTM, Monterrey Mexico, Fall 2007, Spring 2008.

Mentor for student team in the Roanoke Valley Governor's School, project on "Hyper-miling" any late-model car with an OB2 connector and an iPod. Fall 2010.

Panelist for AAAS proposals, 2105.