UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

R.J. Reynolds Vapor Company,

Petitioner

v.

Fontem Holdings 1 B.V.

Patent Owner

U.S. Patent No.: 9,456,632
Issue Date: October 4, 2016
Title: Electronic Cigarette

Inter Partes Review No.: IPR2018-00634

DECLARATION OF DR. ROBERT H. STURGES REGARDING U.S. PATENT NO. 9,456,632

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I. INTRODUCTION

A. Engagement

1. I have been retained by the law firm of Brinks Gilson & Lione on behalf of R.J. Reynolds Vapor Company to provide this Declaration concerning the technical subject matter relevant to the *inter partes* review petition concerning U.S. Patent No. 9,456,632 ("632 patent"; Exhibit 1001).[1] I have been asked to render an opinion regarding the validity of claims 14-16 and 18 (the "challenged claims").

B. Background and Qualifications

2. I retired from Virginia Polytechnic Institute ("Virginia Tech") on September 1, 2017 after 20 years' service as a Professor in the Departments of Mechanical and Industrial Systems Engineering at Virginia Tech. I look forward to moving from "Retiree" status to "Emeritus" status in the next few months. I am still substantially involved with the University in several ways. I am working on two projects with current Ph.D. level graduate students and maintain an on-campus office with all office privileges and a discretionary spending account. I also maintain laboratory space for projects on campus and at Virginia Tech's Corporate Research Center. Prior to joining Virginia Tech, I was first an Assistant Professor

[1] I refer to exhibit numbers that correspond to those I understand will be submitted with the Petition for *Inter Partes* Review.

and then later an Associate Professor in the Mechanical Engineering Department at Carnegie Mellon University in 1987-1997. I have a combined Bachelor of Science and Master of Science degree in mechanical engineering from M.I.T. and a Ph.D. in mechanical engineering from Carnegie Mellon University.

3. 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.

4. 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.

5. My most recent Curriculum Vitae, including my publications and patents, is submitted herewith in Appendix A.

C. Compensation and Prior Testimony

6. I am being compensated at a rate of $400 per hour for my study and time in this matter. I am also being reimbursed for reasonable and customary expenses associated with my work and time in this investigation. My compensation is not contingent on the outcome of this matter or the specifics of my testimony.

7. The list attached at Appendix B identifies my past expert engagements.

D. Information Considered

8. My opinions are based on my years of education, research, and experience, as well as my investigation and study of relevant materials. In forming my opinions, I have considered, among other things, the 632 patent and its prosecution history, as well as the record of the five prior IPRs (IPR2015-00859, IPR2015-01587, IPR2016-01268, IPR2016-01303 and IPR2016-01532) involving U.S. Pat. No. 8,365,742 ("742 patent"), the parent of the 632 patent, the record of the four prior IPRs (IPR2016-01641, IPR2016-01691, IPR2016-01692 and IPR2017-00204) involving U.S. Pat. No. 9,326,548 ("548 patent"), the child of the 632 patent, in addition to the prior art and other materials referred to herein.

9. I may rely upon these materials and/or additional materials to rebut arguments raised by the patent owner.

10. I reserve the right to supplement this Declaration in response to additional evidence that may come to light.

II. LEGAL STANDARDS FOR PATENTABILITY

11. In expressing my opinions concerning the subject matter of the claims of the 632 patent, I am relying upon certain legal principles that counsel has explained to me.

12. It is my understanding that, to anticipate a claim under 35 U.S.C. § 102, a prior art reference must teach every limitation of the claim.

13. It is also my understanding that a claimed invention is unpatentable under 35 U.S.C. § 103 as being obvious if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art ("PHOSITA") to which the subject matter pertains. I also understand that the obviousness analysis takes into account factual inquiries including the level of ordinary skill in the art, the scope and content of the prior art, and the differences between the prior art and the claimed subject matter. I also understand that the prior art reference should be viewed as a whole.

14. I understand that in considering whether an invention is 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 person having ordinary skill in the art. I also understand that other principles may be relied on in evaluating whether a claimed invention would have been obvious, and that these principles include the following:

- Combining prior art elements according to known methods to yield predictable results is likely obvious;
- Simple substitution of one known element for another to obtain predictable results is likely obvious;
- Use of a known technique to improve similar devices (methods, or products) in the same way, using the technique is obvious unless its actual application is beyond the level of skill in the art;
- Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results is likely obvious;
- "Obvious to try" - choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;

- Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art;
- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention may demonstrate obviousness, but proof of obviousness does not depend on or require showing a teaching, suggestion, or motivation to combine;
- Market demand, rather than scientific literature, can drive design trends and may show obviousness;
- In determining whether the subject matter of a patent claim would have been obvious, neither the particular motivation or avowed purpose of the named inventor controls;
- One of the ways in which a patent's subject matter can be proved obvious is by noting that there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims;

- Any need or problem known in the field of endeavor at the time of the invention and addressed by the patent can provide a reason for combining the elements in the manner claimed;
- "Common sense" teaches that familiar items may have obvious uses beyond their primary purposes, and in many cases a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle;
- A person having ordinary skill in the art is also a person of ordinary creativity, and is not an automaton; and
- One should be cautious of using hindsight in evaluating whether a claimed invention would have been obvious.

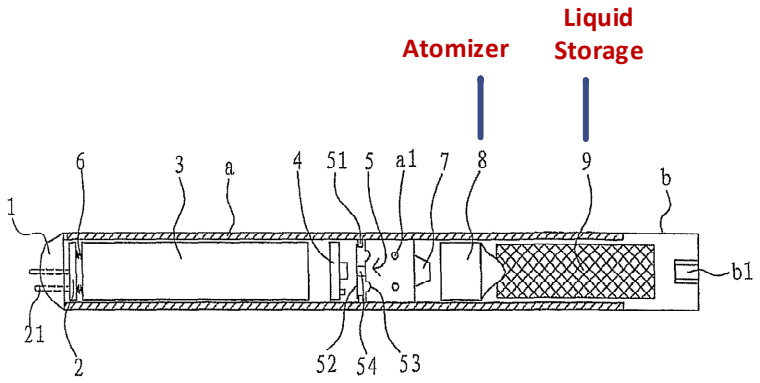
15. In determining obviousness, I understand that evidence of objective indicia of non-obviousness (also known as "secondary considerations") is also considered and that this is to be done before any ultimate determination of obviousness is made. I have been advised that the following factors may be considered as secondary considerations: (1) a long-felt and unmet need in the art for the invention; (2) failure of others to achieve the results of the invention; (3) commercial success of the invention; (4) copying of the invention by others in the field; (5) whether the invention was contrary to accepted wisdom of the prior art; (6) expression of disbelief or skepticism by those skilled in the art upon learning of

the invention; (7) unexpected results; (8) praise of the invention by those in the field; and/or (9) commercial acquiescence (licensing).

16. I also understand that, in order for secondary considerations to be relevant to the issue of obviousness, a patentee must establish a nexus between such secondary considerations and the claimed invention. Stated one way, the nexus requirement means that the secondary consideration is sufficiently derived from merits of the claimed invention, rather than other factors. I understand that if the patentee comes forward with a showing of one or more secondary considerations and the required nexus, then the burden of coming forward with evidence in rebuttal shifts to the party challenging the patent. Additionally, a party asserting invalidity may come forward with evidence of the absence of such secondary considerations or nexus. Further, it is my understanding that evidence of secondary considerations does not always overcome a strong showing of obviousness.

III. OVERVIEW AND BACKGROUND OF THE 632 PATENT

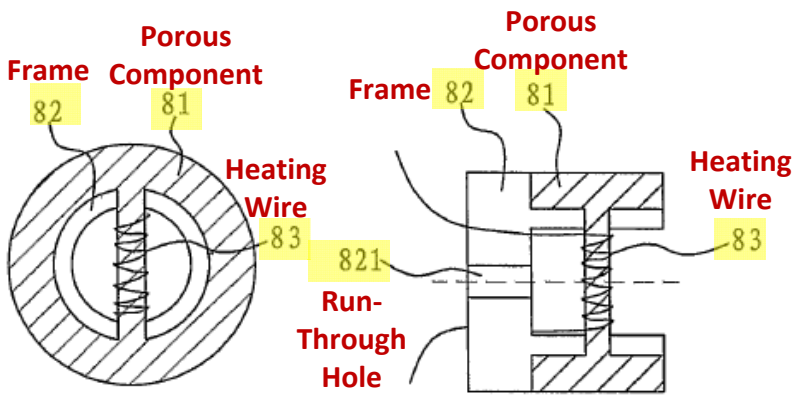
17. The 632 patent discloses an electronic cigarette.



Ex. 1001 at Fig. 1 (Annotated)

18. With respect to Figs. 1 and 10 of the 632 patent, the electronic cigarette includes an operating indicator 1, a battery 3, an atomizer assembly 8, a restriction component 10 and a liquid storage 9. Ex. 1001 at 2:51-63, 2:65-3:1, 3:28-30, 4:5-7, 5:23-34, Figs. 1, 10. The electronic cigarette also includes a shell (a) which is hollow and integrally formed. *Id.* at 2:51-54. The battery assembly connects with said atomizer assembly and both are located in said shell (a). *Id.* at 2:54-56. The shell (a) has through-air-inlets (a1). *Id.* at 2:58-59, Fig. 1. A porous component of the atomizer assembly 8, *i.e.*, protuberance/bulge 812, contacts the liquid storage 9 of the detachable bottle assembly shell (b) "to achieve the capillary impregnation for liquid supply." *Id.* at 3:38-44, 4:5-20, 62-65.

19. Further details of the atomizer assembly 8 are illustrated in annotated Figs. 17 and 18, which are reproduced below. *Id.* at Figs. 17-18.



Ex. 1001 at Figs. 17-18 (Annotated)

20. The atomizer assembly includes "a frame (82), the porous component (81) set on the frame (82), and the heating wire (83) wound on the porous component (81). The frame (82) has a run-through hole (821) on it. The porous component (81) is wound with heating wire (83) in the part that is on the side in the axial direction of the run-through hole (821). One end of the porous component (81) fits with the cigarette bottle assembly." *Id.* at 6:1-10.

21. Claims 14-16 and 18 are the subject of my opinion. Claims 14-16 and 18 are reproduced below:

14. A vaporizing device, comprising:

a battery assembly and an atomizer assembly within an elongated cylindrical housing with the battery assembly electrically connected to the atomizer assembly;

a liquid storage component in the elongated cylindrical housing;

with the elongated cylindrical housing having one or more air inlets;

the atomizer assembly including an atomization chamber having a front end opening and a back end opening to allow air to flow into the atomization chamber from the front end opening and out from the back end opening; and

a heating wire coil wound on a porous component that is perpendicular to a longitudinal axis of the elongated cylindrical housing, with the heating wire coil in an air flow path between the front end opening and the back end opening of the atomization chamber.

15. The device of claim 14 with the atomization chamber having a uniform diameter along the length of the atomization chamber.

16. The device of claim 14 with the heating wire coil having an outer diameter less than an inner diameter of the atomizing chamber.

18. The device of claim 14 further including a restriction component between the hollow cylindrical component and the at least one air inlet, with the restriction component having a restriction hole smaller than the open front end of the hollow cylindrical component.

IV. PERSON HAVING ORDINARY SKILL IN THE ART

22. I understand that the 632 patent must be reviewed through the eyes of a person having ordinary skill in the art (*i.e.*, a "PHOSITA"). I understand that the PHOSITA is presumed to know the relevant prior art. I am advised that that factors that guide the determination of level of ordinary skill in the art may include: the education level of those working in the field, the sophistication of the technology, the types of problems encountered in the art, the prior art solutions to those problems, and the speed at which innovations are made may help establish the level of skill in the art.

23. It is my opinion that relevant and related art for the claims of the 632 patent includes, among other things, electromechanical devices with the ability to atomize liquids and deliver an aerosol to a user. Further, it is my opinion that the PHOSITA for the 632 patent is a person with at least the equivalent of a Bachelor's degree in electrical engineering, mechanical engineering, or biomedical engineering or related fields, along with at least 5 years of experience designing electromechanical devices, including those involving circuits, fluid mechanics and heat transfer. I base my opinions on my review of the 632 patent, the relevant prior art, including art disclosing electronic cigarettes that atomized a nicotine solution to deliver an aerosol to a user to simulate smoking, and my background in designing and developing systems that apply heat transfer and fluid mechanics.

24. For purposes of my opinions as set forth in this Declaration, I have asked to apply the perspective of the PHOSITA as of May 2006. As of this date, I would have qualified as one of skill in the art according to the above definition.

25. I understand that in other IPR proceedings, PO and its expert represented that a PHOSITA for related patents would be a person with a mechanical or electrical engineering degree, industrial design degree, or similar technical degree, or equivalent work experience, and 5-10 years of working in the area of electromechanical devices, including medical devices. This PHOSITA proposed by the PO in those proceedings is not significantly different from my definition of a PHOSITA. Further, my opinion would not change if this level of skill were applied.

V. CLAIM CONSTRUCTION

26. It is my understanding that, in an *inter partes* review proceeding, the terms of the challenged claims should be given their broadest reasonable interpretation, as understood by the PHOSITA and consistent with the disclosure of the 632 patent. I understand that, where a patent applicant provides an explicit definition of a claim term in the specification, that definition may control the interpretation of that term in the claim. I also understand that if no explicit definition is given to a term in the patent specification, the claim terms must be evaluated using the ordinary meaning of the words being used in those claims. I

also understand that the words in the claims are to be evaluated using the perspective of a person of ordinary skill in the art. I have applied this standard to my understanding of the claims and the discussion of the prior art below.

27. In conducting my analysis, I have considered the terms used in claims 14-16 and 18 the 632 patent and what they mean. In my analysis, I have applied a meaning to the terms as they would have been understood by the PHOSITA.

28. I understand that the Board previously interpreted the term "housing" in the parent 742 patent and child 548 patent to be not limited to a one-piece shell in IPR2016-01532 and IPR2016-01691, respectively. Ex. 1017, Institution Decision dated Feb. 7, 2017 at pp. 7-9 (Paper 9), *R.J. Reynolds Vapor Co. v. Fontem Holdings 1 B.V.*, IPR2016-01532 (P.T.A.B., petition filed Aug. 5, 2016); Ex. 1018, Institution Decision dated Mar. 6, 2017 at pp. 6-8 (Paper 9), *R.J. Reynolds Vapor Co. v. Fontem Holdings 1 B.V.*, IPR2016-01691 (P.T.A.B., petition filed Aug. 30, 2016). For purposes of my analysis, I have used the Board's interpretation for the term "housing."

VI. DESCRIPTION OF THE PRIOR ART THAT FORMS THE BASIS FOR UNPATENTABILITY

A. State Of The Art By 2006

29. Electronic cigarettes ("e-cigarettes") were well-known before 2006. In fact, they have been known since the 1980s, as demonstrated by, for example, U.S. Pat. No. 4,947,874 ("Brooks," Ex. 1003). Moreover, the basics of the

technology involved in e-cigarettes have been known since at least the 1930s. *See, e.g.,* Ex. 1004, U.S. Pat. No. 2,057,353 ("Whittemore") at p. 1, 1:50-2:8 (disclosing an electronic vaporizing unit utilizing a porous wick/heating wire coil design).

30. By 2006, much was known about e-cigarettes and the variety of ways they could be designed. *See e.g.,* Ex. 1003, Brooks at Abstract (disclosing "[s]moking articles [that] employ an electrical resistance heating element and an electrical power source to provide a tobacco-flavored smoke or aerosol and other sensations of smoking"); Ex. 1005, U.S. Pat. No. 5,894,841 ("Voges") at 5:48-50, Figs. 1-2 (disclosing a "nicotine dispenser comprising a cigarette-shaped hollow tubular body"); Ex. 1008, U.S. Pat. No. 6,155,268 ("Takeuchi") at 1:3-4 (disclosing a flavor generating device for "enjoying simulated smoking.").

31. As of 2006, a PHOSITA would have understood that an e-cigarette is generally designed to replicate the function and some of the experience of a conventional, combustible cigarette. An e-cigarette provides an aerosol that contains constituents such as nicotine and optionally flavors. A PHOSITA would have appreciated that e-cigarettes can come in different shapes and sizes, and that conventional drug delivery device technology, such as inhalers, vaporizers, nebulizers, etc., can be used to deliver nicotine and flavors. *See, e.g.,* Ex. 1003, Brooks at 3:15-29; Ex. 1005, Voges at 3:7-15, 9:53-10:21.

32. E-cigarettes differ from combustible cigarettes in the way aerosols are formed. In combustible cigarettes, the aerosol is largely formed by the heat created by the combustion of tobacco. An e-cigarette generally is a device for electrically generating an aerosol from nicotine liquid solution for subsequent inhalation by the smoker. The aerosols typically contain nicotine and a carrier as well as flavoring or other desired ingredients. The e-cigarette therefore generally includes three main parts: a means to store the liquid, a heating means for creating the aerosol and/or vapor from the liquid, and a power source, which is typically a battery. In addition, the e-cigarette also includes an inhalation means that enables the user to inhale the aerosols/vapor on demand.

33. By 2006, there were several known means to store liquid in vaporizers and e-cigarettes. Among the earliest known means was to store and/or transport the liquid in porous/fibrous bodies positioned inside the device. *See, e.g.,* Ex. 1004, Whittemore at p. 1, 1:50-2:18; Ex. 1009-00021-24, Chinese Pat. No. 2719043Y ("Hon 043," including certified translation) (disclosing a "solution storage porous body 28" comprising "polypropylene fiber, terylene fiber or nylon fiber," among other materials.).

34. Common techniques for converting liquid into aerosols included using heating and/or piezoelectric elements. These components can be located in the atomizer so as to contact the liquid directly or indirectly. It was also known that

these elements can be used independently or combined together to convert liquid into aerosols. *See, e.g.,* Ex. 1005, Voges at 3:62-4:33, 6:24-30, 10:52-63; Ex. 1008, Takeuchi at Figs. 3-7; Ex. 1009-00024-25, Hon 043 at 10:28-11:2, 11:16-18. One common method of creating aerosols was to utilize heaters, with low thermal mass and sufficient capacity to deliver the needed heat, to rapidly vaporize the liquid. Such heaters were able to rapidly reach temperatures and vaporized the immediately surrounding liquid while power was applied, and then rapidly cooled to stop the vaporization process once the power was turned-off. *See, e.g.,* Ex. 1003, Brooks at 5:38-62.

35. It would also have been well-known to a PHOSITA that heating elements came in different shapes, such as coiled heating wire coils, straight wire coils or rods, thin film wires, plates, etc. As a general matter, selecting any particular shape over another would have been a matter of obvious design choice. *See, e.g.,* Ex. 1003, Brooks at 1:19-32, 2:7-18, 2:36-3:14, 13:20-30; Ex. 1004, Whittemore at Figs. 2-3; Ex. 1008, Takeuchi at Figs. 1-7, 10-11, and 15; Ex. 1009-00011, Hon 043 at Fig 6.

36. Widespread knowledge about the materials and shapes of the heating elements advantageously allowed a skilled person to design and manufacture a low-cost and robust e-cigarette in the desired form. Furthermore, and as shown in the cited prior art references, a skilled person would have known that widely

known orientation, location, and structure of these elements allowed most efficient design of an e-cigarette based on several criteria, such as maximizing the contact of the heating or piezoelectric element with the liquid material, maximizing efficiency of an e-cigarette, minimizing air flow obstruction, etc. Therefore, it would have been obvious to a skilled person to replace, combine, orient, or locate them in any manner that suits a particular e-cigarette design, and a skilled person would have recognized and found it obvious that each of these could be selected, utilized, and applied with straightforward, predictable results.

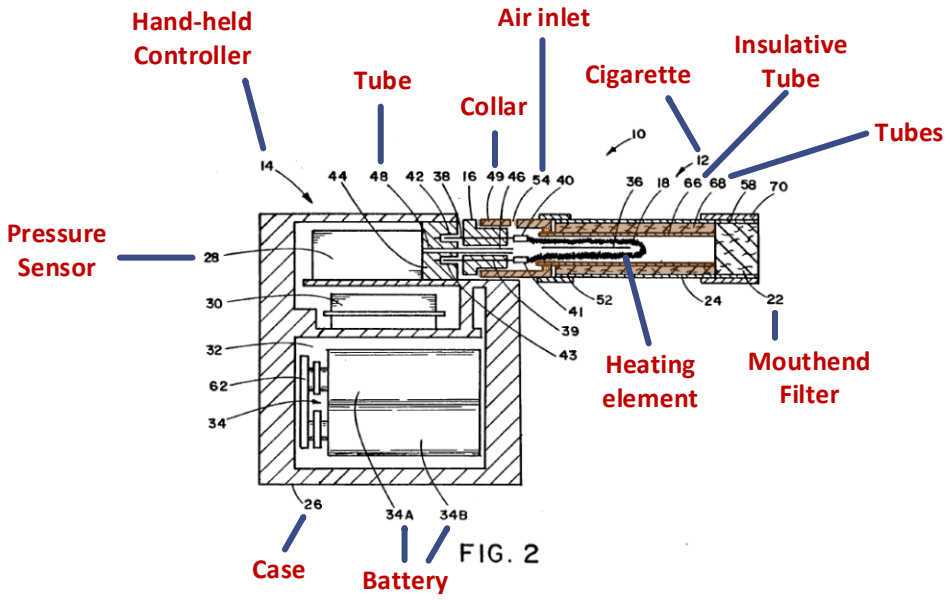
37. Heater coils were particularly well-understood in the art of electronic vaporization devices, and were known to provide high power density and efficient and uniform heating. *See, e.g.*, Ex. 1010, U.S. Pat. No. 5,743,251 ("Howell") at 11:20-22 ("The wire was wrapped in a fashion that produced close tight coils to insure good heat transfer to the tube."); *see also* Ex. 1003, Brooks at 1:64, 2:40-43, 3:4-6. It was similarly well-known to apply this feature of heater coils by wrapping it around a porous material to generate vapor or aerosol (whether for inhalation or other purposes) from liquid being transported due to capillary action within the porous material. *See* Ex. 1004, Whittemore at p. 1, 1:53-2:18; Ex. 1011, U.S. Pat. No. 2,461,664 ("Smith") at 20:36-40; Ex. 1012, U.S. Pat. No. 3,234,357 ("Seuthe") at 4:73-75.

B. Brooks (Ex. 1003)

38. Brooks is titled "Smoking Articles Utilizing Electrical Energy" and discloses "cigarettes and other smoking articles such as cigars, pipes, and the like, which employ an electrical resistance heating element and an electrical power source to produce a tobacco-flavored smoke or aerosol." Ex. 1003, Brooks at 1:6-10. The "Background of the Invention" section explains that many smoking articles and tobacco substitute smoking materials had been proposed in the past as alternatives to smoking products that burn tobacco, including alternatives that generate flavored vapor and/or visible aerosols. *Id.* at 1:19-34. These alternatives included smoking products, flavor generators and medicinal inhalers that utilized electrical energy to vaporize or heat a volatile material, or which otherwise attempted to provide the sensation of cigarette or pipe smoking without burning tobacco. *Id.* at 1:51-56. According to Brooks, "[p]referred smoking articles of the invention are capable of providing the user with the sensations of smoking (e.g., smoking, taste, feel, satisfaction, pleasure, and the like) by heating but not burning tobacco . . . ." *Id.* at 1:11-15; *see also* 3:63-4:2. Accordingly, Brooks discloses an "electronic cigarette," since it is an electronic device that simulates at least some aspects of the experience of smoking.

39. Brooks discloses a smoking article 10 that includes a hand-held controller 14 and cigarette (*e.g.*, a disposable portion) 12 (*see id.* at 4:7-12; 7:15-

16) as shown in Fig. 2.



Ex. 1003, Brooks at Fig. 2 (Annotated)

40. "The cigarette 12 includes electrical connection plug 16, resistance heating element 18 carrying an aerosol forming substance, a roll of tobacco 20, mouth end filter 22, and a resilient overwrap 24." Ex. 1003, Brooks at 7:17-20. The aerosol forming substance can be, for example, "a polyhydric alcohol, such as glycerin, propylene glycol, or a mixture thereof, water; a tobacco material such as tobacco aroma oil, a tobacco essence, a spray dried tobacco extract, a freeze dried tobacco extract, tobacco dust, or the like, in order to provide tobacco flavor; or a combination thereof." *Id.* at 8:8-14.

41. The smoking article also "includes one or more peripheral air inlet openings 54 which provide a flow of ambient air through the cigarette during draw." Ex. 1003, Brooks at 8:43-52. "Alternatively, the air inlet can be positioned

through the extreme inlet end of the cigarette or elsewhere through the periphery of the cigarette, such that drawn ambient air passing through the cigarette to the mouth of the user passes the resistance element." *Id.* at 8:53-57.

42. The hand-held controller 14 includes "a case 26, a puff actuated current actuation mechanism 28 having the form of a pressure sensitive switch, a time-based current control circuit 30, and a chamber 32 into which battery power supply 34 (shown as batteries 34A and 34B) is inserted." Ex. 1003, Brooks at 7:20-25. The case 26 provides "a convenient and aesthetic holder for the user. The outer housing 26 can have a variety of shapes and can be manufactured from plastic, metal, or the like." *Id.* at 9:37-41. The controller can take on many different forms including a cigarette holder and a pipe. *Id.* at 4:46-49. In addition, the controller 14 has a receptacle 44 that "includes tube 48 which is inserted into passageway 46 of plug 16 to be in airflow communication with the internal region of the cigarette. The other end of tube 48 is in airflow communication with pressure sensing switch 28, so that changes in air pressure which occur within the cigarette during draw can be sensed by the switch." *Id.* at 9:41-50. The control circuit 30 is connected to the puff actuated, differential pressure sensitive switch 28 as well as to batteries 34A and 34B. *Id.* at 9:51-55.

43. The Brooks disposable portion 12 includes an "electrical resistance heating element" for generating aerosol from the aerosol forming and/or tobacco

flavor substances. *Id*. at 4:7-12. Because disposable portion 12 includes the components of the device that generate aerosol or vapor, it acts as an "atomizer assembly."

44. Brooks discloses several heating element alternatives. *See,* Ex. 1003, Brooks at 7:48-8:3 ("***Preferred resistance heating element*** include carbon filament yarns … ***Other preferred heating elements*** include carbon felts and activated carbon felts … ***Other suitable heating elements*** include porous metal wires or films; carbon yarns, cloths, fibers, discs or strips; graphite cylinders, fabrics or paints; microporous high temperature polymers having moderate resistivities; ***porous substrates in intimate contact with resistance heating components; and the like***.").[2]

45. In the preferred embodiment, the heating element 18 "is impregnated with or otherwise carries the aerosol forming substance in order that the aerosol forming substance is in a heat exchange relationship with the electrical heating element." *Id.* at 8:4-8. In a *different* embodiment, Brooks discloses that "other

[2] All emphasis added unless otherwise noted.

suitable heating elements" can be "porous ***metal wires***[3] or films; carbon yarns, cloths, ***fibers***." *Id.* at 7:65-68. Another embodiment is described as "a porous substrate in intimate contact with resistance heating components." *Id.* at 8:1-2. A PHOSITA would have understood that this alternative "intimate contact" embodiment necessarily includes a separate porous substrate (that holds at least some liquid to be vaporized) and a separate resistance heating component that is touching the substrate for several reasons. First, in the Background of The Invention section, Brooks describes Whittemore which is an example of a resistance heating component (*i.e.*, filament coil) in intimate contact with a separate porous substrate (*i.e.*, the wick). *Id*. at 1:57-61. Second, the word "contact" means the "union or junction of two surfaces." Ex. 1013 (*Contact,* Merriam-Webster's Collegiate Dictionary (11th ed. 2003)). If the resistance heating component and porous substrate were not two distinct and separate parts,

[3] Brooks also discloses in the Background of The Invention section that resistance heating coils were well-known for heating tobacco or aromatic substances in electrical smoking articles. Ex. 1003 at 1:62-66 ("U.S. Pat. No. 2,104,266 to McCormick proposed an article having a pipe bowl or cigarette holder which included a ***resistance coil*** (i) wound on an insulating and heat resisting material,"), 2:36-43, 2:67-3:14.

then use of the word "contact" in the specification would make no sense because common sense dictates that something cannot be in (intimate) contact with itself.

46. Moreover, a PHOSITA would further have understood that the "intimate contact" embodiment includes a separate porous substrate and separate resistance heating component based on the claims which distinguish between the preferred embodiment and the "intimate contact" embodiment. Specifically, I note that claims 53, 104, and 131 require "an electrical heating element" and "an aerosol forming substance" without any requirement that the aerosol forming substance be carried by the electrical resistance heating element. Ex. 1003, Brooks at claims 53, 104 and 131. In contrast, claims 57, 105 and 132 depend from claims 53, 104 and 131, respectively, expressly add the limitation that the "aerosol forming substance is carried by the heating element prior to use." *Id.* at claims 57, 105, and 132. A PHOSITA would have understood that the independent claims cover *both* the "intimate contact" embodiment and the preferred embodiment where the aerosol is carried by the heating component whereas the dependent claims cover only the preferred embodiment. Indeed, there is no other distinction between the independent and dependent claims. *Id.* at claims 53, 57, 104, 105, 131 and 132. Also in contrast to claims 53, 104, and 131, the resistance heating elements recited in claims 1, 26 and 75 all require that there be an "aerosol forming substance carried by the [electrical resistance] heating element prior to use." *Id.* at

claims 1, 26 and 75. This difference relating to the electrical resistance heating element recited in claims 53, 104, and 131 (*i.e.*, not required to carry the aerosol forming substance) as compared to the electrical resistance heating element in 1, 26, 57, 75, 105 and 132 (*i.e.*, required to carry the aerosol forming substance prior to use) makes clear that the "intimate contact" embodiment includes a separate porous structure and resistance heating components, and is different from the preferred embodiment where the heating element carries the aerosol forming substance prior to use. A PHOSITA would have understood that this difference in the claims is consistent with the written description of the Brooks specification teaching that the aerosol forming substance can be located either "on the resistance heating element *or elsewhere in the article*." *Id*. at 6:45-52. A PHOSITA would have understood that "elsewhere in the article" would have included, *inter alia*, the porous substrate of the "intimate contact" embodiment.

47. In Fig. 2, Brooks discloses that the heating component is housed within concentric tubes - insulative tube 66 and plasticized cellulose acetate tube 68. Ex. 1003, Brooks at 11:6-19, Fig. 2. Collar 49 provides additional housing at an end of the cigarette. Collar 49 and tube 68 together form a housing for the atomizer assembly (i.e., an atomizer assembly housing). In Figs. 4-6, the heater is oriented perpendicularly to the longitudinal axis of the disposable portion 12. *See also, id*. at claims 11, 36, 54, 135 (reciting "wherein the heating element is

positioned substantially perpendicularly to the longitudinal axis of the air passageway.") The housing is identified by the collar 49 and overwrap 24 secured to the collar. *Id.* at 8:47-50, Fig. 4.

48. In operation, a person inhales on the mouthpiece of the device, which creates a pressure drop in the device. The pressure drop is detected by "puff actuated control switch 28" and electrical current subsequently runs through the heating element. *See, e.g.*, Ex. 1003, Brooks at 12:47-57. The electrical current is controlled by a timing means. The timing means regulates current flow to the heating element. *Id*. at 13:62-14:2; *see also id.* at 13:20-30, 14:3-16, 16:32-35, Figs. 9-10, claims 161-202.

49. The current applied to the heating component causes the liquid in the porous material to vaporize. *Id.* at 10:34-58. The vaporized liquid is then inhaled by the person through mouthend filter 22. *Id.* at 10:48-53. In one embodiment, the heating element extends along the length of the cigarette as shown in Figure 2:

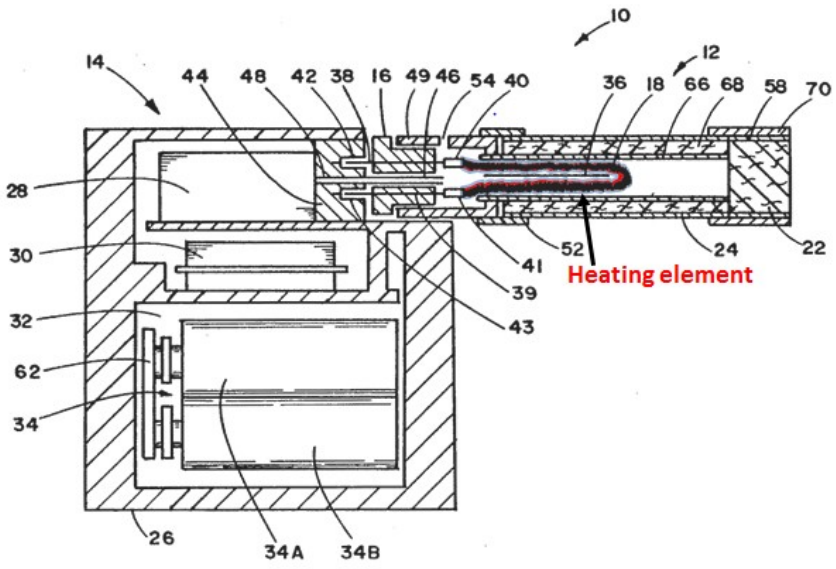


FIG. 2

Ex. 1003, Brooks at Fig. 2 (Annotated)

50. In another embodiment, the heating element extends perpendicularly to the length of the cigarette as shown in Fig. 5:

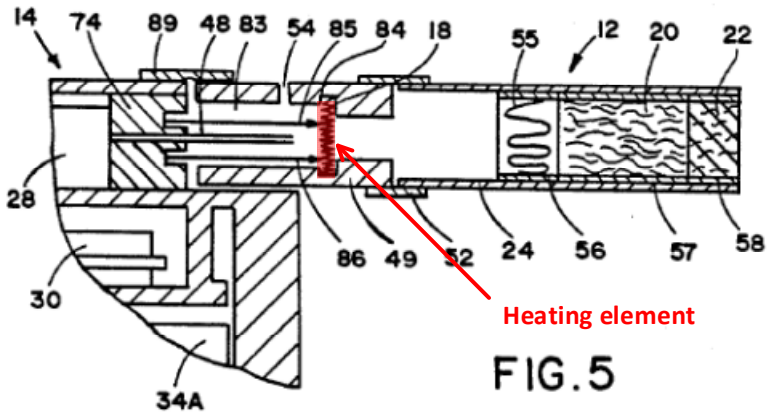


FIG. 5

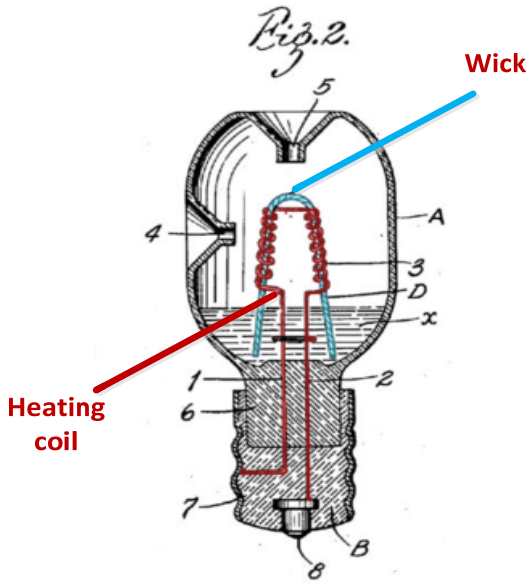
Ex. 1003, Brooks at Fig. 5 (Annotated)

In fact, several claims confirm that the heating element is "positioned substantially perpendicularly" to the longitudinal axis of the air passage way. Ex. 1003, Claims 11, 36, 54, 135.

51. In summary, Brooks discloses an electronic cigarette with an "intimate contact" embodiment where the liquid is stored in a porous substrate where it is converted to aerosol by a resistance heating component that is in contact with a separate porous substrate. The device is divided into two major parts that are electrically and mechanically connected in several different ways, while also facilitating airflow.

C. Whittemore (Ex. 1004)

52. Whittemore discloses a vaporizing unit, which is illustrated in annotated Fig. 2 of Whittemore below. Ex. 1004 at Fig. 2.



53. A vaporizing vessel A is "adapted to hold a liquid medicament *x* and provided with an electrically-operated heating means comprising two electrical conductors 1 and 2 and a filament or heating element 3 combined in such a way that when said conductors are energized by an electric current, the filament 3 will

become heated." Ex. 1004, Whittemore at p. 1, 1:18-28. Whittemore also discloses a wick D around which the heating element 3 is wrapped. According to Whittemore, "a wick D made of any suitable material and combined with the heating element or filament 3 in such a way that a portion of said wick is always in contact or approximate contact with the heating element or filament 3, and a portion of said wick is always in contact with the medicament in the vaporizing vessel, whereby said medicament will be carried by capillary action to a point where it will be vaporized by the heat from the filament 3." *Id.* at p. 1, 1:54-2:8. Whittemore also includes an air inlet orifice 4 and a vapor outlet 5. *Id.* at p. 1, 1:31-33.

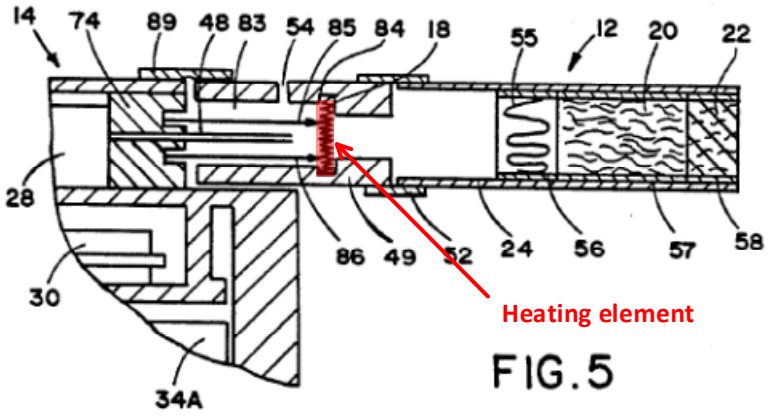
VII. CLAIMS 14-16 AND 18 OF THE 632 PATENT ARE OBVIOUS

A. Motivation For Combining Brooks With Whittemore

54. It is my opinion that each of claims 14-16 and 18 of the 632 patent is obvious based on the combination of Brooks and Whittemore.

55. In my opinion, Brooks by itself discloses or at least renders obvious "a heating wire coil wound on a porous component," as recited in claim 14 of the 632 patent. Brooks discloses that the heating element can constitute a "metal wire," and further discloses that the heating element can constitute a resistance heating component in "intimate contact" with "porous substrates." Ex. 1003 at 7:65-8:3. As explained above, a PHOSITA would have understood that the heating

component and porous substrate are distinct components. Indeed, if the resistance heating component and porous substrate were not distinct components, then they could not be in intimate contact. Brooks consistently depicts the heating component so that it takes the form of a coil:



Ex. 1003, Brooks at Fig. 5 (Annotated)

56. Further, others in the field have described the Brooks device as including an "electrical resistance coil." *See* Ex. 1014, U.S. Pat. Pub. No. 2004/0234916 ("Hale") at ¶[0004] (describing the heating element in U.S. Pat. No. 4,922,901 (Ex. 1015), which is substantially identical to Brooks discussed in this declaration (Ex. 1003), as an "electrical resistance coil"). In addition, Brooks confirms that the use of heater coils was well known as it mentions several other references that include heater coils. *See* Ex. 1003, Brooks at 1:62-66, 2:40-43, 3:4-6. Accordingly, in my opinion, a PHOSITA would have understood that the Brooks heating component could take the form of a heating wire coil, which as explained, was well known. Thus, a PHOSITA would have understood and

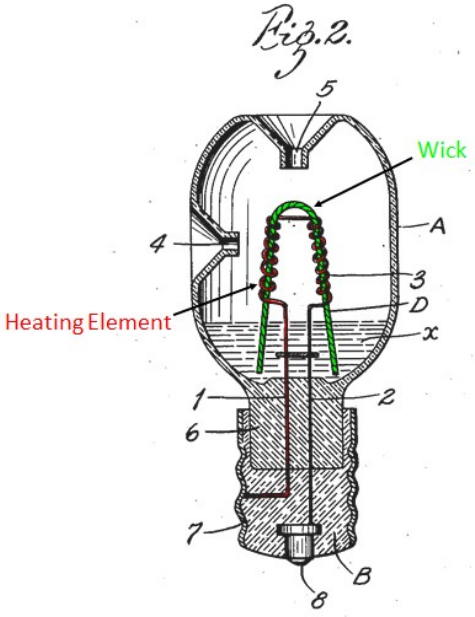
recognized that the embodiment disclosed as using a heating component in "intimate contact" with a porous substrate would have included a resistance heating wire coil wound around the porous substrate.

57. Even if Brooks did not itself disclose a heater wire wound on a porous component, it would have been obvious to a PHOSITA to modify the Brooks device so that "intimate contact" is obtained by coiling the resistance heating component it discloses around the porous substrate in view of the above suggestions in Brooks and in view of the teachings of Whittemore. Whittemore describes a heater wire wound around a porous component. Specifically, Whittemore describes a wick D made of thread or string that is surrounded by "coiled or looped portions" of a "filament 3," which acts as a heater when electric current is run through it:

> …the unit is equipped with a wick D made of any suitable material and combined with **the heating element or filament 3** in such a way that a portion of said wick is always in contact or approximate contact with the heating element or filament 3, and a portion of said wick is always in contact with the medicament in the vaporizing vessel, whereby said medicament will be carried by capillary action to a point where it will be vaporized by

the heat from the filament 3. In the form of my invention shown in Figure 2, **the wick D consists of a thread, string or stand [sic] of some suitable wick material** doubled intermediate its ends so as to form a substantially inverted V- shaped device whose **side portions are encased in and surrounded by coiled or looped portions of the filament 3**, the lower ends or free ends of the side pieces of the wick projecting downwardly into the medicament and terminating at or in close proximity to the closed bottom 6 of the vessel A.

Ex. 1004, Whittemore at p. 1, 1:53-2:18; *see also id*. at p. 2, 1:49-50 (claiming a "porous wick entwined in the filament").

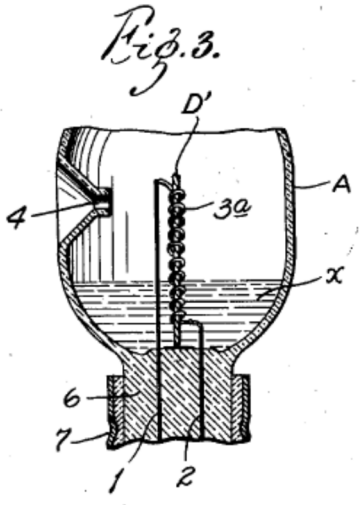


Ex. 1004, Whittemore at Fig. 2 (Annotated)

58. Whittemore's Fig. 3 similarly discloses that a coil wound around a wick is used:

> Figure 3 illustrates another form of my invention, in which **the filament or heating element 3 is constructed in the form of a single vertically-disposed coil attached to the electrical conductors 1 and 2, and arranged so as to surround a wick D** whose lower end terminates in close proximity to the inner face of the bottom 6 of the vaporizing vessel up through which the conductors 1 and 2 project.

Ex. 1004, Whittemore at p. 1, 2:26-34.



Ex. 1004, Whittemore at Fig. 3

59. Whittemore describes wick D as a "porous wick." Ex. 1004, Whittemore at p. 2, 1:49-52. Accordingly, Whittemore discloses that a heater wire coil (filament 3) is wound around a porous component (wick D).

60. In view of these disclosures and to the extent that Brooks did not already disclose or render obvious a heating wire coil "wound around" a porous component, in my opinion it would have been obvious to a PHOSITA to adapt Brooks to include such a structure in view of the teachings of Whittemore.

61. A PHOSITA would have known and been aware of the technique of winding a heating wire or coil around a liquid container to generate vapor as it has been used since well before the claimed priority date of the 632 patent. *See, e.g.,* Ex. 1016, U.S. Pat. No. 1,084,304 ("Vaughn") (filed Jan. 27, 1913) at p. 2, 1:39-43 ("As the current thus passes through the resistance heating coil 13, such coil will be heated and the medicinal compound *a* within the interior of the container 16 will be heated so that a vapor will be generated…"). A PHOSITA also would have known about winding a heater wire or coil around a porous material such as a wick to generate vapor as it also was used well before the claimed priority date of the 632 patent, as Whittemore itself demonstrates. *See* Ex. 1004, Whittemore at p. 1, 1:53-2:18. A PHOSITA would also have been aware of other prior art references showing that winding a heater wire around a porous wick has long been a conventional way of generating vapor. Ex. 1011, U.S. Pat. No. 2,461,664

("Smith") (filed Aug. 30, 1941) at 6:33-40, 20:26-40 (claims 51 and 52 *e.g.,* claiming a "fume generating toy" in which the heating element "comprises loops of a coil of electrical resistance wire and the said capillary feeder comprises a stretch of wick passing axially through said coil of wire"); Ex. 1012, Seuthe (filed Oct. 29, 1962) at 4:73-75 ("The wire 71 is advantageously coiled around a wick or mandrel 63 which is easily wetted.").

62. As noted previously, Brooks also describes how well-known heating coils were in the art by identifying "coil" heaters in three references reviewed in the background of the technology section. *See* Ex. 1003, Brooks at 1:62-64 ("U.S. Pat. No. 2,104,266 to McCormick proposed an article having a pipe bowl or cigarette holder which included ***a resistance coil***…"), 2:40-43 ("In supplemental West German Patent Application No. 2,704,218, Kovacs described the use of a vacuum or draw-actuated switch to switch 'on' the ***battery operated heating coil***."), 3:4-6 ("The article resembled a cigarette holder and reportedly included a ***battery operated heating coil*** to heat an untipped cigarette inserted therein.").

63. Thus, even if it were determined that Brooks does not disclose a distinct heating element that is separate from but in "intimate contact" with a porous substrate, the claims of the 632 patent are nevertheless obvious over the combination of Brooks and Whittemore. As noted above, it would have been obvious to substitute Whittemore's coiled heating wire/wick configuration for

Brooks' heating element. This would be the substitution of a known element (Whittemore's coiled heating wire/wick configuration) for Brooks' heating element to achieve the predictable result of holding and atomizing liquid. Indeed, given how well-established the practice of using a heating wire coil wound around a porous component was in the art, in my opinion applying Whittemore's teaching in this respect to Brooks would simply amount to the application of a known technique (winding a heater wire coil around a porous component) to a similar structure (the resistance heating component in contact with a porous substrate that Brooks discloses). The predictable result would be the transport of liquid aerosol forming substance via capillary action from the porous substrate to the resistance heating component where the liquid aerosol forming substance is held and vaporized; the same transporting and vaporizing function that the porous wick D/heating coil wire 3 configuration performs in Whittemore.

64. Moreover, a PHOSITA would also have been motivated to use a heating wire coil wound around a porous component in the Brooks device because coiled heater wires were known in the art to promote efficient heat transfer. The prevalence of heater coils in vaporization devices is due in large part to their effectiveness in promoting uniform and efficient heat transfer in relatively small volumes. *See* Ex. 1010, Howell (filed May 15, 1996) at 11:20-22 ("The wire was wrapped in a fashion that produced close tight coils to insure good heat transfer to

the tube."); Ex. 1012, Seuthe at 4:73-5:2 (stronger heating effect obtained by winding heater coil around wick in tighter coils).

65. A PHOSITA would have understood that using Whittemore's efficient wick/coil would have been consistent with Brooks' desire to have efficient heating. Thus, Whittemore's configuration is consistent with Brooks' emphasis on the importance of rapid and efficient heating:

> Preferred heating elements normally have low mass, low density, and moderate resistivity, and are thermally stable at the temperatures experienced during use. ***Such heating elements heat and cool rapidly, and thus provide for the efficient use of energy***. Rapid heating of the element also provides almost immediate volatilization of the aerosol forming substance.

Ex. 1003, Brooks at 7:34-40 (emphasis added). Accordingly, a PHOSITA would have known and understood that use of Whittemore's thermally efficient wire wrapped wick is consistent with Brooks' goal of efficient use of energy. Further, a PHOSITA would have known that the wick in Whittemore extends beyond the heating coils, so it can be filled with more fluid (or extend into a liquid reservoir) than the liquid impregnated heating element of Brooks. Accordingly, a PHOSITA

would have been motivated to combine the wick with more fluid from Whittemore with Brooks.

66. Moreover, modifying Brooks with Whittemore's heating coil wire/wick configuration would not have destroyed the operation of the smoking article of Brooks. To the contrary, and as noted above, a PHOSITA would have expected that the proposed modification would provide for efficient heating of the liquid solution.

67. Accordingly, for all of the reasons I have set forth above, in my opinion it would have been obvious for a PHOSITA to adapt the heating component Brooks discloses (*i.e.,* the resistance heating component in intimate contact with a porous substrate that I have discussed above) such that the heating component in intimate contact with the porous substrate (as Brooks already discloses) is obtained by winding the heating component around the porous substrate in coil form (as Whittemore teaches through its filament wound around a porous wick). Such a modification would have been consistent with and not have interfered with the operation of the Brooks device. Indeed, it would have predictably resulted in a heating component that efficiently vaporizes liquid stored in the porous substrate.

B. The Prior Art Discloses Every Element of Claims 14-16 And 18

68. As illustrated in the claim chart below, the combination of Brooks and Whittemore discloses every limitation of claims 14-16 and 18. As a result, given the motivations and reasons to combine references I have described above, claims 14-16 and 18 are unpatentable as obvious under 35 U.S.C. § 103.

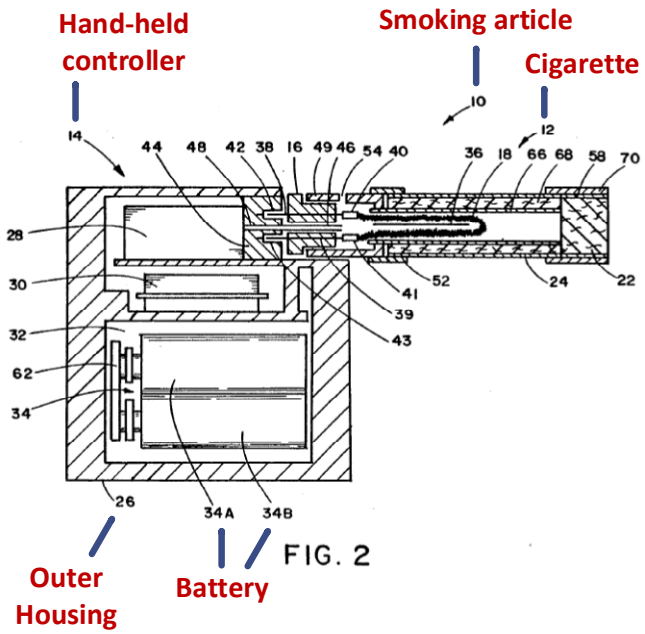
69. Below is a claim chart explaining where and how the preamble language "A vaporizing device, comprising" is disclosed.

Claim 14.[a]	Brooks and Whittemore
14.[a] A vaporizing device, comprising:	I do not believe that the preamble is a claim limitation, but even if I assume it is for purposes of my evaluation, Brooks discloses a vaporizing device. Brooks is directed to "[s]moking articles [that] employ an electrical resistance heating element and an electrical power source to provide a tobacco-flavored smoke or aerosol and other sensations of smoking." Ex. 1003, Brooks at Abstract; *see also* 6:45-52, 10:45-53. **Brooks**: "Smoking articles employ an electrical resistance heating element and an electrical power source to provide a tobacco-flavored smoke or aerosol and other sensations of smoking." Ex. 1003 at Abstract. "The present invention relates to cigarettes and other smoking articles such as cigars, pipes, and the like, which employ an electrical resistance heating element and an electrical power source to produce a tobacco-flavored smoke or aerosol." *Id.* at 1:6-10. "As used herein, and only for the purposes of this application, "aerosol" is defined to include vapors, gases, particles, and the

Claim 14.[a]	Brooks and Whittemore
	like, both visible and invisible, and especially those components perceived by the user to be "smoke-like," generated by action of heat from the resistance heating element upon aerosol forming substances and/or tobacco flavor substances located on the resistance element or elsewhere in the article." *Id.* at 6:45-53. "As a result, the heating element experiences an increase in temperature which in turn heats and volatilizes the aerosol forming substance. The volatilized aerosol forming substance mixes with the drawn air and forms an aerosol. The volatilized aerosol forming substance (in aerosol or vapor form) passes through the tobacco roll 20 where it elutes tobacco flavor from the tobacco, and exits the mouthend filter 22 into the mouth of the user." *Id.* at 10:45-53.

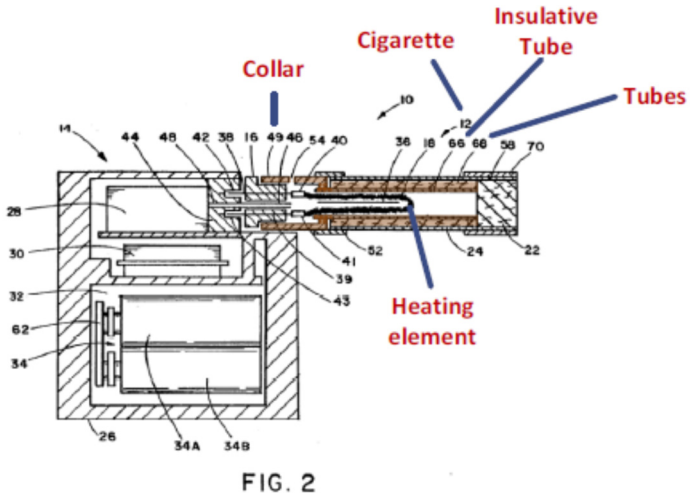
70. Below is a claim chart explaining where and how the claim language "a battery assembly and an atomizer assembly within an elongated cylindrical housing with the battery assembly electrically connected to the atomizer assembly" is disclosed.

Claim 14.[b]	Brooks and Whittemore
14.[b] a battery assembly and an atomizer assembly within an elongated cylindrical housing with the battery assembly electrically connected to the atomizer	Brooks discloses "a battery assembly and an atomizer assembly within an elongated cylindrical housing with the battery assembly electrically connected to the atomizer assembly." Specifically, as shown in annotated Fig. 2 below, Brooks discloses a device having two discrete components: (1) a reusable, hand-held controller 14 that contains batteries and other electronic components (*i.e.*, a battery assembly) and (2) a disposable portion or cigarette 12 that includes the heating component and liquid (*i.e.*, an atomizer assembly). The controller 14 comprises "a case 26 or outer housing" that houses batteries 34A and 34B. Ex. 1003, Brooks at 7:15-25,

Claim 14.[b]	Brooks and Whittemore
assembly;	9:37-41, Fig. 2. Brooks thus teaches a battery assembly (controller 14 including batteries 34A and 34B) within a battery assembly housing (case 26 or outer housing).  Ex. 1003, Brooks at Fig. 2 (Annotated) Moreover, Brooks discloses that the hand-held controller 14 can "have a variety of shapes" and take on other forms including a tubular shape such as a cigarette holder. *Id*. at 4:46-49 ("The reusable controller can be ***in the form of*** a pipe, ***a reusable cigarette holder***, or a hand-held unit or other portable form into which the disposable portion can be inserted."), 9:39-41 (controller "can have a variety of shapes"). A PHOSITA would have understood that a "cigarette holder" is an elongated cylindrical structure since its purpose is to hold an elongated cylindrical cigarette while matching its general appearance and shape. To the extent PO disputes that the controller 14 in the form of a cigarette holder is cylindrical, elongated cylindrical cigarette holder for smoking articles and similar devices were also known in the art, as evidenced by U.S. Patent No. 3,292,635 (Ex. 1019, "Kolodny") at 4:25-26 ("An integral, completely expendable,

	cigarette-cigarette holder [comprises] a ***cylindrical cigarette holder***."), Figs. 1-2. *See also* Ex. 1020, U.S. Patent No. 3,685,521 ("Dock") at 3:17-4:3 ("A ***substantially cylindrical cigarette holder*** of resilient waterproof material, said holder at one end being of a size such as to form a socket designed to accommodate a cigarette …"); Ex. 1005, Voges at 5:48-50, 5:66-6:2, Figs. 1-2 (disclosing a cigarette substitute, which includes a cylindrically shaped battery in a cigarette-shaped hollow tubular body). Indeed, WO00/28843 ("Pienemann," Ex. 1036; English translation, Ex. 1037) discloses that a hand-held controller such as the controller shown in Brooks' Fig. 2 can be incorporated into a cylindrical cigarette shape. Ex. 1037, *compare* Figs. 4a and 4b *with* Fig. 5, *see also* p. 8. Also, it would have been an obvious matter of design choice to configure Brooks' "cigarette holder"-shaped controller to have a generally cylindrical shape in order to mimic the shape of a conventional cigarette. Accordingly, a PHOSITA would have understood that Brooks discloses an elongated cylindrical battery assembly housing (case 26 of, for example, the disclosed "cigarette holder"-shaped embodiment of controller 14). I further note that Brooks discloses that the controller 14 may also be in the form of a pipe, which Brooks discloses as having a narrow tube with a tubular-shaped bowl at one end. Ex. 1003, Brooks at 4:46-49, Figs. 7-8. Brooks further discloses an atomizer assembly ("disposable portion 12" of the smoking article 10, also referred to as "cartridge" or "cigarette 12."). *Id*. at 4:7-12, 7:15-16, Fig. 2. The cigarette 12 includes an atomizer assembly housing in the form of tube 68 and collar 49, which houses an atomizer formed by heating element 18 surrounded by insulative tube 66. *Id.* at 8:43-36, 11:6-16, 17:28-35, Fig. 2 (annotated below). Brooks teaches that the collar 49 has "the form of a thermoplastic tube," and may be formed "from a Delrin cylinder." *Id*. at 8:43-50, 11:42-53, 17:21-22 ("A 9 mm long Delrin tube 49 was fabricated from an 8 mm diameter ***cylinder***."), 22:1-6 ("An insulative collar 49 was formed from a Delrin ***cylinder*** …"), 21-31, Fig. 4. Accordingly, as illustrated in annotated Fig. 2 below, a PHOSITA would have

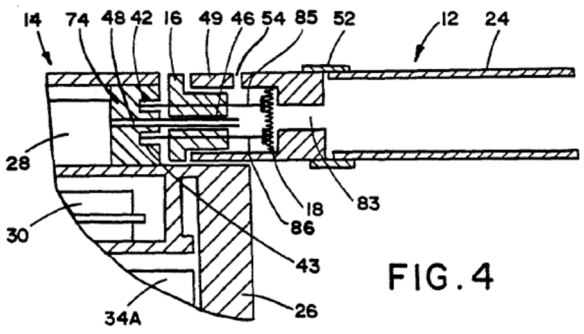
understood that the tube 68 and collar 49 jointly form an atomizer assembly housing that is an elongated cylindrical structure, as they provide the exterior structure of the atomizer assembly.



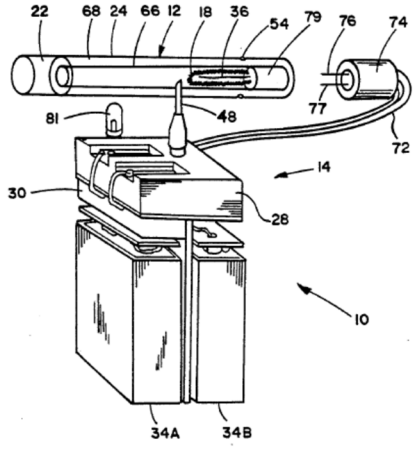
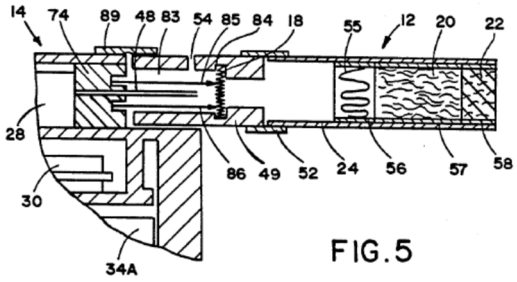
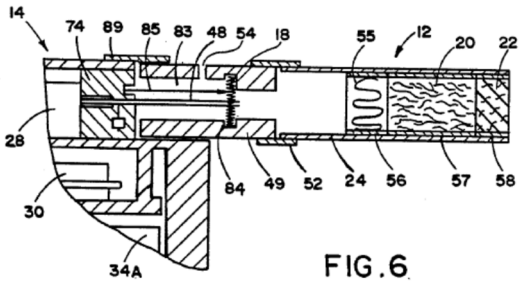
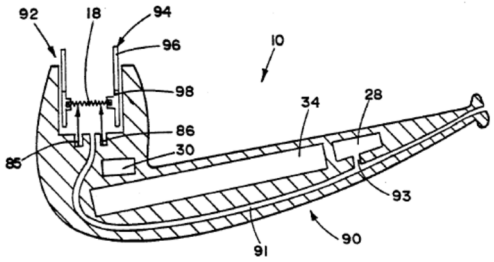
Ex. 1003, Brooks at Fig. 2 (Annotated)

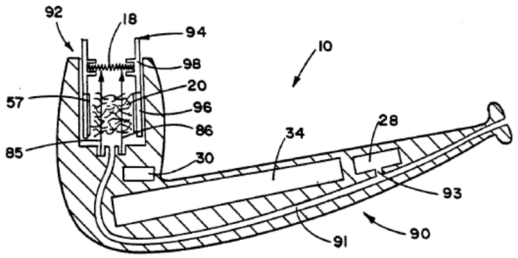
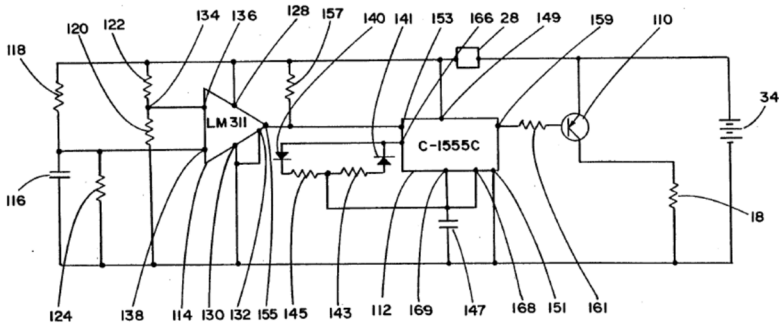
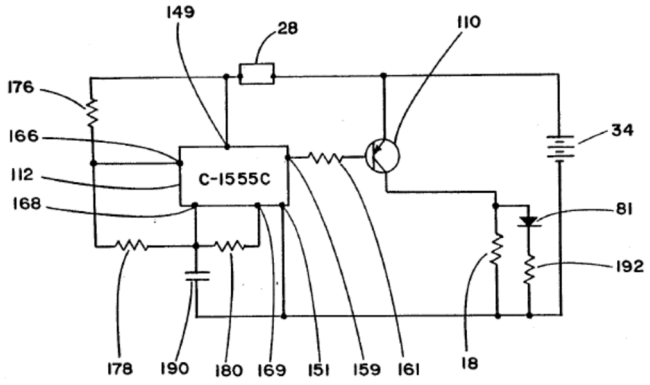
As Figure 2 indicates, the disposable portion of the Brooks device (and, accordingly, its exterior structure) is cylindrical in shape. Further, Brooks makes clear that the disposable portion—which is also referred to as a "cigarette"—simulates a conventional cigarette; as a result, a PHOSITA would have understood it to be an elongated cylindrical structure.

Similarly, Figs. 4-6 show an elongated cylindrical atomizer assembly as the disposable portion is cylindrical in shape as can be seen in Fig. 4 (for example) below:



	Ex. 1003, Brooks at Fig. 4 Therefore, Brooks discloses an elongated cylindrical housing comprising a first elongated cylindrical housing (case 26 of, for example, the disclosed "cigarette holder"-shaped embodiment of controller 14) within which the battery assembly (controller 14 including batteries 34A and 34B) is located, and a second elongated cylindrical housing (tube 68 and collar 49) within which the atomizer assembly (disposable portion or cigarette 12 including heating element 18 and insulative tube 66) is located. Brooks also teaches that the battery assembly (controller 14 including batteries 34A and 34B) is electrically connected to the atomizer assembly (disposable portion or cigarette 12 including heating element 18 and insulative tube 66). Ex. 1003, Brooks at 10:34-38 ("In use, the user inserts the plug 16 of the cigarette 12 into the receptacle 44 of the controller 14. Such action provides ***electrical connection of the resistance heating element 18 with*** the switch 28, the control circuit 30 and ***the batteries 34A and 34B***."), 12:39-46, 14:38-42 ("The transistor 110 acts to control ***the relatively large current which passes through the resistance element 18 from the power source 34*** …"), 15:28-35, Figs. 9-10. The schematic diagrams in Figs. 9 and 10 show that the heating element 18 is electrically connected to the power source/battery 34. **Brooks**: Ex. 1003 at Figs. 2 and 4 (see annotated Fig. 2 and Fig. 4 as shown above).

Claim 14.[b]	Brooks and Whittemore
	 FIG. 3  FIG. 5  FIG. 6  FIG. 7

Claim 14.[b]	Brooks and Whittemore
	 FIG. 8  FIG. 9  FIG. 10 *Id.* at Figs. 3, 5-10. "Referring to FIG. 1, smoking article 10 includes a cigarette 12 and a reusable, hand-held controller 14. The cigarette 12 includes electrical connection plug 16, resistance heating element 18 carrying an aerosol forming substance, a roll of tobacco 20, mouth end filter 22, and a resilient overwrap 24. The preferred controller 14 includes a case 26, a puff actuated

Claim 14.[b]	Brooks and Whittemore
	current actuation mechanism 28 having the form of a pressure sensitive switch, a time-based current control circuit 30, and a chamber 32 into which battery power supply 34 (shown as batteries 34A and 34B) is inserted." *Id.* at 7:15-25. "The reusable controller 14 includes a case 26 or outer housing which provides a convenient and aesthetic holder for the user. The outer housing 26 can have a variety of shapes and can be manufactured from plastic, metal, or the like." *Id.* at 9:37-41. "The reusable controller can be in the form of a pipe, a reusable cigarette holder, or a hand-held unit or other portable form into which the disposable portion can be inserted." *Id.* at 4:46-49. "In one aspect of the invention, the smoking article includes a cigarette or a disposable portion (*e.g.*, a cartridge) which utilizes an air permeable high surface area electrical resistance heating element that normally carries aerosol forming and/or tobacco flavor substances prior to use." *Id.* at 4:7-12. "The embodiment illustrated in FIG. 2 is generally similar to the embodiment of FIG. 1, except that the heating element 18 is positioned within a heat resistant, insulative tube 66. The insulative tube 66 preferably is manufactured from a high temperature plastic such as a polyimide, a ceramic, a heat resistant cellulosic, an extruded tobacco material, an aluminum tube having a surface coating of aluminum oxide, or the like. Preferably, a plasticized cellulose acetate tube 68 circumscribes the insulative tube 66, and is itself circumscribed by paper overwrap 24. This embodiment also includes tipping overwrap 70 circumscribing the mouthend of the cigarette in order to attach filter element 22 to the remaining portion of the cigarette." *Id.* at 11:6-19. "A 39 mm long, 4 mm outer diameter Kapton polyimide tube 66 was slipped over the resistance element 18 and inserted

Claim 14.[b]	Brooks and Whittemore
	about 4 mm into the 4 mm I.D. end of the Delrin tube 49. A 36 mm length of a 8 mm O.D. plasticized cellulose acetate tube 68, SCS-1 from American Filtrona Corp., was slipped over the polyimide tube. This tube 68 was then overwrapped with a layer of Kimberly-Clark P-850-192-2 paper 24." *Id.* at 17:28-35. "In use, the user inserts the plug 16 of the cigarette 12 into the receptacle 44 of the controller 14. Such action provides electrical connection of the resistance heating element 18 with the switch 28, the control circuit 30 and the batteries 34A and 34B." *Id.* at 10:34-38. "The foregoing embodiments preferably incorporate the preferred circuit shown schematically in FIG. 9. In particular, the circuit of FIG. 9 includes a power source 34, the electrical resistance heating element 18, a current actuation mechanism 28, and a preferred current regulating circuit or means for controlling the passage of current through the resistance element during periods of current actuation." *Id.* at 12:39-46. "The transistor 110 acts to control the relatively large current which passes through the resistance element 18 from the power source 34 by switching "on" and "off" in response to current flow from the timer." *Id.* at 14:38-42. "Controllers and smoking articles of the invention also can incorporate the alternate time-based circuit shown schematically in FIG. 10. In particular, the circuit of FIG. 10 includes a power source 34, the electrical resistance heating element 18, a current actuation mechanism 28, and a current regulating circuit or means for controlling the passage of current through the resistance element during current actuation." *Id.* at 15:28-35. "A portion of the length of the electrical connection plug 16 preferably is circumscribed by a collar 49 having the form of a thermoplastic tube, which preferably is friction fit around a

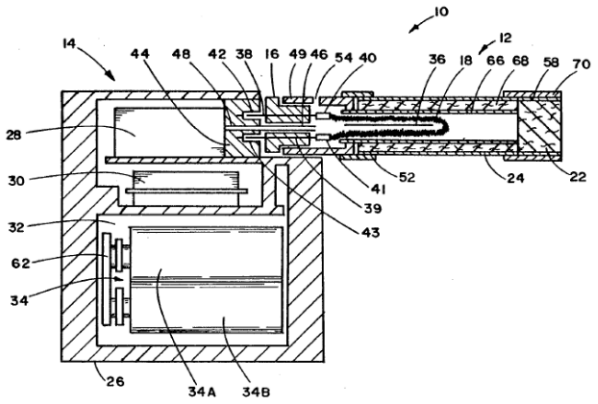
Claim 14.[b]	Brooks and Whittemore
	portion of the length of the plug. The collar 49 in turn is secured to the remaining portion of the cigarette via overwrap 24 using tipping paper 52 or other appropriate means such as adhesive, a friction fit, or the like." *Id.* at 8:43-50. "Referring to FIG. 4, the illustrated embodiment is generally similar to the embodiment of FIG. 2, except that the heating element 18 is a circular disc or pad, preferably formed from an American Kynol carbon felt. The pad is permeable to airflow, and is disposed across an air passageway 83 in tubular collar 49 so that drawn air entering the cigarette 12 through opening 54 passes through the heating element 18. Electrical connection pins 85, 86 from plug 74 contact the heating element and help hold it in place against collar 49. In this embodiment, the collar 49 can be a thermoplastic material, a thermally stable plastic material, a ceramic, or the like. The embodiment illustrated in FIG. 5 is generally similar to the embodiment of FIG. 1. In this embodiment, the heating element 18 is a circular disc or pad of carbon felt disposed across an air passageway 83 extending through tubular collar 49. The pad is held in place by shoulder 84 on the collar 49. In addition, the cigarette does not have an electrical connect plug. Instead, electrical connection pins 85, 86 for the heating element extend from a plug 74 located on the controller 14. The cigarette 12 is held in place relative to the controller 14 via a clip 89 extending from the controller, or other suitable connection means." *Id.* at 11:42-65. "A 9 mm long Delrin tube 49 was fabricated from an 8 mm diameter cylinder. One section, 6 mm long, had a 7 mm inner diameter (I.D.), and a second section, 3 mm long, had a 4 mm I.D. A single air inlet hole 54 was made about 4 mm from the 4 mm I.D. end of the tube using a No. 64 drill bit. The 7 mm I.D. end of the tube 49 was then friction fit over the 7 mm end of plug 16." *Id.* at 17:21-27. "An insulative collar 49 was formed from a Delrin cylinder

Claim 14.[b]	Brooks and Whittemore
	having a length of 9 mm and a diameter of 8 mm to a tubular form having a 3 mm segment of 4.5 mm I.D. and a 6 mm segment of 6 mm I.D. A single air inlet 54 was made about 4 mm from the 6 mm I.D. end of the collar. … The resistance element 18 was inserted into the 6 mm I.D. end of the collar 49 to abut against the 4.5 mm I.D. portion of the collar. The 6 mm I.D. end of the collar 48 then was fit over the narrow end of plug 16 such that the flattened silver solder ends of pins 38 and 39 each contacted the resistance element 18. A resilient paperboard tube having an 8 mm O.D. and a length of 75 mm was abutted against the end of collar 49 opposite plug 16, and the two tubes were held in place using adhesive tape 52." *Id.* at 22:1-6, 21-32.

71. Below is a claim chart explaining where and how the claim language "a liquid storage component in the elongated cylindrical housing" is disclosed.

Claim 14.[c]	Brooks and Whittemore
14.[c] a liquid storage component in the elongated cylindrical housing;	Brooks discloses "a liquid storage component in the elongated cylindrical housing." Brooks discloses *two* liquid storage components. First, Brooks discloses that the "aerosol forming substance" is a solution as it is a liquid with several components. *Id*. at 4:22-25, *see also* 17:6-9. A PHOSITA would have understood that because Brooks' device uses liquid, there must be "a liquid storage component" for the liquid. Indeed, as Brooks makes clear, the aerosol forming substances (*i.e.*, liquid) are "located on the resistance element *or elsewhere in the article*." *Id*. at

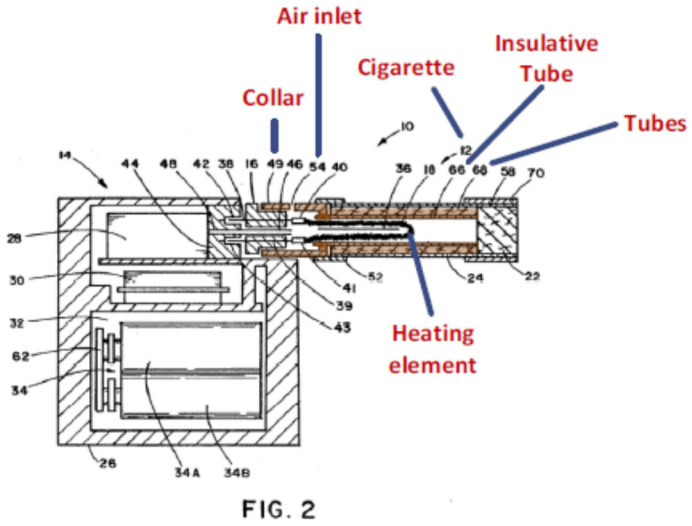
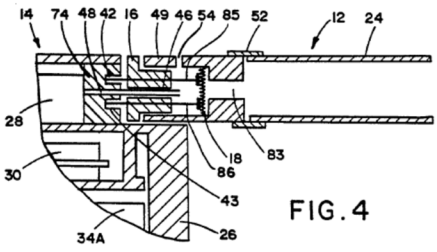
Claim 14.[c]	Brooks and Whittemore
	6:45-52; *see also* 17:6-9. A PHOSITA would have understood that the phrase "elsewhere in the article" refers to elsewhere in the disposable portion 12 (*i.e.*, the atomizer assembly) because that is the portion that is replaced every 6-10 puffs. *Id*. at 4:29-31, 6:32-36, 10:66-11:5. Thus, a PHOSITA would have understood that while liquid could be stored on the heating element, there also could be a liquid storage component located elsewhere in the disposable portion 12 other than the "intimate contact" heating element. Brooks also discloses a second liquid storage component. Specifically, the tobacco roll/charge 20 in Brooks is a liquid storage component located in the atomizer assembly housing (disposable portion 12). Ex. 1003, Brooks at 8:58-60, 9:1-15, Fig. 1. Brooks explains that the tobacco roll 20 can be tobacco filler or "[e]xtruded tobacco materials and other forms of tobacco, such as tobacco extracts, tobacco dust, or the like," and includes various solutions, such as "[t]obacco extracts; tobacco flavor modifiers such as levulinic acid; and other flavoring agents such as menthol, vanillin, chocolate, licorice, and the like." *Id*. at 9:1-15. The tobacco charge is overwrapped with a paper overwrap 57. *Id.* at 9:6-8. A PHOSITA would have known that tobacco charges such as the one described in Brooks contain liquid solutions. *See e.g.,* Ex. 1033, U.S. Pat. No. 4,941,486 ("Dube") at 7:1-11 (describing a charge of tobacco as a blend with reconstituted tobacco where, the "blend has a water, flavoring and glycerin casing applied thereto"); and Ex. 1034, U.S. Pat. No. 7,337,782 ("Thompson") at 1:27-31, 4:42-48 (describing tobacco extract as aqueous). Thus, Brooks discloses two liquid storage components in the atomizer assembly housing of the elongated cylindrical housing: one liquid storage component for storing the aerosol forming substance and a second liquid storage component being the tobacco charge holding liquid that overwrapped with a paper overwrap. Both of these liquid storage components satisfy the claim limitation.

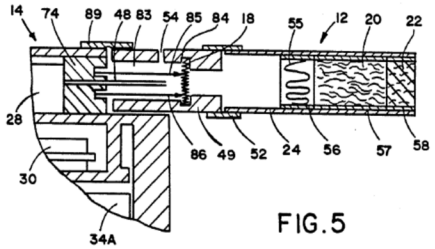
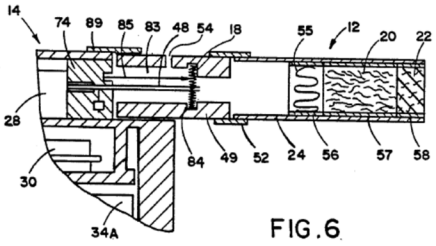
	Brooks:  FIG. 2 Ex. 1003, Fig. 2. "Other suitable heating elements include porous metal wires or films; carbon yarns, cloths, fibers, discs or strips; graphite cylinders, fabrics or paints; microporous high temperature polymers having moderate resistivities; porous substrates in intimate contact with resistance heating components; and the like. Preferably, the heating element 18 is impregnated with or otherwise carries the aerosol forming substance in order that the aerosol forming substance is in a heat exchange relationship with the electrical heating element. The aerosol forming substance can be, for example, a polyhydric alcohol, such as glycerin, propylene glycol, or a mixture thereof; water; a tobacco material such as a tobacco aroma oil, a tobacco essence, a spray dried tobacco extract, a freeze dried tobacco extract, tobacco dust, or the like, in order to provide tobacco flavor; or a combination thereof. Other suitable aerosol forming substances are well known in the art." *Id*. at 7:65-8:15. "While the loading of the aerosol forming substance can vary from substance to substance and from heating element to heating element, the amount of liquid aerosol forming substance used typically will be greater than about 15 mg and preferably ranges from about 25 mg to about 50 mg." *Id.* at

Claim 14.[c]	Brooks and Whittemore
	8:16-22. "…the heating element experiences an increase in temperature which in turn heats and volatilizes the aerosol forming substance. The volatilized aerosol forming substance mixes with the drawn air and forms an aerosol. The volatilized aerosol forming substance (in aerosol or vapor form) passes through the tobacco roll 20 where it elutes tobacco flavor from the tobacco, and exits the mouthend filter 22 into the mouth of the user." *Id*. at 10:45-53. "The cigarette can include a plug spacer member 55 positioned between the heating element 18 and the roll or charge of tobacco 20." *Id*. at 8:58-60. "The tobacco charge 20 can be tobacco filler such as strands or shreds of tobacco laminae, reconstituted tobacco, volume expanded tobacco, processed tobacco stems, or blends thereof. Extruded tobacco materials and other forms of tobacco, such as tobacco extracts, tobacco dust, or the like, also can be employed. Preferably, the tobacco charge 20 is overwrapped with a paper overwrap 57. Tobacco extracts; tobacco flavor modifiers such as levulinic acid; and other flavoring agents such as menthol, vanillin, chocolate, licorice, and the like; can be carried by the heating element, placed between the heating element and the spacer member, applied to the spacer member, blended with the tobacco charge, or applied to the mouthend filter." *Id*. at 9:1-15.

72. Below is a claim chart explaining where and how the claim language "with the elongated cylindrical housing having one or more air inlets" is disclosed.

Claim 14.[d]	Brooks and Whittemore
14.[d] with the elongated	Brooks discloses one or more air inlets (one or more peripheral air inlet openings 54) on collar 49 of the atomizer

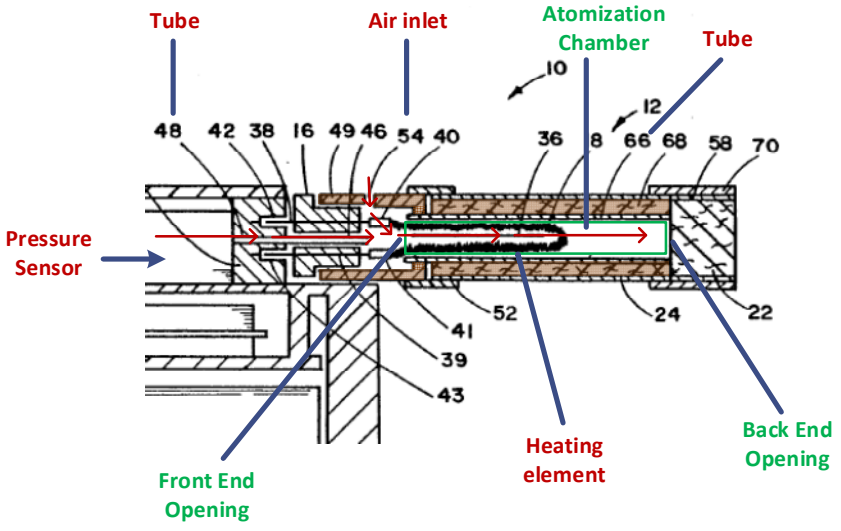
Claim 14.[d]	Brooks and Whittemore
cylindrical housing having one or more air inlets;	assembly housing (tube 68 and collar 49) which is part of the elongated cylindrical housing. Ex. 1003, Brooks at 8:50-57 ("Preferably, the collar 49 includes one or more peripheral air inlet openings 54 which provide a flow of ambient air through the cigarette during draw."), 10:40-53 ("When the user puffs on the mouthend of the cigarette, ambient air enters the cigarette through air inlet 54."), 11:46-49, Figs. 2, 4-6.  FIG. 2 Ex. 1003, Brooks at Fig. 2 (Annotated) **Brooks:** Ex. 1003 at Fig. 2 (see annotated Fig. 2 as shown above).  FIG. 4

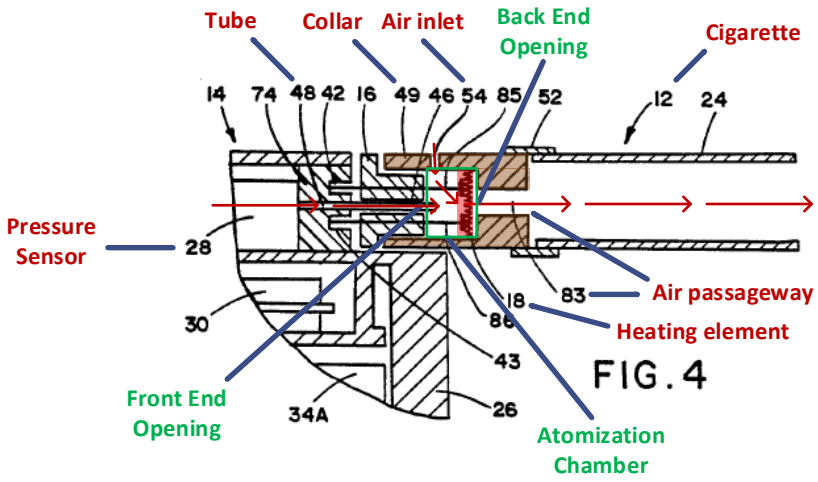
Claim 14.[d]	Brooks and Whittemore
	 FIG.5  FIG.6 *Id.* at Figs. 4-6. "A portion of the length of the electrical connection plug 16 preferably is circumscribed by a collar 49 having the form of a thermoplastic tube, which preferably is friction fit around a portion of the length of the plug. The collar 49 in turn is secured to the remaining portion of the cigarette via overwrap 24 using tipping paper 52 or other appropriate means such as adhesive, a friction fit, or the like. Preferably, the collar 49 includes one or more peripheral air inlet openings 54 which provide a flow of ambient air through the cigarette during draw. Alternatively, the air inlet can be positioned through the extreme inlet end of the cigarette or elsewhere through the periphery of the cigarette, such that drawn ambient air passing through the cigarette to the mouth of the user passes the resistance element." *Id.* at 8:43-57. "In use, the user inserts the plug 16 of the cigarette 12 into the receptacle 44 of the controller 14. Such action provides electrical connection of the resistance heating element 18 with the switch 28, the control circuit 30 and the batteries 34A and 34B. Such action also provides for airflow communication between the switch 28 and the inner portion of the cigarette. When the user puffs on the mouthend of the cigarette, ambient air enters the cigarette through air inlet 54. The pressure

Claim 14.[d]	Brooks and Whittemore
	actuated switch 28 responds to a sensed change in air pressure within the cigarette during draw and permits current flow through the heating element 18. As a result, the heating element experiences an increase in temperature which in turn heats and volatilizes the aerosol forming substance. The volatilized aerosol forming substance mixes with the drawn air and forms an aerosol. The volatilized aerosol forming substance (in aerosol or vapor form) passes through the tobacco roll 20 where it elutes tobacco flavor from the tobacco, and exits the mouthend filter 22 into the mouth of the user. During the puff, the preferred current control circuit (described in detail hereinafter) regulates the flow of current to control the temperature experienced by the heating element and the amount of aerosol forming substance which is volatilized." *Id.* at 10:34-58. "The pad is permeable to airflow, and is disposed across an air passageway 83 in tubular collar 49 so that drawn air entering the cigarette 12 through opening 54 passes through the heating element 18." *Id.* at 11:46-49.

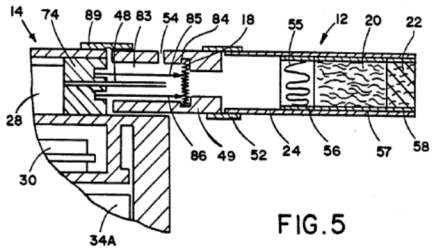
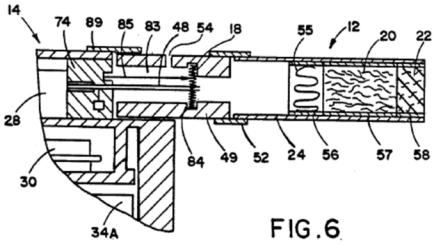
73. Below is a claim chart explaining where and how the claim language "the atomizer assembly including an atomization chamber having a front end opening and a back end opening to allow air to flow into the atomization chamber from the front end opening and out from the back end opening" is disclosed.

Claim 14.[e]	Brooks and Whittemore
14.[e] the atomizer assembly including an atomization chamber having a	Brooks discloses this feature. As discussed in claim 14.[b] above, Brooks discloses an atomizer assembly ("disposable portion 12" or "cigarette 12") including an atomizer assembly housing in the form of tube 68 and collar 49, and an atomizer formed by heating element 18 surrounded by insulative tube 66.

Claim 14.[e]	Brooks and Whittemore
front end opening and a back end opening to allow air to flow into the atomization chamber from the front end opening and out from the back end opening; and	As illustrated in annotated Fig. 2 below, Brooks teaches an atomization chamber (hollow space surrounded by tube 66, highlighted in green) having a front end opening on the left side where air enters the tube 66 from air inlet 54 and pressure sensing tube 48, and a back end opening on the right side where air exits the tube 66 into mouthend filter 22. Also, Brooks discloses that heating element 18 generates aerosol or vapor when electric current runs through it and, accordingly, constitutes an "atomizer." Ex. 1003, Brooks at 10:42-49. The tube 66 houses the atomizer (heating element 18), and therefore is an atomization chamber. Brooks discloses that "ambient air enters the cigarette through air inlet 54," the drawn air passes through the heating element 18 and mixes with the aerosol forming substance to form aerosol, and the aerosol passes through an air passageway 83 and "exits the mouthend filter 22 into the mouth of the user." *Id.* at 10:40-53, 11:46-49; Figs. 2, 4-6; claims 10, 55. As shown in annotated Fig. 2 below by the red arrows, Brooks therefore discloses that air from both the inlet 54 and the tube 48 flows into the atomization chamber at the front end opening, across the heating element 18, and out the atomization chamber at the back end opening to mouthend filter 22. 

Claim 14.[e]	Brooks and Whittemore
	Ex. 1003 at Fig. 2 (Annotated) Annotated Fig. 4 illustrates an alternative embodiment of an atomization chamber highlighted in green (Fig. 4 is a partial sectional view of the smoking article with the mouthend filter 22 (and other parts) omitted). In this alternative embodiment, the atomization chamber is the hollow space surrounded by collar 49. The atomization chamber includes a front end opening on the left side where air enters the chamber from pressure sensing tube 48, and a back end opening on the right side where air exits the chamber into air passageway 83. Also, air inlet 54 is located at the front corner of the atomization chamber and allows air to flow into the chamber. A PHOSITA thus would have understood that air inlet 54 is an alternative front end opening. The chamber highlighted in green houses the atomizer (heating element 18), and therefore is an atomization chamber.  Ex. 1003, Brooks at Fig. 4 (Annotated) Specifically, Brooks discloses that the collar 49 includes one or more air inlet openings 54 "which provide a flow of ambient air through the cigarette during draw." *Id.* at 8:50-52. Brooks also discloses that a puff actuated current actuation mechanism (pressure sensor) 28. *Id.* at 7:20-25, 12:47-13:6.

Claim 14.[e]	Brooks and Whittemore
	Pressure sensing tube 48 is inserted into passageway 46 such that the right end of the tube 48 is "in airflow communication with the internal region of the cigarette." *Id.* at 9:43-50. The left end of the tube 48 is "in airflow communication with pressure sensing switch 28, so that changes in air pressure which occur within the cigarette during draw can be sensed by the switch." *Id.* When a user inhales, air enters the cigarette 12 through air inlet 54. *Id.* at 10:40-53, 11:46-49, Figs. 2, 4-6, claims 10, 55. During draw, air also flows from the pressure sensor 28 through tube 48 into the atomization chamber and generates a change in air pressure. The pressure sensor 28 senses the air pressure change and actuates the flow of current to the heating element. *Id.* at 10:40-45, Figs. 2, 4-6. As illustrated in annotated Fig. 4 above, air from the pressure sensing tube 48 enters the atomization chamber at the front end opening, passes through the atomization chamber including heating element 18, and exits out the back end opening to passageway 83. Air also enters the atomization chamber from air inlet 54 (alternative front end opening), then also passes through the atomization chamber including heating element 18, and exits out the back end opening to passageway 83. Therefore, as depicted in annotated Figs. 2 and 4 above, Brooks discloses the atomizer assembly (disposable portion 12 or cigarette 12) including an atomization chamber (highlighted in green in annotated Figs. 2 and 4) having a front end opening and a back end opening to allow air to flow into the atomization chamber from the front end opening and out from the back end opening (red arrows illustrating an airflow path in the cylindrical atomizer assembly housing from the inlet 54 and pressure sensing tube 48, flowing into the atomization chamber from front end opening, across the heating element 18, and out the atomization chamber from back end opening before exiting mouthend).

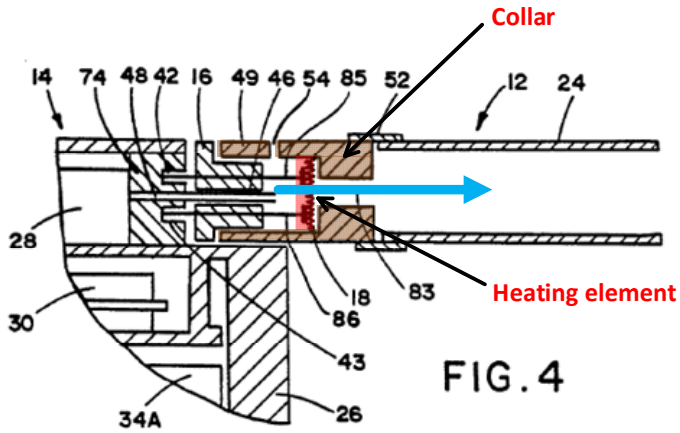
	Brooks: Ex. 1003 at Figs. 2 and 4 (see annotated Figs. 2 and 4 as shown above).  FIG.5  FIG.6 *Id.* at Figs. 5-6. "When the user puffs on the mouthend of the cigarette, ambient air enters the cigarette through air inlet 54. The pressure actuated switch 28 responds to a sensed change in air pressure within the cigarette during draw and permits current flow through the heating element 18. As a result, the heating element experiences an increase in temperature which in turn heats and volatilizes the aerosol forming substance. The volatilized aerosol forming substance mixes with the drawn air and forms an aerosol. The volatilized aerosol forming substance (in aerosol or vapor form) passes through the tobacco roll 20 where it elutes tobacco flavor from the tobacco, and exits the mouthend filter 22 into the mouth of the user." *Id.* at 10:40-53. "The pad is permeable to airflow, and is disposed across an air passageway 83 in tubular collar 49 so that drawn air entering the cigarette 12 through opening 54 passes through the heating element 18." *Id.* at 11:46-49.

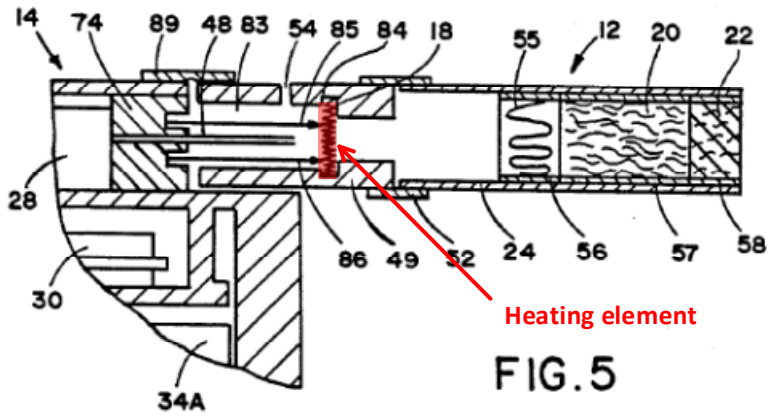
Claim 14.[e]	Brooks and Whittemore
	"Alternatively, the air inlet can be positioned through the extreme inlet end of the cigarette or elsewhere through the periphery of the cigarette, such that drawn ambient air passing through the cigarette to the mouth of the user passes the resistance element." *Id.* at 8:53-57. "The preferred controller 14 includes a case 26, a puff actuated current actuation mechanism 28 having the form of a pressure sensitive switch, a time-based current control circuit 30, and a chamber 32 into which battery power supply 34 (shown as batteries 34A and 34B) is inserted." *Id.* at 7:20-25. "Receptacle 44 also includes tube 48 which is inserted into passageway 46 of plug 16 to be in airflow communication with the internal region of the cigarette. The other end of tube 48 is in airflow communication with pressure sensing switch 28, so that changes in air pressure which occur within the cigarette during draw can be sensed by the switch." *Id.* at 9:43-50. "The circuit includes a puff actuated control switch 28, or some other suitable current actuation/deactuation mechanism, such as a manually actuated on-off switch, a temperature actuated on-off switch, or a lip pressure actuated switch. The preferred puff actuated switch 28 enables current to pass through the heating element 18 only during draw on the article. A typical puff actuated switch includes a means for sensing the difference in air pressure in a region within the previously described cigarette or disposable cartridge and an "on-off" switch responsive thereto. A preferred puff actuated switch 28 is a pressure differential switch such as Model No. MPL-502-V, range A, from Micro Pneumatic Logic, Inc., Ft. Lauderdale, Fla. Another suitable puff actuated mechanism is a sensitive pressure transducer (eg., equipped with an amplifier or gain stage) which is in turn coupled with a comparator for detecting a predetermined threshold pressure. Yet another suitable puff actuated

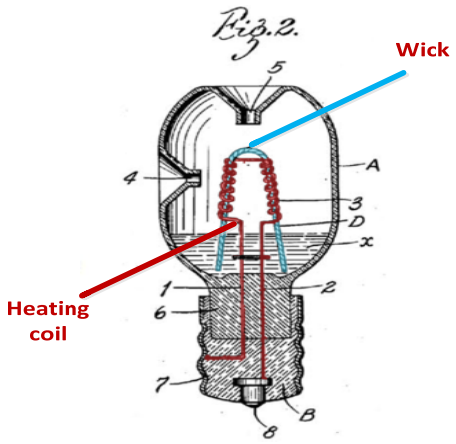
Claim 14.[e]	Brooks and Whittemore
	mechanism is a vane which is deflected by airflow, the motion of which vane is detected by a movement sensing means. Yet another suitable actuation mechanism is a piezoelectric switch. Also useful is a suitably connected Honeywell Microswitch Microbridge Airflow Sensor, Part No. AWM 2100V from Microswitch Division of Honeywell, Inc., Freeport, Ill. Other suitable differential switches, analog pressure sensors, flow rate sensors, or the like, will be apparent to the skilled artisan." *Id.* at 12:47-13:6. "10. The cigarette of claim 1, wherein the cigarette includes an air passageway at least partially therethrough, and the heating element comprises an air permeable heating element positioned in the passageway." *Id.* at 23:7-10 (claim 10). "55. The disposable article of claim 53, wherein the heating element substantially fills the cross sectional area of the air passageway." *Id.* at 25:19-21 (claim 55). *Also see* evidence in claim 14.[b] above.

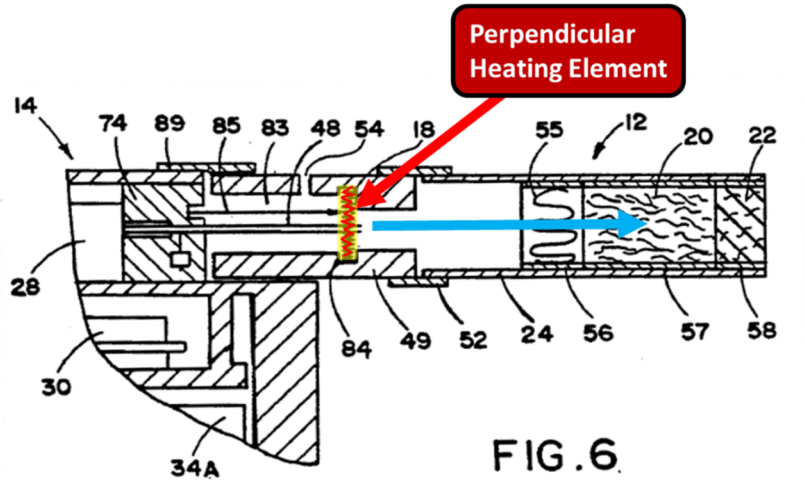
74. Below is a claim chart explaining where and how the claim language "a heating wire coil wound on a porous component that is perpendicular to a longitudinal axis of the elongated cylindrical housing, with the heating wire coil in an air flow path between the front end opening and the back end opening of the atomization chamber" is disclosed.

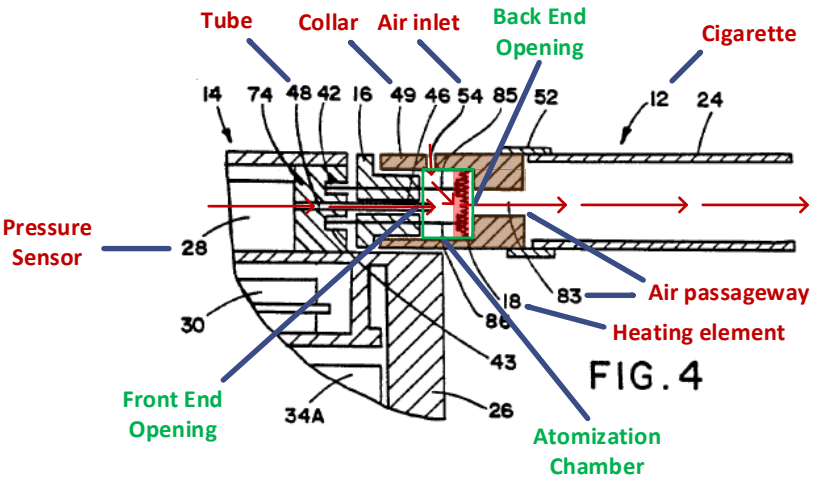
Claim 14.[f]	Brooks and Whittemore
14.[f] a heating wire coil wound on a porous component that is	Brooks in view of Whittemore discloses this feature.

Claim 14.[f]	Brooks and Whittemore
perpendicular to a longitudinal axis of the elongated cylindrical housing, with the heating wire coil in an air flow path between the front end opening and the back end opening of the atomization chamber.	 Ex. 1003, Brooks at Fig. 4 (Annotated) As explained above in Section VI.B above, one embodiment of a heater in Brooks is a resistance heating component is "in intimate contact" with a separate "porous substrate." A PHOSITA would have understood that the "intimate contact" between the resistance heating component and the porous substrate would include a heating wire wound on the porous substrate. As mentioned above, in Brooks' Background section, Brooks describes Whittemore which includes a heating wire wound around a porous wick. Further, as a result of its configuration, Whittemore's heating wire wound around the porous wick uses direct heat exchange to heat the liquid and vaporize it. This is the same preferred heat principle described in Brooks. *Id*. at 8:4-8 ("the aerosol forming substance is in a heat exchange relationship with the electrical heating element."). Thus, a PHOSITA would have understood that the "intimate contact" embodiment would have included Whittemore's known wire coil around a porous wick that operates by direct heat exchange. Brooks further supports that a PHOSITA would have understood that the "intimate contact" embodiment includes heating wire coil wrapped around a porous substrate such as what is shown in Whittemore because Brooks discloses that its

Claim 14.[f]	Brooks and Whittemore
	heating element can constitute a "metal wire," and further depicts embodiments in which the heating element takes the form of a coil as shown in Figs. 1-8. Fig. 5 below shows the coil shape.  FIG. 5 Ex. 1003, Brooks at Fig. 5 (Annotated) Further, others in the field have described the Brooks device as including an "electrical resistance coil." *See* Ex. 1014, Hale at ¶[0004] (describing the heating element in U.S. Patent No. 4,922,901 (Ex. 1015), which is substantially identical to Brooks discussed in this declaration, as an "electrical resistance coil"). In addition, Brooks confirms that the use of heater coils was well known as it mentions several other references that include heater coils. *See* Ex. 1003, Brooks at 1:62-66, 2:40-43, 3:4-6. Accordingly, as discussed, since the heating element may take the form of a resistance heating component in contact with a porous body, a PHOSITA would have understood Brooks to disclose that the heating component can be a wire coil wound around the porous body, since coils are wound by their very nature. Moreover, as stated above, a PHOSITA would have been aware of Whittemore which is expressly described in Brooks. Ex. 1003, Brooks at 1:57-61. Whittemore describes a wick D

Claim 14.[f]	Brooks and Whittemore
	made of thread or string that is surrounded by "coiled or looped portions" of a "filament 3" which acts as a heater when electric current is run through it: "…the unit is equipped with a wick D made of any suitable material and combined with **the heating element or filament 3** in such a way that a portion of said wick is always in contact or approximate contact with the heating element or filament 3, and a portion of said wick is always in contact with the medicament in the vaporizing vessel, whereby said medicament will be carried by capillary action to a point where it will be vaporized by the heat from the filament 3. In the form of my invention shown in Figure 2, **the wick D consists of a thread, string or stand [sic] of some suitable wick material** doubled intermediate its ends so as to form a substantially inverted V-shaped device whose **side portions are encased in and surrounded by coiled or looped portions of the filament 3**, the lower ends or free ends of the side pieces of the wick projecting downwardly into the medicament and terminating at or in close proximity to the closed bottom 6 of the vessel A." Ex. 1004, Whittemore at p. 1, 1:53-2:18. 

Claim 14.[f]	Brooks and Whittemore
	Ex. 1004, Whittemore at Fig. 2 (Annotated) For the reasons I set forth above and as previously discussed, it would have been obvious to a PHOSITA to adapt Brooks' resistance heating component in intimate contact with a porous substrate such that the heating component is a heating wire coil wound around the porous substrate, as taught by Whittemore. When Brooks is modified this way, the part of the porous substrate where the heating wire coil is wound is perpendicular to the longitudinal axis of the disposable portion 12, which is shown below by the blue arrow:  Ex. 1003, Brooks at Fig. 6 (Annotated) Because the porous substrate (in yellow) of the modified heating element 18 is vertically oriented in the cross-section of the disposable portion 12, it is perpendicular to the longitudinal axis (depicted in blue) of the disposable portion 12. Indeed, this perpendicular orientation is expressly claimed in Brooks. *Id.*, *see* Claims 11, 36, 54, and 135. Furthermore, as discussed in claim 14.[e] above, Brooks discloses the atomizer assembly including an atomization chamber having a front end opening and a back end opening, and air flows into the atomization chamber from front end opening, across the heating element 18, and out the

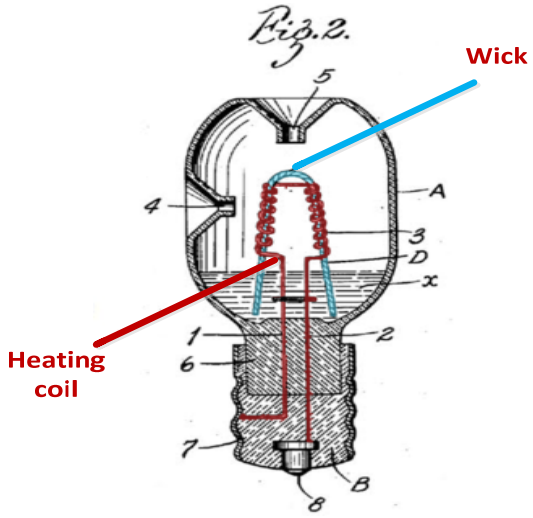
Claim 14.[f]	Brooks and Whittemore
	atomization chamber from back end opening before exiting mouthend filter 22. Indeed, every figure in Brooks discloses that the heating element is in the airflow path. *Id*. at Figs. 1-8. Therefore, as illustrated in annotated Figs. 2 and 4 below, Brooks teaches the heating wire coil 18 in an air flow path (red arrows) between the front end opening and the back end opening of the atomization chamber.  Ex. 1003 at Fig. 4 (Annotated) **Brooks**: "Other suitable heating elements include porous metal wires or films; carbon yarns, cloths, fibers, discs or strips; graphite cylinders, fabrics or paints; microporous high temperature polymers having moderate resistivities; porous substrates in intimate contact with resistance heating components; and the like." Ex. 1003, Brooks at 7:65-8:3. "Preferably, the heating element 18 is impregnated with or otherwise carries the aerosol forming substance in order that the aerosol forming substance is in a heat exchange relationship with the electrical heating element. The aerosol forming substance can be, for example, a polyhydric alcohol, such as glycerin, propylene glycol, or a mixture thereof; water; a tobacco material such as a tobacco aroma oil, a tobacco

	essence, a spray dried tobacco extract, a freeze dried tobacco extract, tobacco dust, or the like, in order to provide tobacco flavor; or a combination thereof. Other suitable aerosol forming substances are well known in the art. See, for example, U.S. Pat. Nos. 4,714,092 and 4,756,318. While the loading of the aerosol forming substance can vary from substance to substance and from heating element to heating element, the amount of liquid aerosol forming substance used typically will be greater than about 15 mg and preferably ranges from about 25 mg to about 50 mg." *Id.* at 8:4-22. "As used herein, and only for the purposes of this application, "aerosol" is defined to include vapors, gases, particles, and the like, both visible and invisible, and especially those components perceived by the user to be "smoke-like," generated by action of heat from the resistance heating element upon aerosol forming substances and/or tobacco flavor substances located on the resistance element or elsewhere in the article." *Id.* at 6:45-52. "Over the years, there have been proposed numerous smoking products, flavor generators and medicinal inhalers which utilize electrical energy to vaporize or heat a volatile material, or attempt to provide the sensations of cigarette or pipe smoking without burning tobacco. U.S. Pat. No. 2,057,353 to Whittemore, Jr. proposed a vaporizing unit. In particular, a wick reportedly carried liquid medicament by capillary action to a point where the liquid was vaporized by an electrical resistance heating element. U.S. Pat. No. 2,104,266 to McCormick proposed an article having a pipe bowl or cigarette holder which included a resistance coil (i) wound on an insulating and heat resisting material, and (ii) contained in an insulated chamber. Prior to use of the article, the pipe bowl was filled with tobacco or the holder was fit with a cigarette. Current then was passed through the resistance coil. Heat produced by the resistance coil was transmitted to the tobacco in the bowl or holder,

	resulting in the volatilization of various ingredients from the tobacco. A thermostatic switch was employed to maintain a predetermined temperature range to which the tobacco was heated. U.S. Pat. No. 3,200,819 to Gilbert proposed a smokeless, non-tobacco cigarette having a flavor cartridge, such as a porous substrate impregnated with mentholated water. The article included a battery for powering a tube or bulb which was illuminated before assembly. The bulb was placed in a tubular liner, which was in turn located within a tube of plastic having the size, color and form of a cigarette. In use, the illuminated bulb reportedly heated the flavored air drawn through passages formed between the bulb and the tubular liner. As such, warm, moist, flavored air was delivered to the user." *Id.* at 1:51-2:18. "1. A cigarette for use with a source of electrical power comprising: (a) an electrical resistance heating element having a surface area greater than 1 m^2 /g; (b) aerosol forming substance carried by the heating element prior to use; and (c) tobacco." *Id.* at claim 1. "26. A disposable portion of a smoking article for use with a source of electrical power comprising: (a) an electrical resistance heating element having a surface area greater than 1 m^2g; and (b) aerosol forming substance carried by the heating element prior to use." *Id.* at claim 26. "53. A disposable portion of a smoking article for use with a source of electrical power comprising: (a) an air passageway at least partially through the disposable portion; (b) an air permeable electrical heating element located in the air passageway; and (c) an aerosol forming substance." *Id.* at claim 53.

Claim 14.[f]	Brooks and Whittemore
	"57. The disposable article of claim 53, 54, 55 or 56, wherein the aerosol forming substance is carried by the heating element prior to use." *Id.* at claim 57. "75. A smoking article for use with a source of electrical power comprising: (a) an electrical resistance heating element having a surface area greater than 1 m^2g; (b) aerosol forming substance carried by the heating element prior to use; and (c) puff actuated control means for permitting current flow through the heating element during draw by the user." *Id.* at claim 75. "104. A smoking article for use with a source of electrical power comprising: (a) an electrical resistance heating element; (b) aerosol forming substance; (c) switch means for actuating and deactuating current flow through the heating element; and (d) time based means for (i) permitting unrestricted current flow through the heating element for an initial predetermined time period upon current actuation, and (ii) for subsequently regulating current flow until current deactuation. 105. The smoking article of claim 104, wherein the aerosol forming substance is carried by the heating element prior to use." *Id.* at claims 104, 105. "131. A smoking delivery article for use with a source of electrical power comprising: ((a) an air passageway at least partially through the article; ((b) an air permeable electrical resistance heating element located in the air passageway; ((c) an aerosol forming substance; (d) puff actuated control means for permitting current flow through the heating element during draw by the user; and

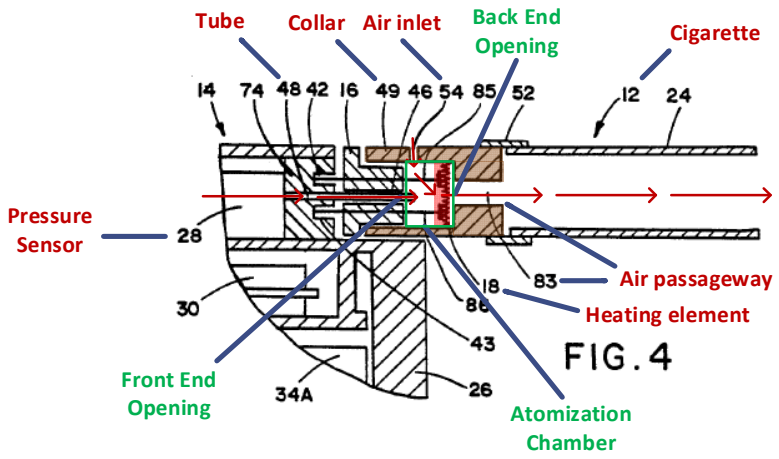
Claim 14.[f]	Brooks and Whittemore
	(e) a mouth end. 132. The smoking article of claim 131, wherein the aerosol forming substance is carried by the heating element." *Id.* at claims 131, 132 "11. The cigarette of claim 10, wherein the heating element is positioned substantially perpendicularly to the longitudinal axis of the air passageway." *Id.* at 23:11-13 (claim 11). "36. The disposable article of claim 35, wherein the heating element is positioned substantially perpendicularly to the longitudinal axis of the air passageway." *Id.* at 24:22-24 (claim 36). "54. The disposable article of claim 53, wherein the heating element is positioned substantially perpendicularly to the longitudinal axis of the air passageway." *Id.* at 25:16-18 (claim 54). "134. The smoking article of claim 133, wherein the aerosol forming substance is carried by the heating element." *Id.* at claim 134. "135. The smoking article of claim 131, 132, 133 or 134, wherein the heating element is positioned substantially perpendicularly to the longitudinal axis of the air passageway." *Id*. at claim 135. *Id.* at Figs. 2, 4, 6 (see annotated Figs. 2, 4, 6 as shown above). *Also see* evidence in claim 14.[e] above. **Whittemore**

Claim 14.[f]	Brooks and Whittemore
	 Ex. 1004, Whittemore at Fig. 2 (annotated). "In the drawing A designates the vaporizing vessel of my improved unit, said vessel being preferably constructed in the form of a hollow glass container adapted to hold a liquid medicament x and provided with an electrically-operated heating means comprising two electrical conductors 1 and 2 and a filament or heating element 3 combined in such a way that when said conductors are energized by an electric current, the filament 3 will become heated." *Id.* at p. 1, 1:19-28. "In order that the unit will function properly, even though the heating element or filament 3 is spaced a considerable distance above or away from the medicament *x*, the unit is equipped with a wick D made of any suitable material and combined with the heating element or filament 3 in such a way that a portion of said wick is always in contact or approximate contact with the heating element or filament 3, and a portion of said wick is always in contact with the medicament in the vaporizing vessel, whereby said medicament will be carried by capillary action to a point where it will be vaporized by the heat from the filament 3." *Id.* at p. 1, 1:50-2:8. "A therapeutic vaporizing unit adapted to be plugged into a conventional socket terminal of an electric circuit,

Claim 14.[f]	Brooks and Whittemore
	comprising . . . a porous wick entwined within the filament for lifting the medicament by capillary attraction whereby the liquid becomes vaporized upon the filament becoming heated. *Id.* at Claim 9.

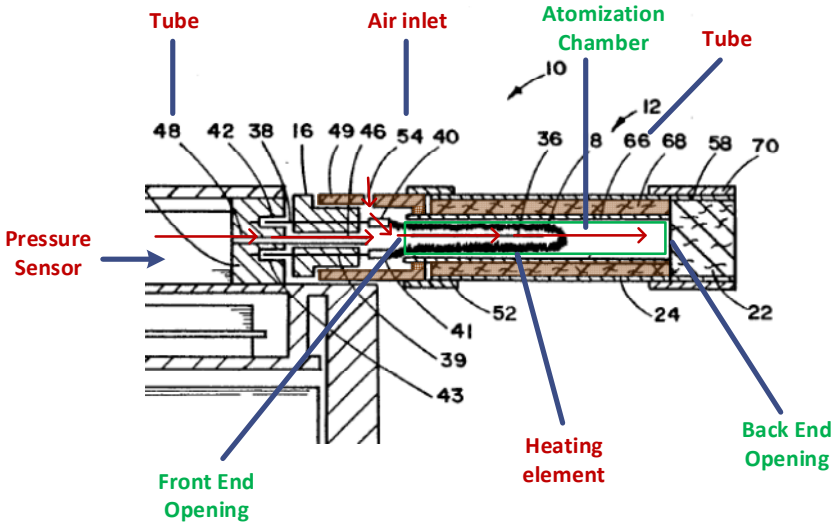
75. Below is a claim chart explaining where and how the claim language "[t]he device of claim 14 with the atomization chamber having a uniform diameter along the length of the atomization chamber" is disclosed.

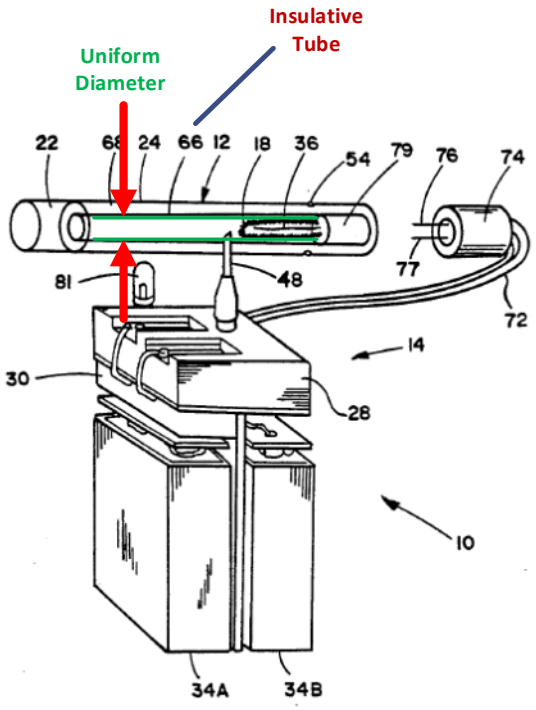
Claim 15	Brooks and Whittemore
15. The device of claim 14 with the atomization chamber having a uniform diameter along the length of the atomization chamber.	Brooks discloses the atomization chamber having a uniform diameter along the length of the atomization chamber. As discussed in claim 14.[e] above, Brooks discloses an atomization chamber as depicted by the green line in annotated Figs. 2 and 4. As illustrated in annotated Fig. 4 below, the atomization chamber is the hollow space surrounded by collar 49. Brooks teaches that the collar 49 has "the form of a thermoplastic tube," and may be formed "from a Delrin cylinder." Ex. 1003, Brooks at 8:43-50, 11:42-53, 17:21-22, 22:1-6, 21-32, Fig. 4. As illustrated in annotated Fig. 4 below, the atomization chamber has a uniform diameter along the length of the atomization chamber (cylindrical collar 49). *Id.*



Ex. 1003 at Fig. 4 (Annotated)

As shown in annotated Figs. 2-3 below, the alternative embodiment of the atomizer chamber, which is the hollow space in insulative tube 66, has a uniform diameter along its length. For example, Brooks discloses that in one embodiment, tube 66 is 39 mm long and has a 4 mm outer diameter. *Id*. at 17:28-31. Indeed, tube 66 is shown as having a consistent diameter in Fig. 2 and Fig. 3 as shown below.



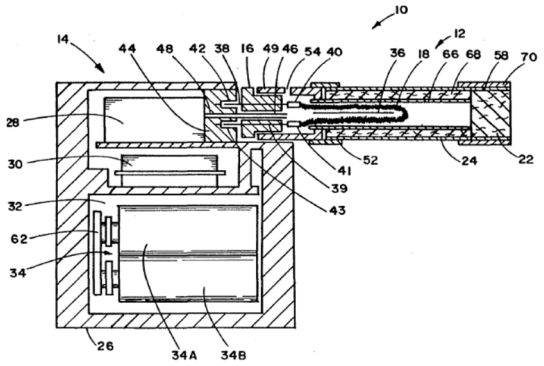
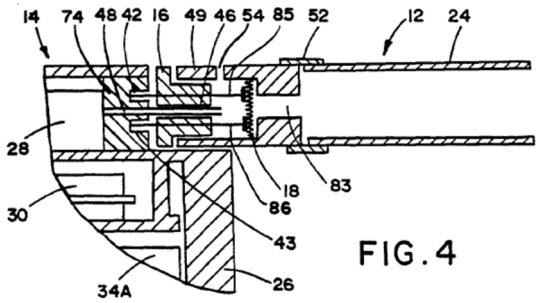
Claim 15	Brooks and Whittemore
	 FIG. 3 Ex. 1003 at Figs. 2-3 (Annotated) **Brooks**: *Id*. at Figs. 2-4 (see annotated Figs. 2-4 as shown above). "A portion of the length of the electrical connection plug 16 preferably is circumscribed by a collar 49 having the form of a thermoplastic tube, which preferably is friction fit around a portion of the length of the plug. The collar 49 in turn is secured to the remaining portion of the cigarette via overwrap 24 using tipping paper 52 or other appropriate means such as adhesive, a friction fit, or the like." *Id.* at 8:43-50. "Referring to FIG. 4, the illustrated embodiment is generally similar to the embodiment of FIG. 2, except that the heating element 18 is a circular disc or pad, preferably formed from an American Kynol carbon felt. The pad is permeable to airflow, and is disposed across an air passageway 83 in tubular collar

Claim 15	Brooks and Whittemore
	49 so that drawn air entering the cigarette 12 through opening 54 passes through the heating element 18. Electrical connection pins 85, 86 from plug 74 contact the heating element and help hold it in place against collar 49. In this embodiment, the collar 49 can be a thermoplastic material, a thermally stable plastic material, a ceramic, or the like. The embodiment illustrated in FIG. 5 is generally similar to the embodiment of FIG. 1. In this embodiment, the heating element 18 is a circular disc or pad of carbon felt disposed across an air passageway 83 extending through tubular collar 49. The pad is held in place by shoulder 84 on the collar 49. In addition, the cigarette does not have an electrical connect plug. Instead, electrical connection pins 85, 86 for the heating element extend from a plug 74 located on the controller 14. The cigarette 12 is held in place relative to the controller 14 via a clip 89 extending from the controller, or other suitable connection means." *Id.* at 11:42-65. "A 9 mm long Delrin tube 49 was fabricated from an 8 mm diameter cylinder. One section, 6 mm long, had a 7 mm inner diameter (I.D.), and a second section, 3 mm long, had a 4 mm I.D. A single air inlet hole 54 was made about 4 mm from the 4 mm I.D. end of the tube using a No. 64 drill bit. The 7 mm I.D. end of the tube 49 was then friction fit over the 7 mm end of plug 16. A 39 mm long, 4 mm outer diameter Kapton polyimide tube 66 was slipped over the resistance element 18 and inserted about 4 mm into the 4 mm I.D. end of the Delrin tube 49." *Id.* at 17:21-31. "An insulative collar 49 was formed from a Delrin cylinder having a length of 9 mm and a diameter of 8 mm to a tubular form having a 3 mm segment of 4.5 mm I.D. and a 6 mm segment of 6 mm I.D. A single air inlet 54 was made about 4 mm from the 6 mm I.D. end of the collar.

Claim 15	Brooks and Whittemore
	… The resistance element 18 was inserted into the 6 mm I.D. end of the collar 49 to abut against the 4.5 mm I.D. portion of the collar. The 6 mm I.D. end of the collar 48 then was fit over the narrow end of plug 16 such that the flattened silver solder ends of pins 38 and 39 each contacted the resistance element 18. A resilient paperboard tube having an 8 mm O.D. and a length of 75 mm was abutted against the end of collar 49 opposite plug 16, and the two tubes were held in place using adhesive tape 52." *Id.* at 22:1-6, 21-32. *Also see* evidence in claim 14.[e] above.

76. Below is a claim chart explaining where and how the claim language "[t]he device of claim 14 with the heating wire coil having an outer diameter less than an inner diameter of the atomizing chamber" is disclosed.

Claim 16	Brooks and Whittemore
16. The device of claim 14 with the heating wire coil having an outer diameter less than an inner diameter of the atomizing chamber.	Brooks discloses this feature. As discussed in claim 14.[e] above, Brooks discloses an atomization chamber or atomizing chamber as depicted by the green line in annotated Figs. 2 and 4. (Independent claim 14 recites "*an* atomization chamber" while dependent claim 16 recites "*the* atomizing chamber." I have assumed for purposes of my analysis that the "atomization chamber" and "atomizing chamber" recited in claims 14 and 16, respectively, refer to the same component.) As discussed above, the atomization chamber in Fig. 2 is the hollow space surrounded by tube 66 and the atomization chamber in Fig. 4 is the area surrounded by the collar 49. In both embodiments, the heating wire coil is located inside the

Claim 16	Brooks and Whittemore
	atomizing chamber. Ex. 1003, Brooks at 11:6-9 ("the heating element 18 is positioned within a heat resistant, insulative tube 66"), 42-45. This necessarily means that the wire must have an outer diameter that is less than the inner diameter of the atomization chamber. Indeed, if it did not, then the atomizers would not fit inside them. Notably, in every figure in Brooks, the heating element fits inside the atomization chamber. **Brooks**:  FIG. 2  FIG. 4

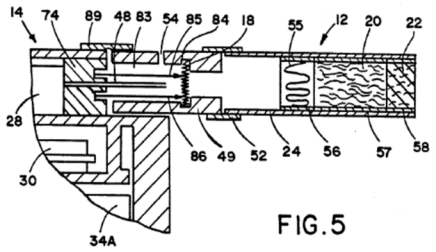


FIG.5

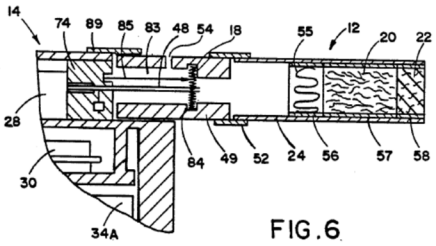


FIG.6

Id. at Figs. 2, 4-6.

"The embodiment illustrated in FIG. 2 is generally similar to the embodiment of FIG. 1, except that the heating element 18 is positioned within a heat resistant, insulative tube 66." *Id.* at 11:6-9.

"Referring to FIG. 4, the illustrated embodiment is generally similar to the embodiment of FIG. 2, except that the heating element 18 is a circular disc or pad, preferably formed from an American Kynol carbon felt. The pad is permeable to airflow, and is disposed across an air passageway 83 in tubular collar 49 so that drawn air entering the cigarette 12 through opening 54 passes through the heating element 18. Electrical connection pins 85, 86 from plug 74 contact the heating element and help hold it in place against collar 49. In this embodiment, the collar 49 can be a thermoplastic material, a thermally stable plastic material, a ceramic, or the like.

The embodiment illustrated in FIG. 5 is generally similar to the embodiment of FIG. 1. In this embodiment, the heating element 18 is a circular disc or pad of carbon felt disposed across an air passageway 83 extending through tubular collar 49. The pad is held in place by shoulder 84 on the collar 49. In addition, the cigarette does not have an electrical connect plug. Instead, electrical connection pins 85, 86 for the heating

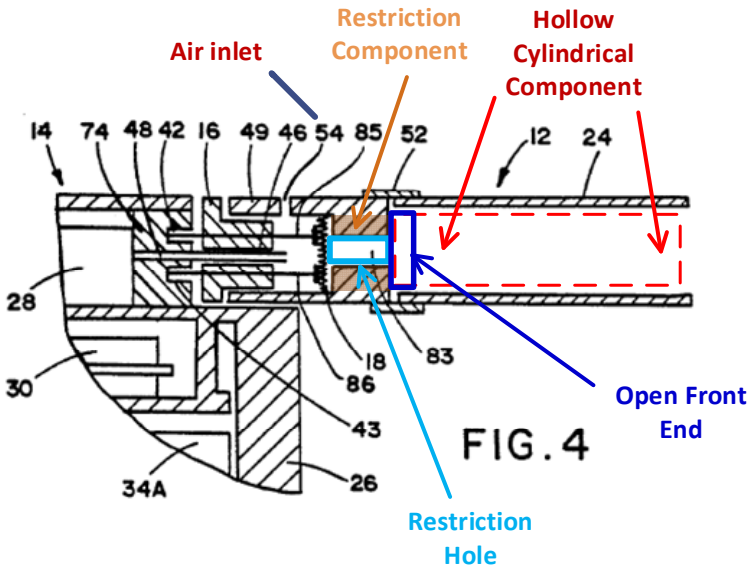
Claim 16	Brooks and Whittemore
	element extend from a plug 74 located on the controller 14. The cigarette 12 is held in place relative to the controller 14 via a clip 89 extending from the controller, or other suitable connection means. The embodiment illustrated in FIG. 6 is generally similar to the embodiment of FIG. 5, except that the pressure sensing tube 48 also is used as one of the connecting pins (e.g., in lieu of connection pin 86 of FIG. 5).” *Id.* at 11:42-12:2. *Also see* evidence in claim 14.[e] above.

77. Below is a claim chart explaining where and how the claim language “[t]he device of claim 14 further including a restriction component between the hollow cylindrical component and the at least one air inlet, with the restriction component having a restriction hole smaller than the open front end of the hollow cylindrical component” is disclosed.

Claim 18	Brooks and Whittemore
18. The device of claim 14 further including a restriction component between the hollow cylindrical component and the at least one air inlet, with the restriction component	I note that claim 18 depends from claim 14, and recites “*the* hollow cylindrical component’” “*the* at least one air inlet,” and “*the* open front end of the hollow cylindrical component.” Claim 14, however, does not recite any “hollow cylindrical component,” “at least one air inlet,” or “open front end of the hollow cylindrical component.” Thus, the terms “*the* hollow cylindrical component’” “*the* at least one air inlet,” and “*the* open front end of the hollow cylindrical component” recited in claim 18 lack antecedent basis. I have assumed for purposes of my analysis that claim 18 requires “*a* hollow cylindrical component,” “*an* at least one air inlet” and “*an* open front end of the hollow cylindrical

Claim 18	Brooks and Whittemore
having a restriction hole smaller than the open front end of the hollow cylindrical component.	component" when these terms are recited first time in the claim. Brooks discloses a collar 49 circumscribing electrical connection plug 16 at one end and including "one or more peripheral air inlet openings 54." Ex. 1003, Brooks at 8:43-57, Figs. 2, 4. The other end of collar 49 opposite to the end circumscribing the plug 16 is a necked portion (highlighted in light brown color in annotated Fig. 4 below) which narrows the space immediately after the heating element 18 and defines an air passageway 83. *Id.* at 11:42-53, 22:21-23, Fig. 4. As discussed in claim 15 above, the collar 49 has a tubular or cylindrical shape. Drawn air enters the cigarette 12 through air inlet 54, passes through heating element 18, and then exit through air passageway 83 defined by the necked, narrow portion of cylindrical collar 49. *Id.* The necked portion of cylindrical collar 49 narrows and thereby restricts the air flow from the atomization chamber to the mouthend, and therefore is a restriction component (highlighted in light brown color below) having a restriction hole (the internal hollow space formed by the cylindrical collar 49, highlighted in light blue below). Similarly, the front and back end openings of the restriction hole, and passageway 83 all have smaller diameters than the atomization chamber before the restriction

component.



Ex. 1003 at Fig. 4 (Annotated)

Brooks also discloses a hollow component between the necked, narrow portion of cylindrical collar 49 and plug spacer member 55, defined by overwrap tube 24. *Id.* at 8:43-50, 58-68, Figs. 4-6. Brooks further teaches that plug spacer member 55 can be a "cylindrical plug." *Id.* A PHOSITA would have understood that the hollow component disposed between the cylindrical collar 49 and cylindrical plug spacer member 55 would be cylindrical as well. The left side of the hollow cylindrical component (highlighted in dark blue) is open to the restriction hole in upstream, and thus is an open front end. Also as illustrated in annotated Fig. 4 above, the restriction component (necked, narrow portion of cylindrical collar 49 highlighted in light brown color) is located between the hollow cylindrical component (highlighted in red) and the at least one air inlet (air inlet openings 54), and the restriction hole (highlighted in light blue) is smaller than the open front end (highlighted in blue) of the hollow cylindrical component.

Brooks:

Id. at Fig. 4 (see annotated Fig. 4 as shown above).

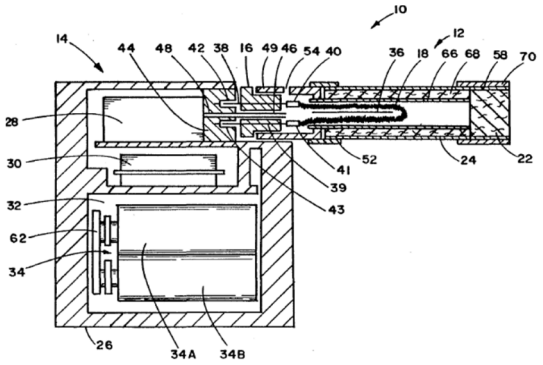


FIG. 2

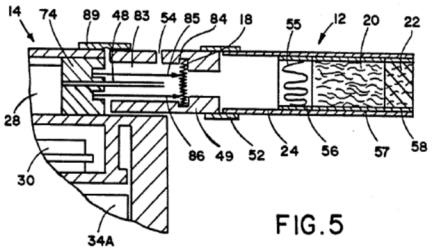


FIG.5

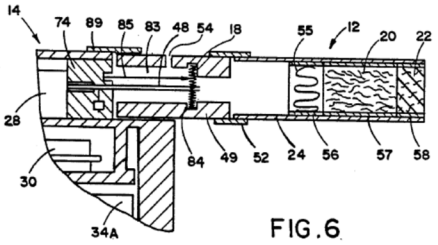


FIG.6

Id. at Figs. 2, 5-6.

"A portion of the length of the electrical connection plug 16 preferably is circumscribed by a collar 49 having the form of a thermoplastic tube, which preferably is friction fit around a portion of the length of the plug. The collar 49 in turn is secured to the remaining portion of the cigarette via overwrap 24 using tipping paper 52 or other appropriate means such as adhesive, a friction fit, or the like. Preferably, the collar 49 includes one or more peripheral air inlet openings 54 which provide a flow of ambient air through the cigarette during draw. Alternatively, the air inlet can be positioned through the extreme inlet end of the cigarette or elsewhere through the periphery of the cigarette, such that drawn ambient air passing through the cigarette to the mouth of the user passes the

Claim 18	Brooks and Whittemore
	resistance element. The cigarette can include a plug spacer member 55 positioned between the heating element 18 and the roll or charge of tobacco 20. The plug spacer member 55 conveniently permits passage of aerosol therethrough, while preventing tobacco filler from contacting the heating element. The plug spacer member can be a cylindrical plug of pleated tobacco paper (eg., pleated tobacco paper of the type commercially available from Kimberly-Clark Corp. as P144-185-GAPF Reconstituted Tobacco Sheet). Preferably, the spacer member is overwrapped with a paper overwrap 56." *Id.* at 8:43-68. "Referring to FIG. 4, the illustrated embodiment is generally similar to the embodiment of FIG. 2, except that the heating element 18 is a circular disc or pad, preferably formed from an American Kynol carbon felt. The pad is permeable to airflow, and is disposed across an air passageway 83 in tubular collar 49 so that drawn air entering the cigarette 12 through opening 54 passes through the heating element 18. Electrical connection pins 85, 86 from plug 74 contact the heating element and help hold it in place against collar 49. In this embodiment, the collar 49 can be a thermoplastic material, a thermally stable plastic material, a ceramic, or the like." *Id.* at 11:42-53. "The resistance element 18 was inserted into the 6 mm I.D. end of the collar 49 to abut against the 4.5 mm I.D. portion of the collar." *Id*. at 22:21-23. *Also see* evidence in claim 15 above.

78. I am not aware of any secondary considerations that would change my opinion.

VIII. CONCLUSION

79. For the reasons set forth above, it is my opinion that the subject matter recited in claims 14-16 and 18 of the 632 patent would have been obvious to a person having ordinary skill in the art at the time of the invention.

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

Dated: March 1, 2018

Dr. Robert H. Sturges

Exhibit A

CURRICULUM VITAE

Robert H. Sturges, Jr.

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; teleoperator controls research.
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 sheet metal and wire harness 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

CONSULTING EXPERIENCE: (from 5 years to present)

Canon, K.K.: Intellectual property, device analysis
Subject: Patent infringement issue involving driving hardware for toner cartridges, analysis of accused devices, validity analysis, ITC and IPR declarations.

PHPK, Inc: Intellectual property, device analysis
Analysis of drawing sets for cryogenic valves and fittings, determination of extent of copying of proprietary material.

Simmons Co.: Intellectual property, device analysis
Subject: Patent infringement issue involving automatic manufacture of bed frames, analysis of accused devices, validity analysis, software analysis.

National Standard, Inc.: Intellectual property, device analysis
Subject: Patent infringement issue involving automatic manufacture of weld wire, analysis of accused devices, validity analysis.

Legget & Platt, LLC.: Intellectual property, device analysis
Subject: Patent infringement issue involving automatic manufacture of wire frames for box springs, analysis of accused devices, validity analysis.

ROY-G-BIV Corp.: Intellectual property, software
Subject: Patent infringement issue involving motion control software, validity analysis.

Daifuku, Ltd.: Intellectual property, device analysis
Subject: Patent infringement issue involving automated material handling systems, analysis of accused devices, validity analysis, IPR rulings.

iLife Technologies: Intellectual property, device analysis
Subject: Patent infringement issue involving wearable sensor systems, analysis of accused devices, validity analysis.

La-Z-Boy, Inc.: Intellectual property, device analysis
Subject: Trade secret issue involving motion furniture mechanisms, analysis of accused devices.

RJ Reynolds, Inc.: Intellectual property, device analysis
Subject: Patent infringement issue involving electronic cigarettes.

Diebold, Inc.: Intellectual property, device analysis
Subject: Automated teller machines, analysis of devices, expert report, court testimony.

SRAM: Intellectual property, device analysis
Subject: Patent infringement issue involving bicycle components, IPR declarations.

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. Pogozelski, “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, “Analaysis 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 Rezania, “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 Machinese," 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"

In Progress:

R. Jientrakul, "Vision-based Factory Automation"
R. Rich, "Optimization of a Truck-drone in Tandem Delivery Network"

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.

Fall 2004 In ISE4264 Selected a new up-to-date textbook, authored ten new hands-on assignments, carried out major upgrade to the equipment in the DH197 lab for this purpose.

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.

j3. Sturges, R.H., and Wright, P.K., 1989 "A Quantification of Dexterity," *Journal of Robotics and Computer Integrated Manufacturing,* Vol. 6, No. 1, pp 3-14.

j4. Sturges, R.H., 1989. "A Quantification of Manual Dexterity: the Design for Assembly Calculator," *Journal of Robotics and Computer Integrated Manufacturing,* Vol. 6 No. 3, pp 237-252.

j5. Sturges, R.H., 1989. "Toward a Rational Workholding Methodology" *Journal of Robotics and Computer Integrated Manufacturing.* Vol. 9, No. 3.

j6. Sturges, R.H., and Wang, W., 1990. "Application and Experimental Results of Geometric Models of Face Milling" ASME *Manufacturing Review.* Vol 3, No. 2, pp 115-122.

j7. Sturges, R.H., 1990. "A Quantification of Machine Dexterity Applied to an Assembly Task," *International Journal of Robotics Research,* Vol 9. No. 3, pp 49-62.

j8. Wong, J. H.-W., and Sturges, R.H., 1992. "Design for Assembly Factors for Large and Heavy Parts" *ASME Journal of Mechanical Design,* Vol. 116. No. 2, pp 508-510.

j9. Sturges, R.H., 1992. "Monitoring Milling Processes through AE and Tool/Part Geometry," ASME *Journal of Engineering for Industry.* Vol. 114, No. 1, pp 8-14.

j10. Sturges, R.H., and Kilani, M., 1992. "Towards an Integrated Design for Assembly Evaluation and Reasoning System" *Journal of Computer Aided Design.* Vol 24, No. 2, February, pp 67-79.

j11. Kilani, M. I., and Sturges, R.H., 1992. "Detection and Evaluation of Orientation Features for CAD Part Models" *Journal of Engineering Design.* Vol 2, No. 3, Jan 1992.

j12. Sturges, R.H., and Laowattana, S., 1993. "A Flexible Tendon-Controlled Device for Endoscopy," *International Journal of Robotics Research.* Vol. 12 No. 2, pp 121-131, April 1993

j13. Sturges, R.H., O'Shaughnessy, K., & Reed R. G., 1993. "A Systematic Approach to Conceptual Design Based on Function Logic" *Int'l Journ. of Concurrent Engineering: Research & Applications (CERA),* Vol. 1, No. 2, June 1993, pp 93-106.

j14. Sturges, R.H., 1994. "A Review of Teleoperator Safety," *Int'l Journ. of Robotics and Automation,* Vol. 9, No. 4, Nov, 1994, pp 175-187.

j15. Reed, R.G., & Sturges, R.H., 1994. "A Model for Performance-Intelligent Design Advisors," *Int'l Journ. of Concurrent Engineering: Research & Applications (CERA),* Vol. 2, No. 3, Sept. 1994.

j16. Sturges, R.H., 1995. "Design of a Vernier Punch and Die Set for Single-Minute Bending Set-Ups," *Journal of Mechanical Design.* Vol 117, No. 3, pp 396-401.

j17. Sturges, R.H., and Laowattana, S., 1995. "Virtual Wedging in Three Dimensions," *Journal of Mechanical Design.* Vol 118, No. 1, pp 99-105.

j18. Sturges, R.H., & Laowattana, S., 1995."Design of an Orthogonal Compliance for Polygonal Peg Insertion," *Journal of Mechanical Design.* Vol 118, No. 1, pp 106-114.

j19. Sturges, R.H., Kilani, M., and O'Shaughnessy, K., 1995. "A Computational Model of Conceptual Design Based on Extended Function Logic" *AI EDAM.* Vol. 10, pp. 255-274.

j20. Elkins, K. & Sturges, R.H., 1996. "In-Process Angle Measurement and Control for Sheet Metal Manufacture," *Journ. of Intelligent Manufacturing.* Vol. 7, No. 3, pp 177-187.

j21. Roston, G. & Sturges, R.H., 1996. "Genetic Algorithm Synthesis of Four-bar Mechanisms," *AI EDAM,* Vol. 10, pp. 371-390.

j22. Sturges, R.H. & Hunt, D.O., 1996."Acquisition Time Reduction through New Design for Assembly Heuristics," *Journ. of Engineering Design.* Vol. 7 No. 2, Spring, 1996, pp 195-208.

j23. Roston, G. & Sturges, R.H., 1996. "Using the Genetic Design Methodology for Structure Configuration," *Microcomputers in Civil Engineering.* Vol. 11 , No. 3, pp. 175-184.

j24. Sturges, R.H., Laowattana, S., & Sathirakul, K, 1996. "Directly Visualizing Spatial Freedom from Solid Models," *International Journal of Robotics Research.* Vol 15, No. 5, pp. 505-521.

j25. Wang, C-H., & Sturges, R.H., 1996. "Preliminary Process Planning with Concurrent Multiple Representations of Parts," *Journ. of Intelligent Manufacturing.* Vol 7, pp 133-144.

j26. Sturges, R.H., & Sathirakul, K., 1998. "Jamming Conditions for Multiple Peg and Hole Assemblies," *Robotica,* Vol. 16 pp. 329-345.

j27. Elkins, K. & Sturges, R.H., 1999 "Non-Iterative Control of Small Radius Bend Angle." *SME Journal of Manufacturing Processes.* Vol 1, No 1, pp. 18-30, May 1999.

j28. Elkins, K. & Sturges, R.H., 1999 “Springback Analysis and Control in Small Radius Air Bending,” ASME *Journal of Manufacturing Science and Engineering.* Vol. 121, No. 4, pp. 679-688.

j29. Sturges, R.H., & Laowattana, S., “Constraint Network Analysis of Three Dimensional Insertion Tasks,” *Journal of Intelligent Manufacturing.* Volume 13, No. 1, February 2002, pp 19 – 38

j30. Elkins, K. & Sturges, R.H., “Design of a Sensor for On-Line Measurement of Loaded Bend Angle for Pressbrake Control,” *Journal of Flexible Automation and Intelligent Manufacturing.* December 2000.

j31. Ayyadevara, V. R., Bourne, D.A., Shimada, K., and Sturges, R.H., "Interference-free Polyhedral Configurations for Stacking" IEEE Transactions on Robotics and Automation, Vol.18, No.2, Apr 2002, pp 147-165

j32. Babiceanu, R. F., F. Frank Chen, Robert H. Sturges, “A Framework for Control of Automated Material Handling Systems using the Holonic Manufacturing Approach,”. accepted by the *International Journal of Production Research* (IJPR). Scheduled for publication: August 2004

j33. Sturges, R.H., 1999 "Myth and Value in Conceptual Design" accepted by *Journal of Flexible Automation and Intelligent Manufacturing.*. Publication date uncertain due to merger of the Journal.

j34. Sturges, R.H., & Sathirakul, K., “Multiple Peg Assembly Analysis through a Partitioning of the Jamming Space,” accepted *Journal of Applied Mechanisms and Robotics.* April, 2000.

j35. Sturges, R.H., & Sathirakul, K., "Solving Off-Axis Peg-In-Hole Insertion Problems With An RRR Compliant Mechanism" accepted *Journal of Applied Mechanisms and Robotics.* April, 2000.

j36. Kanarat, A. and Sturges, R. H., “Motion planning for nonholonomic mobile robots under control uncertainty,” *Computer-Aided Design and Applications,* Vol. 1 Nos. 1-4, 2004, CAD ’04, pp tbd

j37. Anderson, R. and Sturges, R. H., “The Use of Behavior in the Design of Complex Systems” *Computer-Aided Design and Applications,* Vol. 1 Nos. 1-4, 2004, CAD ’04, pp tbd

j38. R. F. Babiceanu, F. F. Chen and R. H. Sturges, "Real-Time Holonic Scheduling of Material Handling Operations in a Dynamic Manufacturing Environment," Robotics and Computer Integrated Manufacturing, 2004, (accepted 8/2004).

j39. R. F. Babiceanu, F. F. Chen and R. H. Sturges, "A Framework for Control of Automated Material Handling Systems Using the Holonic Manufacturing Approach," International Journal of Production Research, Vol. 42, No. 17, 2004.

j40. R. F. Babiceanu, F. F. Chen, and R. H. Sturges (2005) "The influence of material handling operations on the schedule makespan in manufacturing cell environments" *Transactions of NAMRI/SME*, Volume 33.

j41. Wiedmann, S., & Sturges, R.H., "A Full Kinematic Model of Thread-Starting for Assembly Automation Analysis", ASME Journal of Mechanical Design.Vol. 128:No. 1 pp 116-127

j42. Wiedmann, S., & Sturges, R.H., "Spatial Kinematic Analysis of Threaded Fastener Assembly", ASME Journal of Mechanical Design.Vol. 128:No. 1 pp 128-136

j43. Musa, R, Sturges, R.H., & Chen F.F. (2006) "Process Capability Allocation in the Extended Enterprise Environment" *Transactions of the NAMRI/SME*, Volume 34, pp tbd.

j44. Fong, N., & Sturges R.H., "A Control Design Strategy of a Reconfiguration Manufacturing System" accepted with revisions, *International Journal of Manufacturing Technology and Management* (IJMTM).

j45. Fong, N.H., Sturges, R.H & Shewchuk, J. "Dynamic Modeling of Multi-Stage Feedback Control Manufacturing Systems" *International Journal of Manufacturing Research (IJMR)* - special issue on "Innovation in Manufacturing", Vol.2, No.3, 2007.

j46. Fong, N.H., & Sturges, R.H., "Complex Plane Design Strategy for a Responsive Lean Manufacturing System", *International Journal of Computer Applications in Technology* (IJCAT) Vol 34 No. 3, 2009.

j47. Chaudhari, Gaurav S., Sturges, Robert H., Sandu, Corina, "Impact of combined feedback-feedforward control based ordering policies on supply chain stability and responsiveness", accepted by *Systems Research and Behavioral Science,* 2011, pp-tbd.

j48. Daniel W. Steeneck , Timothy C. Krometis, Robert H. Sturges, "A Procedure for Using Ship Tow-tank Data to Simulate Ship Motion and Inclusion of Perturbations", *Computing Science and Technology International Journal* (*CSTIJ*), Vol. 2, No. 4 (September, 2012) ISSN 2162-0660 (print) ISSN 2162-0667 (on-line).

j49. David B. Bateman, Igor A. Zamlinsky, and Robert H. Sturges, "Controller and Platform Design for a Three Degree of Freedom Ship Motion Simulator", *Computing Science and Technology International Journal* (*CSTIJ*), Vol. 2, No. 3 (September, 2012) ISSN 2162-0660 (print) ISSN 2162-0667 (on-line).

j50. Sturges, R.H., " Real-World Automation Control through the USB Interface". *Int'l Journ. of Engineering Inventions*, ISSN: 2278-7461, Vol. 2, No. 6, pp 48-56, April 2013.

j51. Anderson, R.J., & Sturges, R.H., "System Behaviors and Measures: Logical and State Complexity in Naval Weapons Elevators". *Complex Systems*, Vol 22, No. 3. pp 247-309

j52. Anderson, R.J., & Sturges, R.H., "System Behaviors and Measures: Compressed State Complexity and Number of Unique States Used in a Naval Weapons Elevators". *Complex Systems,* Vol 23, No. 1. pp 27-54, 2014

j53. Anderson, R.J., & Sturges, R.H., "Static Measures of Complexity in Naval Weapons Elevator System, Alternative Logic, and Mobile Carriage Systems". *Complex Systems,* Vol 23, No. 2. pp 149-176, 2014

j54. Sturges, R.H., "Material Removal by Arc Ablation". *Int'l Journ. of Engineering Science and Invention,* ISSN: 2319-6734, Vol. 3, No. 6, pp 1-6, June 2014.

j55. Sturges, R.H., "Simple and Inexpensive Hobbing for the General Shop". *Int'l Journ. of Engineering Inventions,* ISSN: 2278-7461, e-ISSN: 2278-7461, p-ISSN: 2319-6491, Volume 4, Issue 8 [January 2015] pp: 14-22.

j56. Ferrandez, S.M., Harbison, T., Weber, T., Sturges, R.H., Rich, R.K., "Optimization of a Truck-drone in Tandem Delivery Network Using K-means and Genetic Algorithm", *Journal of Industrial Engineering and Management,* JIEM, 2016 – 9(2): 73-89 – Online ISSN: 2013-0953 – Print ISSN: 2013-8423

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j60. Kanarat, A. & Sturges, R. H., "Modeling and Simulation of a Multi-Unit Tracked Vehicle" , submitted for review to the Journal of Robotic Systems.

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E. *Abstracts, Reviews:* None

F. *Other Writings:*

Theses:

Sturges, R.H., 1969. "Design Modifications of the ME Brailler," 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 Axisymm-etric 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.

Exhibit B

Robert H. Sturges, Jr., Ph.D., PE

Litigation Support Experience

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Reed Smith
Case Name:	Vamco v. Sankyo
Services Provided:	Hired by Vamco, expert report, depositions, testimony
Disposition:	Judgment in favor of Vamco
Date:	February 1991

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Buchanan Ingersoll
Case Name:	TDC Electronics v. Toll Partners, Inc.
Services Provided:	Hired by Toll Partners, expert report, depositions, testimony
Disposition:	Judgment (3x) in favor of Toll Partners
Date:	August 1992

Expert Engagement:

Type of Matter:	Trade Secret
Law Firm:	Buchanan Ingersoll
Case Name:	Hauser v. RACO
Services Provided:	Hired by Hauser, expert report, depositions, testimony
Disposition:	Judgment in favor of Hauser
Date:	October 1992

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Reed Smith
Case Name:	McClain v. KNI
Services Provided:	Hired by KNI, expert report, depositions, demonstratives, testimony
Disposition:	Judgment in favor of KNI
Date:	June 1994

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Buchanan Ingersoll
Case Name:	Stnd Car Truck v. A. Stucki Co.
Services Provided:	Hired by A. Stucki Co, expert report, depositions, demonstratives, testimony
Disposition:	Judgment in favor of Stucki
Date:	Aug 1995

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Cleary Gottlieb
Case Name:	Ricoh Co v. ICMI/Nashua
Services Provided:	Hired by Ricoh, expert report, depositions, testimony
Disposition:	Judgment in favor of Ricoh
Date:	May 1996

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Buchanan Ingersoll
Case Name:	Ductmate v. Mez
Services Provided:	Hired by Ductmate, expert report, depositions, testimony
Disposition:	Judgment in favor of Ductmate
Date:	May 1996

Expert Engagement:

Type of Matter:	Patent
Law Firm:	N/A
Case Name:	II-VI Corp. v. Raiskin
Services Provided:	Hired by II-IV Corp, expert report, depositions, testimony
Disposition:	Judgment in favor of II-VI
Date:	Jan 1996

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Merchant & Gould
Case Name:	Century v. Chevron
Services Provided:	Hired by Chevron, expert report, depositions, testimony
Disposition:	Judgment in favor of Chevron
Date:	March 1996

Expert Engagement:

Type of Matter:	Accident
Law Firm:	Buchanan Ingersoll
Case Name:	Kennedy v. Shadyside Hospital
Services Provided:	Hired by Shadyside Hospital, expert report, depositions
Disposition:	Settled in favor of Shadyside Hospital
Date:	Sept 1996

Expert Engagement:
Type of Matter: Patent
Law Firm: Buchanan Ingersoll
Case Name: AGR
Services Provided: Hired by Buchanan Ingersoll, written opinion
Disposition: ---
Date: Sept 2001

Expert Engagement:
Type of Matter: Patent
Law Firm: Buchanan Ingersoll
Case Name: Electrogrip v. MEC
Services Provided: Hired by MEC, expert report, deposition
Disposition: Settled
Date: Aug 1998

Expert Engagement:
Type of Matter: Patent
Law Firm: Kane Dalsimer
Case Name: Daktronics v. Trans-lux
Services Provided: Hired by Trans-lux, expert report, depositions
Disposition: Settled
Date: October 1999

Expert Engagement:
Type of Matter: Patent
Law Firm: Kane Dalsimer
Case Name: Kirsh v. Brother, Int'l
Services Provided: Hired by Brother Int'l, expert report, depositions, testimony
Disposition: Settled
Date: June 1999

Expert Engagement:
Type of Matter: Trade Secret
Law Firm: N/A, FTI Consulting
Case Name: Memtec v. Puroflow
Services Provided: Hired by Memtech, expert report, depositions, testimony
Disposition: Judgment in favor of Puroflow
Date: February 1999

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Myers Bigel
Case Name:	Tee-Lok v. MiTek
Services Provided:	Hired by Tee-Lok, expert report, depositions, testimony
Disposition:	Judgment in favor of MiTek
Date:	August 1999

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Lewis Rice
Case Name:	Engle v. Systemation
Services Provided:	Hired by Engle, expert report, depositions, testimony
Disposition:	Judgment in favor of Engle
Date:	2000

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Buchanan Ingersoll
Case Name:	GETS v. Wabtech
Services Provided:	Hired by Wabtech, expert report, depositions, testimony
Disposition:	Judgment in favor of Wabtech
Date:	May 2003

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Lewis Rice
Case Name:	TruFitness v. Precor
Services Provided:	Hired by TruFitness, expert report, depositions, testimony
Disposition:	Judgment in favor of TrueFitness
Date:	Jan 2001

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Lewis Rice
Case Name:	SRAM v. AD-II
Services Provided:	Hired by SRAM, expert report, depositions, testimony
Disposition:	Judgment in favor of SRAM
Date:	Jan 2002

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Pillsbury Winthrop
Case Name:	Kirsch v. TABS
Services Provided:	Hired by TABS, expert report, depositions, testimony
Disposition:	Judgment in favor of TABS
Date:	Feb 2006

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Stradling Yocca
Case Name:	Intuitive v. Computer Motion
Services Provided:	Hired by Computer Motion, expert report, depositions, testimony
Disposition:	Settled: buyout of Computer Motion by Intuitive
Date:	May 2003

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Moss & Rocovich
Case Name:	Musser v. Group7
Services Provided:	Hired by Musser, expert report, depositions, testimony
Disposition:	Judgment in favor of Musser
Date:	March 2004

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Reed Smith
Case Name:	Medrad v. Liebel-Flarsheim
Services Provided:	Hired by Medrad, expert report, depositions, testimony
Disposition:	Judgment in favor of Medrad (historic)
Date:	March 2005

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Buchanan Ingersoll
Case Name:	Newell v. Intercrown
Services Provided:	Hired by Intercrown, expert report, deposition
Disposition:	Settled
Date:	Aug 2010

Expert Engagement:
Type of Matter: Contract/Technical
Law Firm: N/A
Case Name: Morrill Motors v. Lamb Technicon
Services Provided: Hired by Lamb Technicon, expert report, depositions, testimony
Disposition: Settled in favor of Lamb Technicon
Date: March 2005

Expert Engagement:
Type of Matter: Patent
Law Firm: Oblon Spivak
Case Name: Ricoh v Katun
Services Provided: Hired by Ricoh, expert reports, depositions
Disposition: Settled
Date: June 2007?

Expert Engagement:
Type of Matter: Patent
Law Firm: Oblon Spivak
Case Name: NPI v. Gamber-Johnson
Services Provided: Hired by Gamber-Johnson, expert report, deposition
Disposition: Settled
Date: June 2006

Expert Engagement:
Type of Matter: Patent
Law Firm: Myers Bigel
Case Name: Avitech v. Embrex
Services Provided: Hired by Embrex, expert report, depositions, testimony
Disposition: Settled in favor of Embrex
Date: ?

Expert Engagement:
Type of Matter: Patent
Law Firm: Vorys Sater Seymour & Pease
Case Name: Kendall Holdings v. Eden Cryogenics, LLC
Services Provided: Hired by Kendall, expert report, court testimony
Date: 2008-11

Expert Engagement:
Type of Matter: Patent
Law Firm: Banner & Witcoff
Case Name: Sure Bros. v. N/A
Services Provided: Hired by Sure Bros., expert report
Disposition: Settled

Date: Feb 2008

Expert Engagement:
Type of Matter: Patent
Law Firm: Polsinelli
Case Name: Dentsply v. Forestadent
Services Provided: Hired by Dentsply, expert report, depositions, testimony
Disposition: Judgment in favor of Forestadent
Date: Feb 2010

Expert Engagement:
Type of Matter: Trade Secret
Law Firm: Vorys Sater
Case Name: Kendall Holdings v. Eden Cryogenics
Services Provided: Hired by Kendall, expert report, depositions, testimony
Disposition: Jury in favor of Kendall
Date: Oct 2013

Expert Engagement:
Type of Matter: Patent
Law Firm: Thompson Hine
Case Name: Hyko v. Hillman
Services Provided: Hired by Hyko, expert report, depositions, testimony
Disposition: Judgment in favor of Hyko
Date: June 2012

Expert Engagement:
Type of Matter: Patent, ITC
Law Firm: Fitzpatrick Cella
Case Name: Canon KK v. Multiple Defendants
Services Provided: Hired by Canon KK, expert report, depositions, testimony
Disposition: Judgment in favor of Canon KK
Date: August 2012

Expert Engagement:
Type of Matter: Patent
Law Firm: McDermott Will & Emory
Case Name: Lincoln Electric v. National Standard
Services Provided: Hired by National Standard, expert report, depositions, testimony
Disposition: Settled in favor of National Standard
Date: July 2012

Expert Engagement:
Type of Matter: Patent
Law Firm: Hayes Boone
Case Name: Imaginal v. Legget & Platt

Services Provided:	Hired by Legget & Platt, expert report, depositions, testimony
Disposition:	Settled in favor of Legget & Platt
Date:	Aug 2012

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Orrick
Case Name:	Imaginal v. Legget & Platt
Services Provided:	Hired by Legget & Platt, expert report, depositions, testimony
Disposition:	Settled in favor of Legget & Platt
Date:	Oct 2014

Expert Engagement:

Type of Matter:	Patent, IPR
Law Firm:	Fitzpatrick Cella
Case Name:	Canon KK v. General Plastic
Services Provided:	Hired by Canon KK, expert report, deposition
Disposition:	Jury held for Canon
Date:	20 June 2017

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Boies Schiller
Case Name:	ROY-G-BIV v. ABB
Services Provided:	Hired by ROY-G-BIV, expert report, depositions
Disposition:	Settled, ROY-G-BIV patents held valid in landmark AIA case
Date:	Sept 2014

Expert Engagement:

Type of Matter:	Patent
Law Firm:	Beck Thomas
Case Name:	Ductmate Ind. v. Famous Distr.
Services Provided:	Hired by Ductmate, expert report, declarations
Disposition:	Settled in favor of Ductmate
Date:	Nov 2014

Expert Engagement:

Type of Matter:	Patent
Law Firm:	McCarter English
Case Name:	OncQue v KAZ
Services Provided:	Hired by OncQue, expert report
Disposition:	Settled
Date:	November 2015

Expert Engagement:

Type of Matter: Patent
Law Firm: Dickstein Shapiro/ Blank Rome
Case Name: Murata v. Daifuku
Services Provided: Hired by Daifuku, expert report, depositions, IPR
Disposition: Settled
Date: Sept 2016

Expert Engagement:
Type of Matter: Patent
Law Firm: Munck Wilson Mandala
Case Name: Nintendo v iLife
Services Provided: Hired by iLife, expert report, depositions
Disposition: settled
Date: --

Expert Engagement:
Type of Matter: Patent
Law Firm: Greenberg Traurig
Case Name: Megdal v La-Z-Boy
Services Provided: Hired by La-Z-Boy, expert report, court testimony
Disposition: ---
Date: 6 March 2016

Expert Engagement:
Type of Matter: Patent
Law Firm: Brinks Gilson
Case Name: Fontem v RJReynolds Vapor
Services Provided: Hired by RJReynolds, IPR expert reports, depositions
Disposition: ongoing
Date: June 2016

Expert Engagement:
Type of Matter: Patent
Law Firm: Mintz Levin
Case Name: Medigus v Endochoice
Services Provided: Hired by Medigus, expert consulting
Disposition: Defendants defaulted
Date: 2 Nov 2016

Expert Engagement:
Type of Matter: Patent
Law Firm: Alston & Bird
Case Name: Hyosung v Diebold
Services Provided: Hired by Diebold, expert report, court testimony

Disposition: Hearing Completed
Date: 4 Nov. 2016

Expert Engagement:
Type of Matter: Patent
Law Firm: Lewis-Rice
Case Name: Fox Factory v SRAM; SRAM v Fox Factory
Services Provided: Hired by SRAM, expert reports, depositions
Disposition: On going
Date: Nov. 2016

Expert Engagement:
Type of Matter: Patent
Law Firm: Bragalone Conroy
Case Name: AMS/Wi-LAN v Multiple Defs
Services Provided: Hired by AMS, technical support
Disposition: On going
Date: April 2016

Expert Engagement:
Type of Matter: Patent
Law Firm: Foley & Lardner
Case Name: Honeywell v Research Products Corp
Services Provided: Hired by RPC, technical support
Disposition: On going
Date: Feb. 2018

Additional Litigation Consulting Experience

- Emery Tree Services, Inc., Pittsburgh, PA: Intellectual property, device analysis
- Baxter Healthcare, Chicago, IL: Manufacturing Process Analysis
- AGR International, Inc., Pittsburgh, PA: Intellectual property, device analysis
- U.S. Filter, Inc., Orlando, FL: Intellectual property, device analysis
- Enviro Tek, Inc., Waterford, VA: Process design and analysis
- Bear Archery, Inc., Orlando, FL: Manufacturing/Tolerance analysis
- Westinghouse AirBrake Company, Pittsburgh, PA: Intellectual property, device analysis
- Marvin Windows, Inc.: Intellectual property, device analysis
- Musser Lumber, Inc., device analysis.
- Excel Products, Inc.: Intellectual property, device analysis
- Simmons Co.: Intellectual property, device analysis

Additional Consulting Experience

- Rockwell International Corp., Raleigh, NC: Engine valve line welding robot design and controls
- W G Products, 7875 Saltsburg Rd., Pittsburgh, PA: Magnetic field/structure analysis for high current circuit breakers
- Westinghouse Electric Corp., Pittsburgh, PA: Robotic handling system design for Savannah River Laboratory,
- Hall Industries, Inc., Pittsburgh, PA: Electromechanical system design, manufacturing process controls
- Lord Corp, Aerospace Products Division, Erie, PA: Design for manufacture
- American Carbon & Metals Corp., Pittsburgh, PA: Design, device analysis
- Sensus Technologies, Inc., Uniontown, PA: Automatic assembly system analysis