

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Mercedes-Benz USA, LLC,
Petitioner,

v.

Westport Fuel Systems Canada, Inc.
Patent Owner.

Case IPR2023-00351
Patent 6,575,138

**DECLARATION OF DR. GLENN BOWER
IN SUPPORT OF MERCEDES-BENZ'S PETITION
FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 6,575,138**

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1. I, Dr. Glenn Bower, of the town of Arena, in the state of Wisconsin, United States of America, declare:

I. INTRODUCTION

A. Engagement

2. I have been retained on behalf of Mercedes-Benz USA, LLC (“**Petitioner**”) to offer technical opinions relating to U.S. Patent No. 6,575,138 (Ex. 1001) (the “**138**” or “**138 Patent**”) and prior art references relating to its subject matter.¹

3. I have no financial interest in any party or in the outcome of this proceeding. I am being compensated for my work as an expert on an hourly basis at my standard consulting rate. My compensation is not dependent on the outcome of these proceedings or the content of my opinions.

B. Background and Qualifications

4. I am currently a Scientist III at the University of Wisconsin-Madison Engine Research Center and Teaching Faculty III in the University of Wisconsin-Madison Mechanical Engineering Department. A copy of my curriculum vitae and past 5 years of professional witness history is included as Exhibit 1003.

¹ For brevity, when providing citations herein, I will generally refer to the name of the reference, rather than the exhibit number. The exhibit numbers associated with each reference can be found on Appendix A.

5. I earned the degree of Bachelor of Science in Mechanical Engineering from the University of Wisconsin-Platteville, and a Master of Science and a Doctor of Philosophy degree from the University of Wisconsin-Madison, both in the Department of Mechanical Engineering. My graduate advisor was Professor David E. Foster, who specialized in engines, combustion, and chemical kinetics.
6. I am a Board Certified Registered Professional Engineer in the State of Wisconsin: license # 29717.
7. In my roles of Scientist III at the University of Wisconsin-Madison Engine Research Center and Teaching Faculty III in the University of Wisconsin-Madison Mechanical Engineering Department, I teach or have taught various courses including engineering economics, freshman design, thermodynamics, fluid mechanics, internal combustion engines, and senior design. I also oversee the college's automotive shop and conduct research at the Engine Research Center. I have been on the faculty at the University of Wisconsin-Madison since 1997.
8. In addition to my teaching activities, I am the automotive advisor to several undergraduate and graduate level student automotive teams from the University Of Wisconsin College Of Engineering that are entered in international engineering design competitions. These competitions include/included the SAE Clean Snowmobile Challenge, the Baja SAE, the Formula SAE, FutureCar, FutureTruck, Challenge X, EcoCar and the SAE Autodrive Challenge II. As the automotive

advisor, I interact with approximately 50 students each semester that are enrolled in independent study. Each student selects his/her design project, some of which concentrate on calibrating an engine. To prepare each team for its international competition, I guide the students in designing, building, and testing all aspects of the vehicles. I teach students at all levels not only the technical aspects of building a vehicle, but the intricacies of each of the engine's components and how it affects the overall engine/vehicle performance. Several of the automotive teams program and calibrate their respective engine/vehicle controllers.

9. During Challenge X, I was the liaison to General Motors Europe for the distribution of the GM/Fiat 1.9 Liter Turbo-Diesel engine to all interested competitors. During preparation, I visited the GM/Fiat manufacturing and development facility in Turin, Italy. I interacted with engineers responsible for all aspects of this engine, including the Bosch common rail fuel injection system. I summarized all pertinent information and distributed it to the competitors.

10. I have been an active member of the Society of Automotive Engineers (SAE) since 1988.

11. In addition to being the faculty advisor for the Formula SAE, the Formula SAE Electric, Baja SAE, the SAE Clean Snowmobile and the SAE Autodrive Challenge II teams, I am the University of Wisconsin-Madison SAE Student Section Faculty advisor. I have served as the SAE Milwaukee Section Nominating

Committee Representative and routinely organize and chair technical sections for the SAE Small Engine Technology Conference. During my tenure, I have peer reviewed numerous technical papers.

12. I have been actively consulting since receiving my Ph. D. in 1992. I have developed and certified engine combustion analysis systems, been retained as a professional witness in personal injury cases and State of Wisconsin vehicular accident with injury cases, patent litigation, international arbitration and hybrid vehicle development.

13. I have extensive practical experience in automotive powertrains, including hybrids and electrics, alternative fuels, engine emissions, engine aftertreatment systems, vehicle testing, high speed photography and in-cylinder engine combustion in addition to engine and hybrid controls. I am an experienced machinist and welder.

14. I also have experience with the U. S. Patent system. I am a named inventor of U.S. Patent No. 6,231,135 B1 for a Hybrid Brake System.

C. Information Considered

15. I have reviewed the '138 Patent and its prosecution history as well as the other materials referenced below in Appendix A (Exhibits) and Appendix B (Additional Materials Considered). Counsel has informed me that I should consider these materials through the lens of one of ordinary skill in the art related to the

'138 Patent at the time of the earliest purported priority date of the '138 Patent, and I have done so during my review of these materials. I am informed that the '138 Patent claims priority to a provisional application (US60/159,791, EX1007, the “**Provisional**”). Based on my opinion below that the subject matter of Claims 1-3, 6, 13-14, 16-22, 26-28, and 41 of the '138 Patent are not disclosed by the Provisional, I have been asked to assume a priority date of March 9, 2000, for Claims 1-3, 6, 13-14, 16-22, 26-28, and 41 (the “**Critical Date**”).

16. My analyses are based on my years of education, research, and work experience, as well as my investigation and study of relevant materials.

17. I may rely on these and additional materials to respond to arguments raised by the Patent Owner. I may also consider additional documents and information in further analyses—including documents that may not yet have been provided to me.

18. My review and assessment of the materials provided in this proceeding is ongoing, and I will continue to consider any new material as it is provided. I reserve the right to review, supplement, and amend my analyses based on new information and on my continuing review of the materials already provided.

II. THE '138 PATENT

A. Background of the Technology

1. Overview of Reciprocating Internal Combustion Engines

19. Almost all internal combustion engines use reciprocating engine geometry where pistons move up and down inside the cylinders and, through each piston and a connecting rod, transfer power to the crankshaft and then to whatever the engine is driving. The pistons therefore move from the bottom of the cylinder to the top of the cylinder and then back down again. The bottom position of the piston is called "bottom dead center" ("BDC"), or sometimes "bottom center " ("BC"). The top position of the piston is called top dead center " ("TDC") or "top center" ("TC"). Each upward or downward motion of the piston is called a "stroke".

20. The most common type of internal combustion engine uses a four-stroke cycle (See Figure 1-2 from the 2nd Edition of Heywood below). These four strokes - a series of downward and upward motions of the piston - are called the intake stroke, compression stroke, expansion stroke and exhaust stroke. Normally, combustion occurs just before the end of the compression stroke through the start of the expansion stroke.

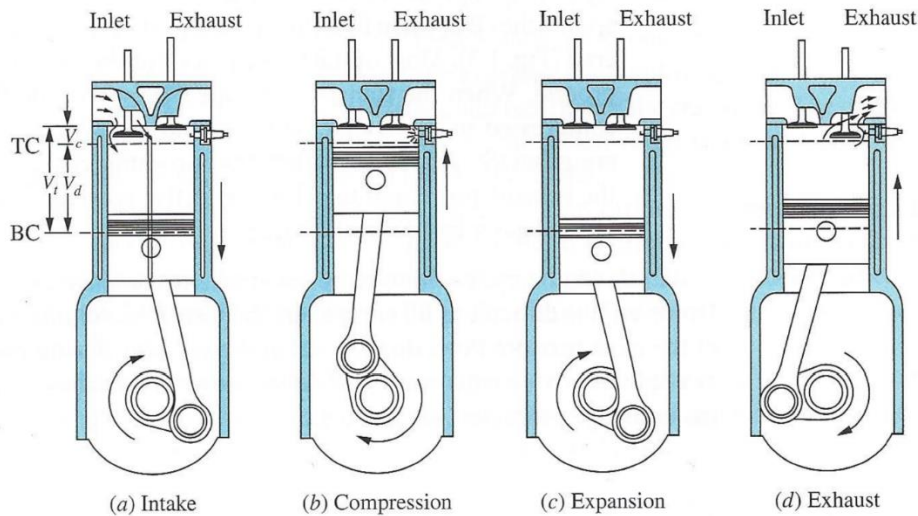


Figure 1.2 The four-stroke operating cycle.¹²

21. Internal combustion engines are used to produce power by burning hydrocarbon fuels mixed with air.

22. Compression-ignition (Diesel), internal combustion engines generate power at the crankshaft via reciprocating pistons that compress and ignite atomized/vaporized diesel fuel with air in the cylinders. Diesel engines activate intake and exhaust valves to pull ambient (intake) air into the engine and expel combusted products and/or used air out of the engine. Once the intake air is trapped in an engine's cylinder, it is compressed by pushing the piston upward in the cylinder causing the temperature and pressure of the trapped air to increase drastically. As the piston approaches its top-most position, the engine injects diesel fuel into this hot air at pressures over 20,000 psi (Heywood, 1st ed., at 522). This ultra-high injection pressure creates very small droplets that are subsequently

vaporized by the hot air in the cylinder. Once vaporized, it mixes with this trapped air. Ultimately, this vaporized fuel reaches its self-ignition temperature and the fuel ignites. Once the fuel ignites, it creates a local 'hot spot' that subsequently ignites any additional fuel and air mixtures entering this volume.

23. As the combustion process progresses, high-pressure, high-temperature exhaust gases are produced in the combustion chamber and the piston is "pushed" back down toward the bottom dead center position. Work is transferred from the high-pressure, high temperature gases by the downward movement of the piston to the crankshaft. The exhaust gases resulting from the combustion of the fuel and air mixture, along with any unburnt portion of the fuel and air mixture, are expelled through the cylinder exhaust port to an exhaust system for discharge to the atmosphere.

24. Spark-ignited (gasoline) engines are very similar to compression ignition engines except the start of the combustion process is initiated by producing a plasma (spark) using a spark plug. Once initiated, the combustion proceeds from the spark plug to the outer regions of the combustion chamber where the flame is extinguished next to the wall.

25. Gasoline engines under load, inject the exact amount of fuel necessary to combust almost all the oxygen molecule tapped in its cylinder. This is necessary to optimize the engines 3-way catalyst to create ultra-low emissions.

26. Diesel engines operating at capacity, in contrast, only utilize 50 to 60% of the oxygen trapped in their cylinders. The fuel being sprayed into the combustion chamber cannot mix with all of the air/oxygen in the combustion chamber.

27. Today, most Diesel engines utilize a common rail fuel injection system which allows for pre-injections, multiple main injections and post-injections. The pre-injections and main injections are ratioed and positioned by the engine manufacturer to produce acceptable levels of in-cylinder soot and Oxides of Nitrogen (NOx) while also reducing the audible noise that the engine emits.

28. According to Heywood (2nd ed., p. 546), the newest option for controlling multiple injections is a common rail fuel system operating at pressures up to 200 MPa is piezo-actuated injected needles. “Injectors . . . can provide up to five injections per cylinder per cycle. Use of the piezo-injectors in diesel engines reduces engine noise and air-pollutant emissions significantly, and increases power output and efficiency.”

29. Either compression-Ignition (Diesel) or spark-ignited engines can also utilize a turbochargers to extract energy from the exhaust products which is then used to compress the inlet air to double or triple the density of the surrounding atmosphere; increasing the power output of the engine.

2. What is a fuel injector used for?

30. A fuel injector is used to introduce a precise amount of fuel into an engine for combustion. The fuel injector is also intimate in the mixing of the fuel with air prior to/during combustion.

31. As emission standards have become more stringent for gasoline powered automobiles, the fuel injector was moved from the back side of the intake valve (i.e. port injection) to directly injecting into the cylinder. The change constrains the fuel to the combustion chamber which lowers evaporative emissions while eliminating transient fueling unknowns. Creating a cleaner, more responsive and more fuel efficient engine.

32. Gaseous fueled (normally natural gas) direct-injection engines injection engines require a means (i.e. compressor or pump) for delivering high pressure natural gas to the injector. The fuel has to be injected and allowed to mix with the combustion chamber air prior to be ignited by a glow plug, spark plug or a diesel pilot injection.

33. In compression ignition (Diesel) engines, the fuel is ‘broken’ into droplets while it is injected. The fuel evaporates from the surface of the droplets; for an injector producing smaller droplets, the fuel is evaporated quicker. Evolution of the compression ignition injector has led to higher injection pressures coupled with smaller nozzle holes which produce smaller droplets.

3. Parts of a fuel injector

34. All direct-injection injectors have similar features. The external shape is a normally a long cylinder as the injector has to be mounted through the depth of the cylinder head. The injection nozzle will protrude into the combustion chamber while the fuel will enter the injector through a fuel port on the top (fitting) or center (fuel passage integrated into cylinder head) of the injector body.

35. Internally, almost all fuel injectors have a spring that is responsible for sealing the injection needle against the injector nozzle. Internally, the injector has clearances so that the fuel can flow from the injector inlet port to the injector nozzle.

36. Gasoline and Diesel direct injection (DI) fuel injectors share the common purpose of distributing the fuel into their respective combustion chambers in such a way that the fuel and air are mixed and combusted as 'cleanly' and efficiently as possible. Regardless of engine type (i.e. gasoline or diesel), the nozzle geometry (i.e. nozzle type, number of holes, diameter of holes, location of holes) and injection pressure must be engineered so that the fuel spray is optimal for the combustion chamber geometry and the corresponding trapped air flow pattern/intensity for each engine.

37. Over the past 20 to 25 years, in automotive applications, most gasoline and diesel DI fuel systems incorporate a common rail (fuel rail) design. The incorporation of the common rail allows the engineer to independently vary the

injection pressure and the number and duration of injections. This technology was paramount to emission reductions and efficiency gains in this timeframe.

38. Generally, a gasoline DI fuel injector operates at a lower (i.e. 8% to 10%) injection pressure than a diesel fuel injector and must be accounted for when sizing the nozzle return/seating spring; a simple calculation that balances the spring force against the injection pressure pushing against any unbalanced needle area. A calculation that any undergraduate engineering student could complete: a mundane task for a POSITA.

39. All direct injection injectors will also have a mechanism for activating the injection process by overcoming the force of the spring sealing the injector nozzle.

40. According to the '138 patent, there are two different types of hydraulic operators that can be utilized to control of the injection process. There are active and passive.

41. An **active hydraulic operator** has a high pressure hydraulic source that generates the actuation force for the injector valve. ('138:1:16-21.) Piezo actuated injectors that utilize a differential piston (hydraulic amplifier) to amplify the actuators displacement is an example of an active hydraulic operator as defined by the '138.

42. A **passive hydraulic link** is defined by the '829 as being a 'sandwich' of hydraulic fluid that is axially compressed during the needle opening or closing.

The hydraulic fluid transmits a force but is not the source of the force.

43. It is impossible to utilize a **passive hydraulic link** in a natural gas injector without the integration of a non-consumable hydraulic fluid (provisional).

B. Background of the Patent

44. The challenged claims of the '138 are directed to internal combustion engine direct fuel injection systems, particularly high pressure injection systems. ('138, 1:16-21.) The background section of the '138 concedes that much of its disclosure exists in the prior art. The '138 concedes that the use of fuel injection valves actuated via piezoelectric or magnetostrictive actuators was already known. (Id., 2:58-62.) Additionally, the '138 acknowledges prior art valves using hydraulic amplifiers to transmit actuation forces. (Id., 2:52-57.)

45. When discussing the prior art, the '138 contends that the prior art valves have delayed valve actuation due to intermediate action of a hydraulic fluid – i.e., fluid displacement. (Id., 2:35-39.) The '138 further alleges that this problem can be overcome by removing the “intermediate active hydraulic operator generating any actuating forces” with an arrangement that permits direct actuation of the valve needle. (Id., 2:64-67.)

46. To supposedly correct this issue, the '138 discloses a “passive hydraulic link,” which it describes as allegedly being different and distinct from “[c]onventional active hydraulic operators.” (*Id.* at 7:27-39.) Specifically, the '138 describes an “passive hydraulic element” as using an associated high pressure hydraulic system

47. For example, the '138 indicates that these convention systems “need to be connected to a source [reservoir] of high pressure hydraulic fluid [fluid is pressurized using the pump] and have valves [control valve] for controlling the flow of the hydraulic fluid in and out of the active hydraulic operator [flow shown by arrows].” (*Id.* 7:39-44.) The '138 contends that operation of the active hydraulic operator includes moving the hydraulic fluid in and out of a hydraulic cylinder to generate the actuator force. (*Id.*) By adding fluid to the hydraulic cylinder, the needle is moved in a direction, and then when fluid is removed from the cylinder, the needle is moved in an opposite direction. (*Id.* 7:44-52.)

48. According to the '138, the “passive” hydraulic link includes a hydraulic cylinder 160 around a hydraulic piston 114b, in which the hydraulic piston 114b is free to move in a longitudinal direction within the hydraulic cylinder 160. (*Id.*, 11:65-12:3.)

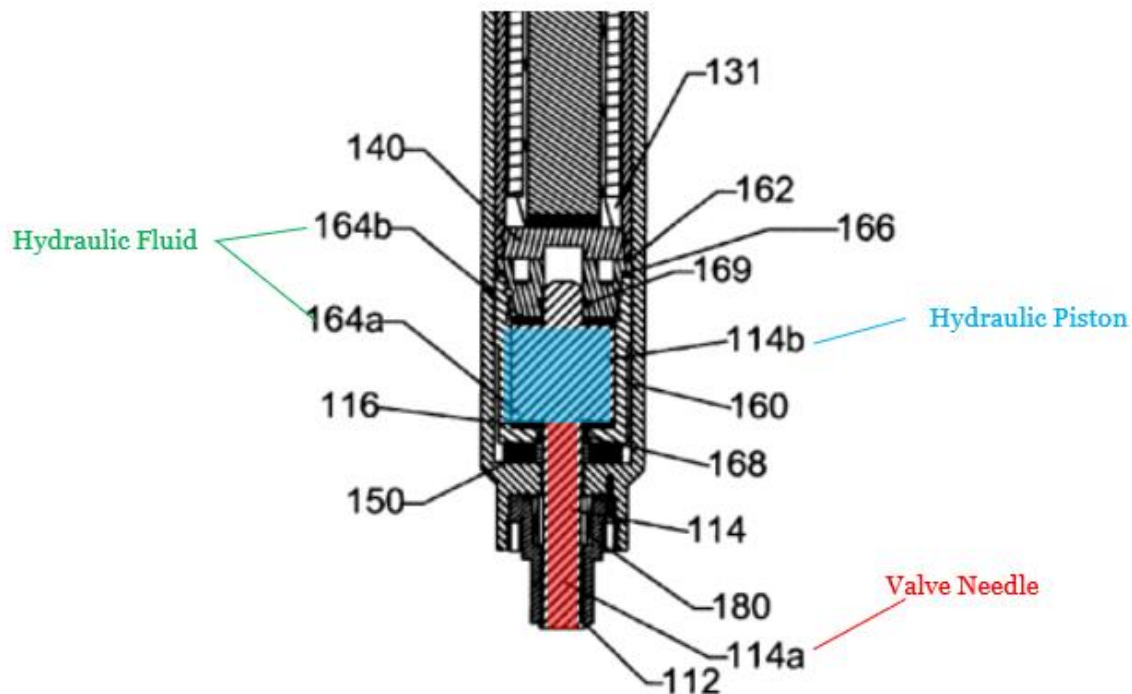


FIG. 1

(Id., FIG. 1 (cropped and annotated).)

49. Hydraulic fluid 164 is sealed within the hydraulic cylinder 160. (*Id.*, 12:7-9.)

A small gap between an outer diameter of the hydraulic piston 114b and the inner diameter of the hydraulic cylinder 160 permits the hydraulic fluid 164 to move from a bottom side of the hydraulic piston 114b to a top side of the hydraulic piston 114b, but the '138 indicates that “the flow of hydraulic fluid through the gap is insignificant during the time span of fuel injection events.” (*Id.*, 12:14-26.)

Therefore, as alleged by the '138, the hydraulic fluid 164 “has a sufficiently high

viscosity and bulk modulus so that it acts as an incompressible solid [during activation].”

50. I have reviewed the prosecution history of the '138. The '138 claims priority to the Provisional, filed on October 15, 1999, as well as U.S. Patent No. 6,298,829, filed on March 9, 2000 and issued on October 9, 2001. During examination, original claims 1-41 were rejected in view of U.S. Patent No. 5,630,550 (“**Kurishige**”) The rejection indicated that Kurishige expressly disclosed all elements of the independent claims with the exception of “the pressure transmitting fluid act[ing] substantially as a solid.” (*Id.*, 126.) However, the Office Action claimed that Kurishige’s teaching “an increase/decrease of the viscosity coefficient . . . of the pressure transmitting medium can be controlled between -30°C and 200°C which suggests that the fluid acts substantially as a solid.” (*Id.*)

51. In response, Patent Owner argued that the prior art, unlike the '138, taught displacement and dynamic flow of hydraulic fluid to cause movement of the needle valve, and taught an apparatus reliant on the flow of liquid hydraulic fluid from one chamber to another to operate a needle. (*Id.* at 133-36.) The Examiner then issued a Notice of Allowance generally reciting the independent claims of the '138 as “reasons for allowance.” (*Id.* at 168.)

C. Person of Ordinary Skill in the Art

52. It is my opinion that a person of ordinary skill in the art (“**Person of Ordinary Skill in the Art**”) in the field of the ‘138 Patent would have had a degree in mechanical engineering or a similar discipline, along with 2 years of professional experience working with the design and development of fuel injection systems for internal combustion engines or an equivalent level of skill, knowledge, and experience. This POSITA would be aware of and generally knowledgeable about how fuel injector valves are structured and operate, and how they are used to deliver fuel to an engine’s combustion chambers. The more education one has, the less experience needed to attain an ordinary level of skill.

53. I am familiar with the knowledge and capabilities of one of ordinary skill in these areas. Specifically, my experience working within the industry, with undergraduate and post-graduate students, with colleagues from academia, and with engineers practicing in industry has allowed me to become directly and personally familiar with the level of skill of individuals and the general state of the art.

D. Lack of Disclosure in Provisional

54. I have compared the Provisional to the claims of the ’138. Numerous claim elements required by the claims I reviewed (Claims 1-3, 6, 13-14, 16-22, 26-28, and 41) are not referenced anywhere in the Provisional, and are thus not supported, in my opinion, by the Provisional. First, independent claims 1 and 3 recite a

“hydraulic fluid thickness . . . with said thickness being substantially constant while said actuator assembly is activated and wherein said thickness of said hydraulic link is adjustable while said actuator is not activated.” This is not supported by the Provisional, which does not even use the terms “hydraulic fluid thickness,” “substantially constant,” or “adjustable.” (See Ex.1008, “Redline.”) Although, the Provisional describes hydraulic fluid within a hydraulic cavity of an injector, see Ex. 1008, 12 and 13, the “thickness” of this fluid is not described. Nor does the Provisional describe or explain that any “thickness” is “substantially constant” or “adjustable” depending on if the actuator assembly is activated, as claim 1 requires.

55. Second, independent claims 1 and 41 recite that the “hydraulic fluid acts substantially as a solid.” The Provisional does not support this at least because it does not describe the hydraulic fluid acting “substantially as a solid.” (See Redline) The Provisional only describes that the hydraulic fluid “acts as a solid,” (see Provisional, 12-13, but does not provide support for the broader limitation in the claims of the fluid acting only “substantially” as a solid.

56. Third, independent claims 1 and 41 recite an “interior chamber fluidly connected to said fuel inlet port” and “a fluid passage from said interior chamber to said combustion chamber.” The Provisional does not describe an “interior chamber” or a “fluid passage” from this chamber. Because the Provisional does not

describe any “interior chamber,” it also does not describe any such chamber “fluidly connected” to a fuel inlet port.

57. Fourth, the operating temperature of the Hydraulic Link was switched from -40 to 125 °F (p. 11:20) in the provisional to -40 to 125 °C in the patent (13:11-12). Since almost every engine mounts the fuel injector into the engine’s cylinder head which is water cooled in a temperature range of 212 to 240 °F, using the provisional’s teachings, a POSA would not apply this technology to an engine fuel injector.

58. Finally, the provisional disclosed that “[t]o accommodate thermal elongation, the fluid inside the hydraulic chamber 28 leaks from one side to the other, while the hydraulic chamber spring 52 ensures that the hydraulic chamber 28 and the needle valve 14 are in *direct* contact at all time.” (p.14, 11:14) If the hydraulic chamber is in DIRECT contact with the needle valve, then a” hydraulic fluid thickness” cannot exist.

III. THE ELEMENTS IN CLAIMS 1-3, 6, 13-14, 16-22, 26-28 AND 41 OF THE ’138 PATENT ARE DISCLOSED IN THE PRIOR ART

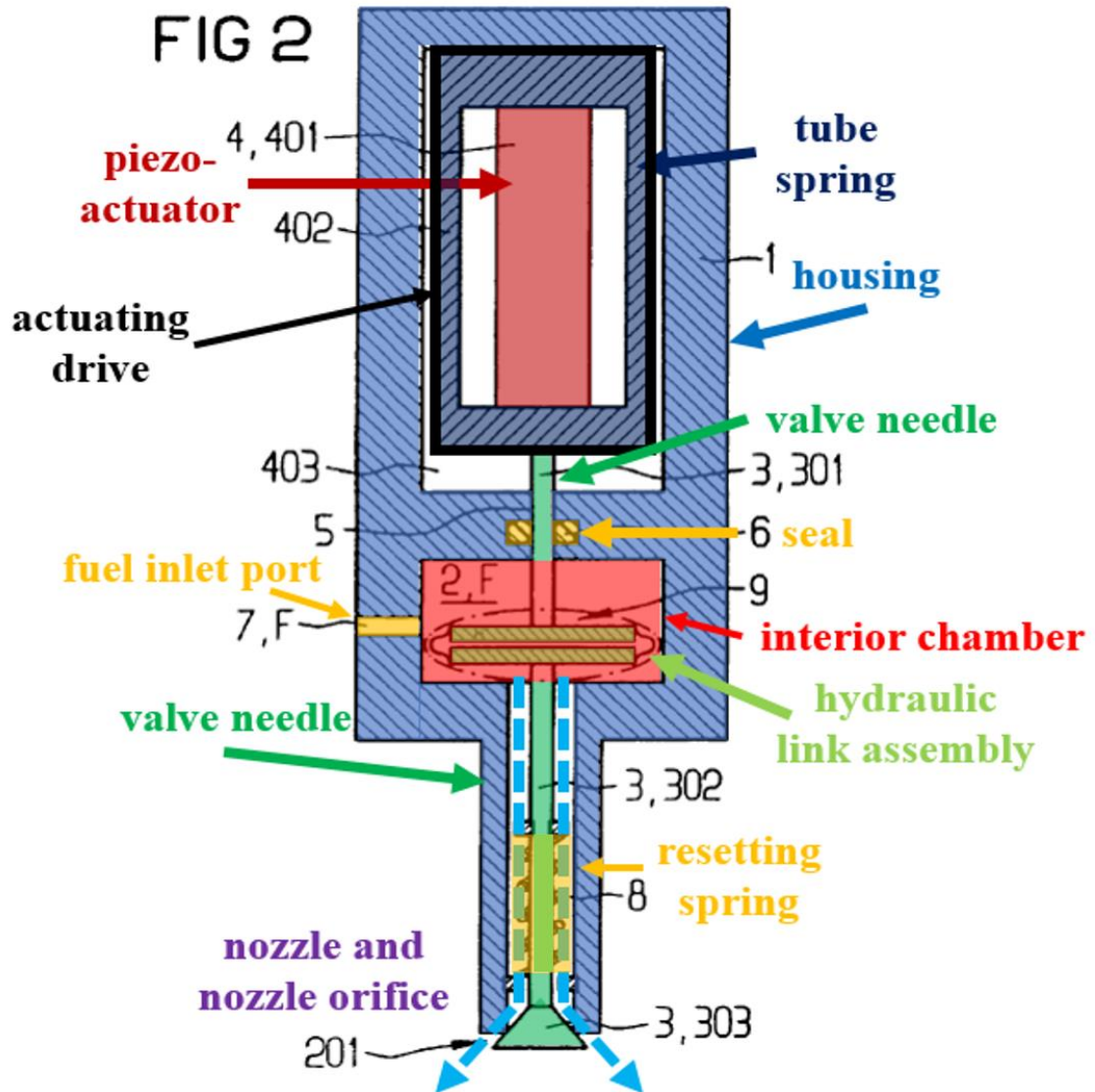
59. I have been asked to provide an analysis as to whether the elements of the challenged claims (*i.e.*, 1-3, 6, 13-14, 16-22, 26-28 and 41) of the ’138 Patent are disclosed in the primary prior art reference: (a) U.S. Patent No. 6,530,273 (Ex. 1004) (“**Gottlieb**”). I was also asked to consider these references in view of certain additional references for some of the limitations of the challenged claims,

including German Patent Application No. DE19838862A1 (Ex. 1005) (“**Gottlieb (DE)**”).

60. My analysis of these prior art references relative to the elements of the challenged claims—specifically, how and where the prior art references disclose the limitations of the challenged claims—is provided below. The citations that I have included are not intended to provide an exhaustive list, but rather provide examples of how the references disclose or teach the elements of these claims.

A. Grounds Based on Gottlieb

61. Gottlieb is U.S. Patent No. 6,530,273. Gottlieb discloses “[a] metering device and method for delivering fluid that employs a compensating element” that may be “utilized for fuel injection, preferably gasoline direct injection.” (EX 1004 (“Gottlieb”), Abstract, 3:27-29.)



(Gottlieb, FIG. 2 (annotated).)

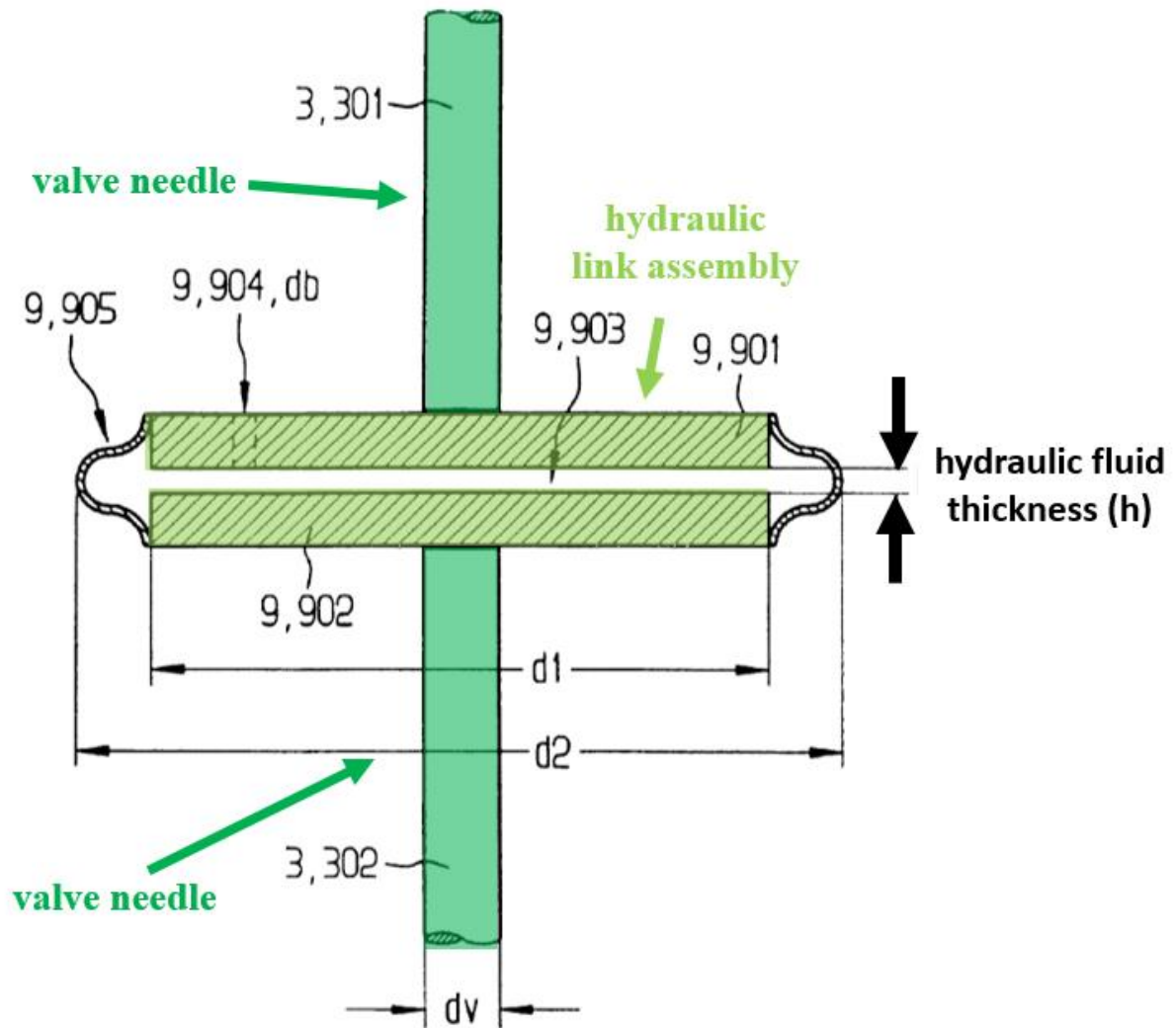
62. With reference to FIG. 2 (annotated above), Gottlieb discloses a “metering device with [a] compensating element” that may be used for fuel injection applications, such as gasoline direct injection. (Gottlieb, 3:26-29, 54-55.) The metering device, or fuel injector, is made up of a housing 1 having an input fuel

inlet port 7 and an output nozzle and nozzle orifice 201. (Gottlieb, 3:61-4:24.) A resetting spring 8 applies a closing force on a valve needle 3 having a with a seal head 303 to hydraulically seal the nozzle and nozzle orifice 201. (*Id.*, 4:15-24.) An actuating drive 4—including piezo-actuator 401 held under compressive strain by tube spring 402—applies an opening force to valve needle 3 to cause the metering device to deliver fluid, such as inject fuel. (*Id.*, 3:65-4:3.)

63. Fuel is input at the fuel inlet port 7, passes through interior chamber 2, travels through an annular space around the valve needle 3, and is output through the nozzle and nozzle orifice. Actuating drive 4 is sealed from interior chamber 2 by a seal 6 around valve needle 3.

64. The opening and closing forces are transmitted from the actuating drive 4 and resetting spring 8, respectively, through the valve needle 3 and a hydraulic link assembly 9 (compensating assembly comprising a hydraulic fluid) connected to the first and second parts of the valve needle 3. (Gottlieb, 4:63-5:57, 6:65-7:55, 8:14-45.)

FIG 1



(Gottlieb, FIG. 1 (annotated).)

65. With reference to FIG. 1 (annotated above), Gottlieb discloses a detailed view of the hydraulic link assembly 9, illustrating hydraulic chamber 903, first wall 901, second wall 902, and outside wall 905. (Gottlieb, Fig. 1, 4:63-5:14.) The outside wall 905 is a flexible stainless steel bellows, so the height of the hydraulic chamber 903 can vary as fluid—such as fuel—enters or leaves the chamber 903

through at least one compensating element opening 904 in first wall 901. (*Id.*, 5:25-50.) In an exemplary embodiment, the opening 904 is shaped as a micro bore. Opening 904 “must be so small that effectively no volume exchange occurs between the hydraulic chamber 903 and the fluid chamber 2 throughout the duration of the actuation process.” (*Id.*, 6:20:22): i.e. the hydraulic chamber does not change significantly during actuation. “The compensating chamber preferably contains a fluid that exhibits a high spring constant” (*Id.*, 6:20:22): i.e. **fluid thickness being substantially constant**. The micro bore diameter is also sized such that the pressure of fluid within the hydraulic chamber can equilibrate with fluid outside the chamber when the actuating drive is not activated. Thus, the height of the hydraulic chamber 903 can increase or decrease to account for thermal expansion, tolerances, or other effects.

1. Ground 1a – Gottlieb Discloses Claims 1-3, 6, 8-21, 26-29, 34-37, and 41

a. Independent Claim 1

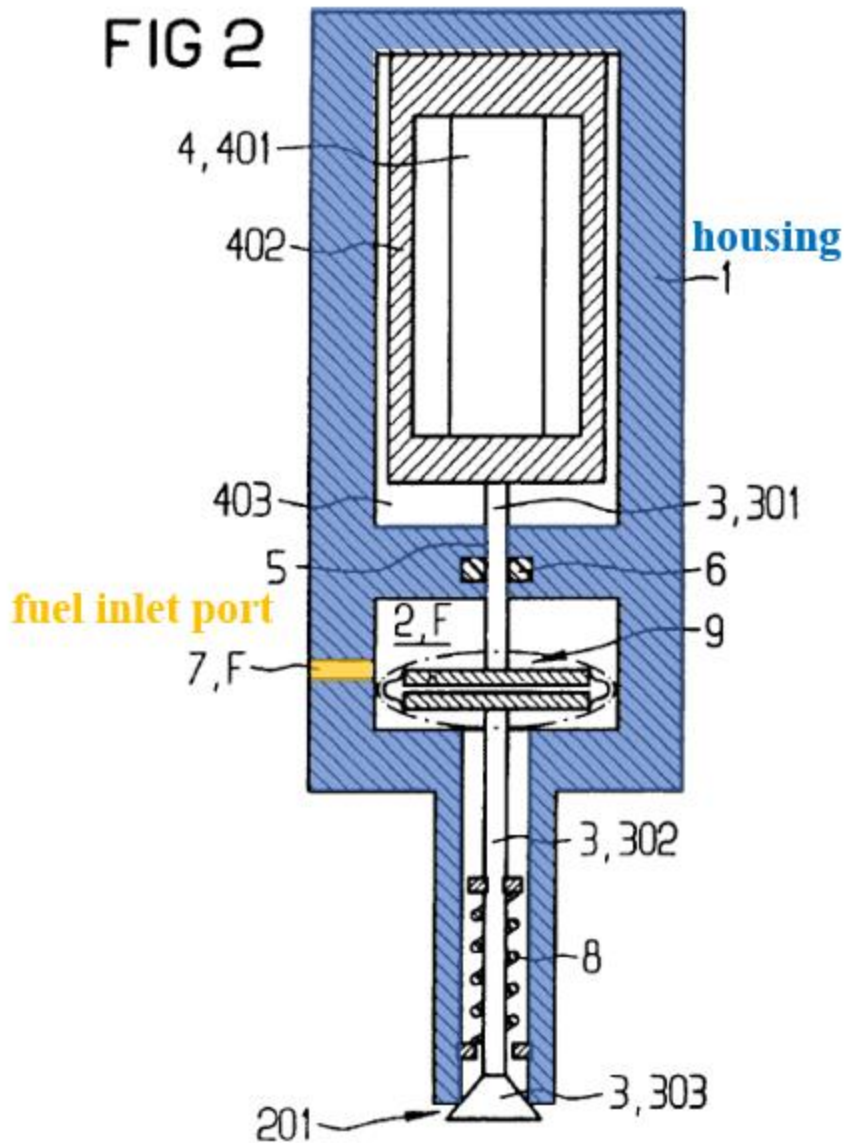
Claim 1[A]: An injection valve for injecting fuel into a combustion chamber of an internal combustion engine, said injection valve comprising:

66. In my opinion, Gottlieb discloses Claim 1[A]. Gottlieb discloses an injection valve that is a metering device “utilized for fuel injection, preferably gasoline direct injection.” (*See* Gottlieb, 3:27-29, Figures 1-2; *see also id.*, claims 12-13 (indicating the metering device is “installed within an internal combustion engine,”

20.) Gottlieb also discloses that the metering device is “utilized for injecting gasoline into a fuel engine.” (*Id.*, 6:41-44; *see also id.*, 4:48-51 (“The assumptions made in this calculation . . . are typical for fuel injectors within automobile engines.”), 7:5-6 (“The closing force is typically greater than 10 N during a gasoline or like fuel injection process.”).) Thus, Gottlieb discloses an injection valve for injecting fuel into the combustion chamber of the disclosed “internal combustion engine.”

Claim 1[B]: (a) a valve housing comprising: a fuel inlet port;

67. In my opinion, Gottlieb discloses Claim 1[B]. With reference to FIG. 2 (below), Gottlieb discloses that its fuel-injection valve includes “housing 1,” and that this housing comprises a fuel inlet port, “fluid feeder 7.” (Gottlieb, 3:62-64, Figure 2; *see also id.*, 3:67-4:7, 4:15-24, 5:36-67, claim 12.) In particular, Gottlieb explains that there is a “fluid chamber 2 . . . installed in” in the housing 1, and this “fluid chamber 2 is charged with a fluid F via a fluid feeder 7, typically under a pressure that ranges from 150 bar to 200 bar. The fluid feeder is preferably of a known type such as one that is utilized in a common-rail system.” (*Id.*, 3:60-4:3, 4:21-24.) As can be seen in Figure 2, this “fluid feeder 7” (fuel inlet port) is included in the wall of the housing 1 of Gottlieb’s fuel-injection valve:

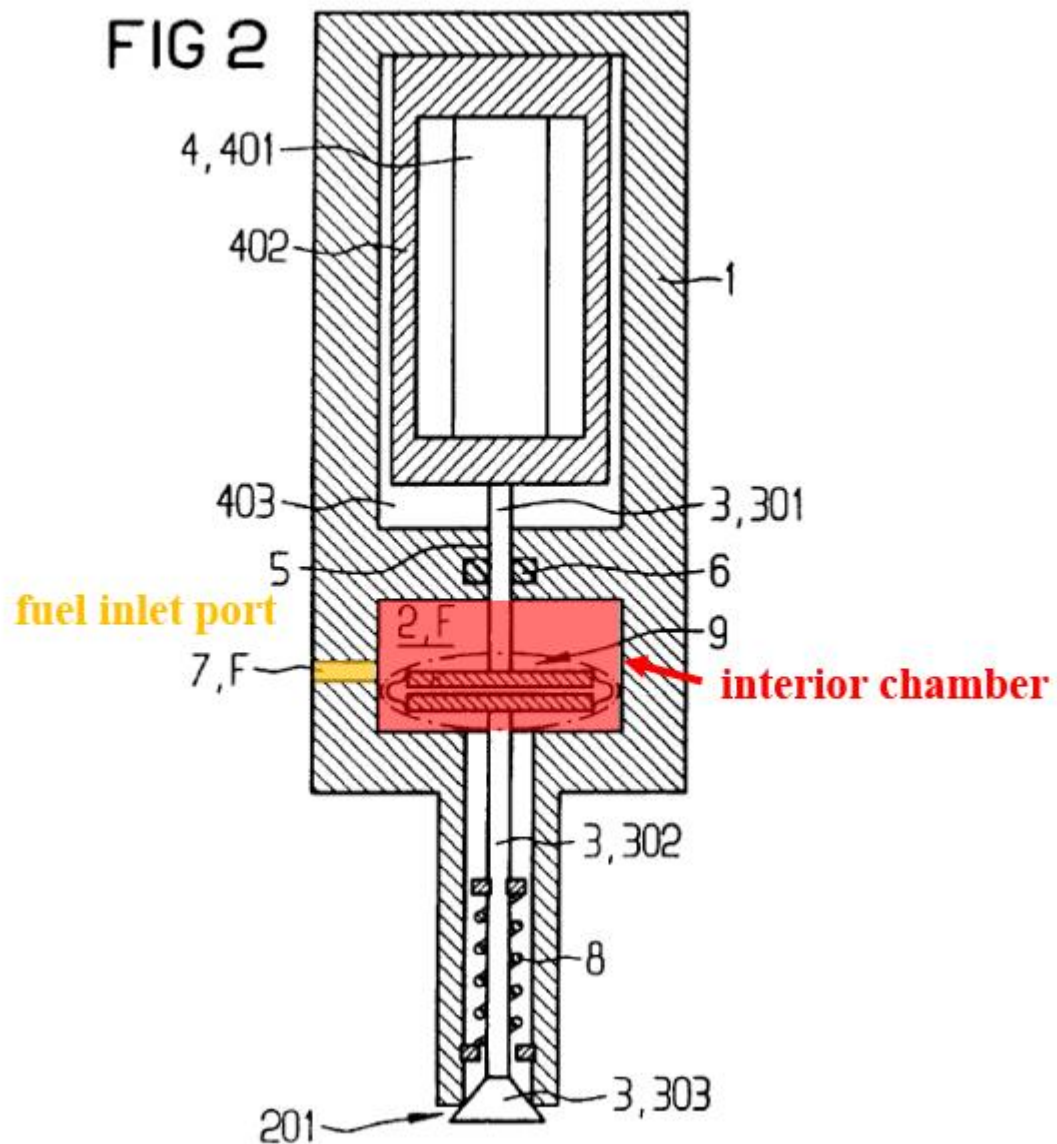


(Gottlieb, FIG. 2 (annotated).)

Claim 1[C]: an interior chamber fluidly connected to said fuel inlet port;

68. In my opinion, Gottlieb discloses Claim 1[C]. With reference to FIG. 2 (below), Gottlieb discloses that the housing 1 of the fuel-injection valve includes an interior chamber, “fluid chamber 2,” fluidly connected to fuel inlet port, “fluid

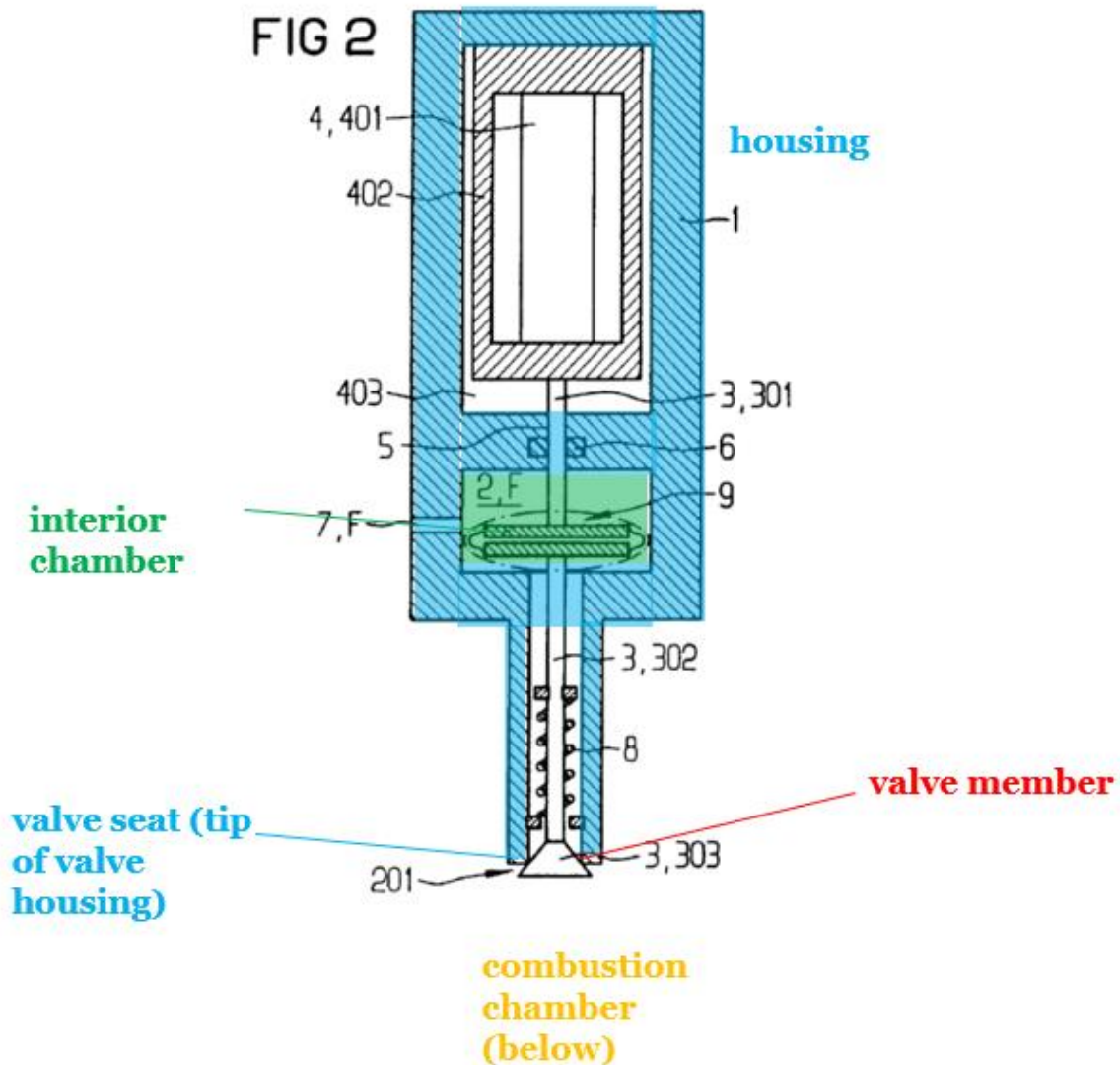
feeder 7.” (Gottlieb, 4:20-21 (“The fluid chamber 2 is charged with fluid F via a fluid feeder 7 The fluid feeder is preferably of a known type such as one that is utilized in a common-rail system.”); *see also id.*, 2:6-7, 2:24--48, 3:62-65, 4:4--13, 4:67-5:3, 5:36-40, 5:51-57; 7:28-38, 8:14-45.)



(Gottlieb, FIG. 2 (annotated).)

Claim 1[D]: and a valve seat for cooperating with a valve member to seal said interior chamber from said combustion chamber when said injection valve is closed;

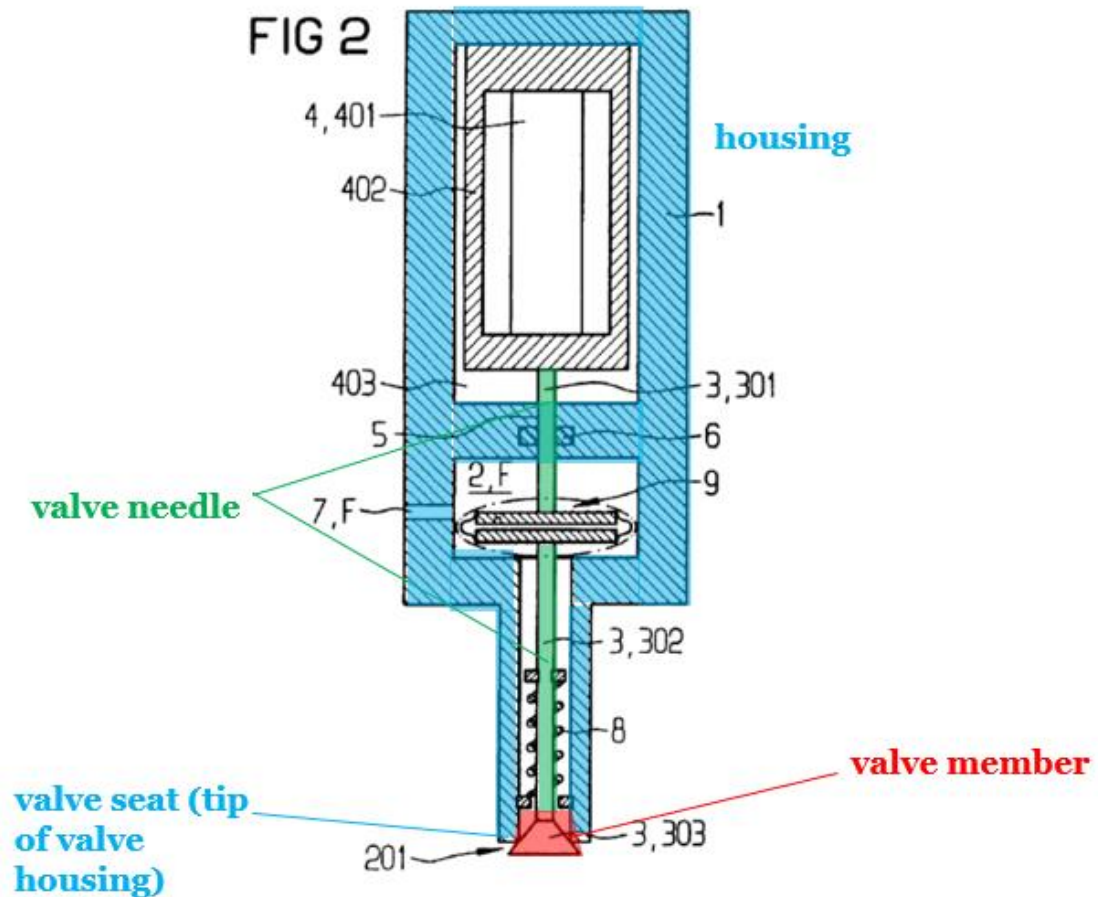
69. In my opinion, Gottlieb discloses Claim 1[D]. With reference to Figure 2 below, Gottlieb discloses a valve seat (the tip of valve housing 1) for cooperating with a valve member (the valve needle 3 and seal head 303) to seal said interior chamber (fluid chamber 2) from a combustion chamber when the injection valve is closed. (Gottlieb 3:61-4:25.)



(Gottlieb, FIG. 2 (annotated).)

Claim 1[E]: (b) said valve member having one end disposed within said valve housing and an opposite end extendable from said valve seat toward said combustion chamber, wherein said valve member comprises a sealing surface that fluidly seals against said valve seat when said injection valve is closed and that is liftable away from said valve seat when said injection valve is open;

70. In my opinion, Gottlieb discloses Claim 1[E]. With reference to FIG. 2 (below), Gottlieb discloses a “valve member” (the valve needle 3) with an end within the valve housing “housing 1” (i.e., the end opposite the sealing end) and an opposite “sealing” end extending toward a combustion chamber. Gottlieb teaches a valve needle “valve needle 3” disposed within said valve housing “housing 1” wherein said valve needle “valve needle 3” is movable between a closed and an open position. (Gottlieb, 2:15-18.)



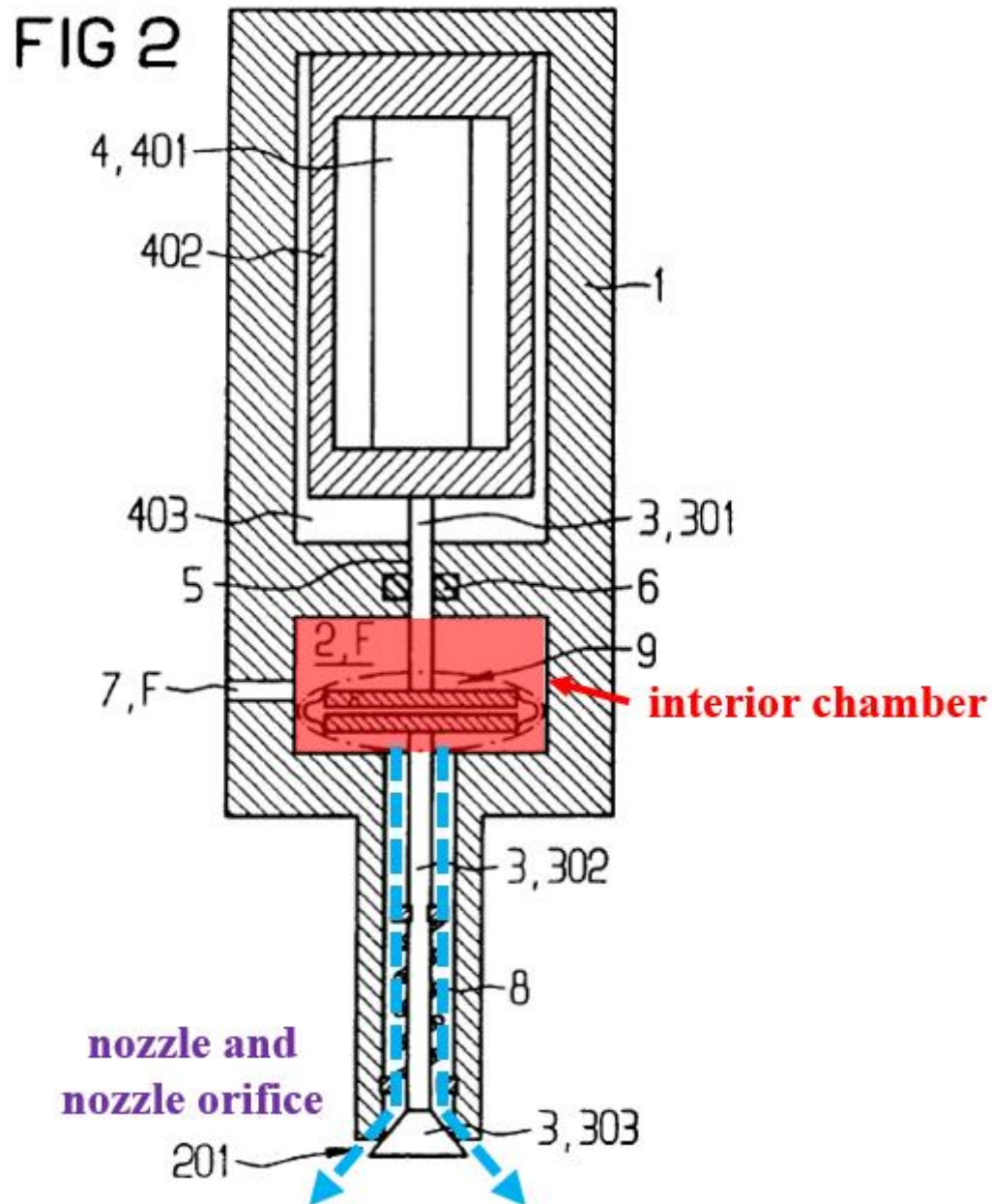
(Gottlieb, FIG. 2 (annotated).)

71. Gottlieb discloses that a sealing end of the valve needle, “seal head 303,” contacts a valve seat “tip of valve housing 1” to fluidly seal the interior “fluid chamber 2” from the nozzle “orifice 201.” (*See, e.g.*, Gottlieb, 2:15-18, 3:61-4:32, 7:28-38.) In particular, when the sealing end contacts the valve seat to fluidly seal fluid chamber 2 from the nozzle orifice 201, the valve is in a closed position. (Gottlieb, 4:11-14 (“The seal head 303 is preferably placed against the orifice or opening 201 on the outside of the fluid chamber 2. In this way, the seal head 303 hydraulically seals the orifice opening.”), 7:28-38, 8:36-45, FIG. 2.)

72. Gottlieb further discloses an open position at which the sealing end of the valve needle 3, “seal head 303,” is spaced apart from the valve seat, which is the tip of valve “housing 1,” whereby the interior “fluid chamber 2” is fluidly connected with nozzle “orifice 201.” (Gottlieb, 2:15-18, 3:61-67, 4:14-32, 6:9-11, 6:65-7:21, 8:14-45.) For example, Gottlieb discloses that the “fluid chamber 2 ... leads to the outside at an orifice or opening 201.” (*Id.*, 3:61-63.) Gottlieb explains that the orifice 201 and chamber 2 are “open” when the “seal head 303” of the needle “3” is “lifted from the orifice or opening 201 wherein the fluid is delivered through the opening 201.” (*Id.*, 8:13-35, Claim 1.)

73. Gottlieb additionally discloses that the valve needle lift to open the valve equals the distance traveled by said “seal head 303” (sealing end) away from said valve seat (tip of valve housing 1”). (*See id.*, 2:15-18, 3:61-67, 4:14-32, 6:9-11,

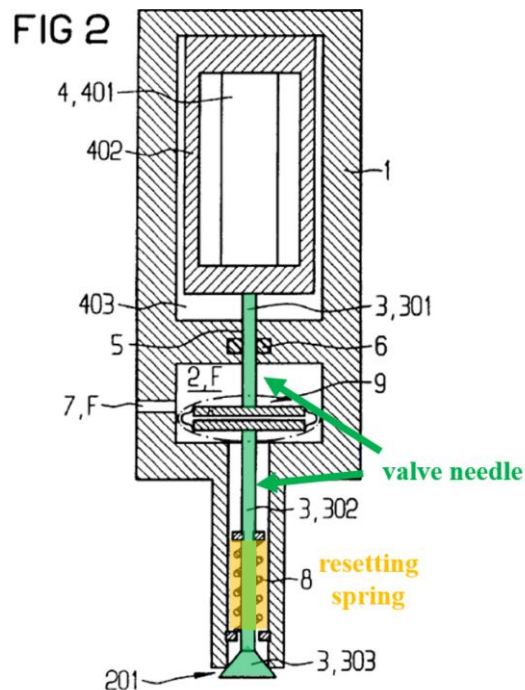
6:65-7:21, 8:14-45.) As described in Gottlieb, valve needle 3 is located within housing 1 and “at one end at one end is fastened at an actuating drive 4 and leads through the fluid chamber 2” and “at its end opposite of the actuating drive 4[] is equipped with a seal head 303.” (*Id.*, 3:64-65, 4:10-11.) Gottlieb discloses that this actuating drive 4 includes a “piezo-actuator 401.” (*Id.*, 3:61-67, 6:65-7:1, 7:28-38, 8:13-45.) During the metering process, when the valve is opened, Gottlieb explains that “the piezo-actuator 401 moves the valve needle 3 a distance or length that ranges from 10 μm to 100 μm ,” thereby spacing the seal head 303 from the nozzle orifice 201 by that distance, which is also the lift distance. (*Id.*, 4:26-28, 8:13-45.) And by lifting the seal head 303 from the valve seat, the interior chamber 2 is fluidly connected with the nozzle orifice 201:



(Gottlieb, Fig. 2 (annotated); *see also id.*, 8:13-45) noting that when the metering device is open, the “seal head 303 is lifted from the orifice or opening 201 wherein the fluid is delivered through the opening 201.”

Claim 1[F]: (c) a biasing mechanism associated with said valve member, said biasing mechanism applying a closing force to said valve member when said valve member is in said closed position;

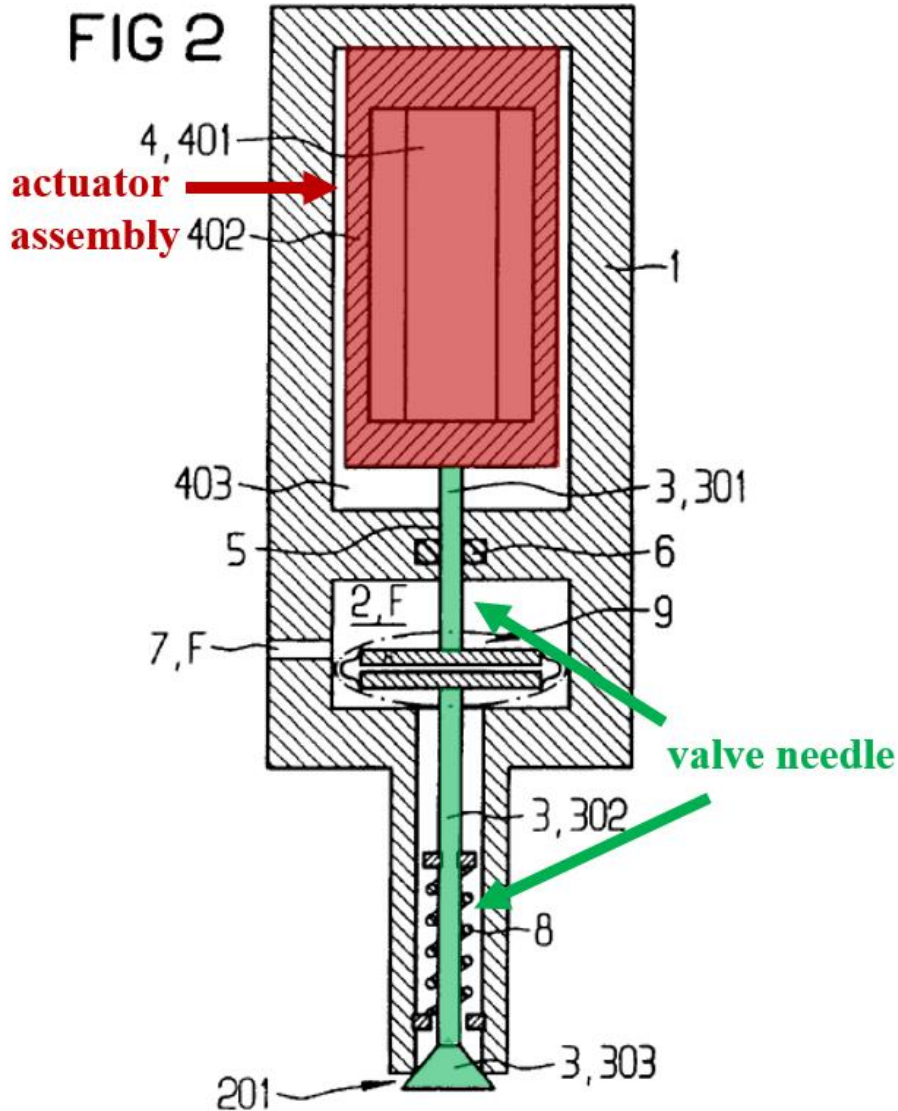
74. Gottlieb discloses Claim 1[F]. With reference to FIG. 2 (below), Gottlieb discloses “resetting spring 8” (biasing mechanism) that applies a closing force to the valve needle 3 (valve member) for biasing the valve needle 3 in a closed position. As described in Gottlieb, “[i]n order to close the orifice or opening 201 . . . the valve needle 3 is pushed in the direction of an actuating drive 4 via a resetting spring 8 so that the seal head 303 is pressed against the housing 1.” (*Id.* at 4:15-18, 6:65-7:20 (noting that the resetting spring provides a “closing force”), 7:28-38.)



(*Id.*, FIG. 2 (annotated).)

Claim 1[G]: (d) an actuator assembly associated with said valve member, wherein said actuator assembly may be activated to apply an opening force to said valve member stronger than said closing force, for moving said valve member to said open position;

75. In my opinion, Gottlieb discloses Claim 1[G]. Gottlieb discloses an “actuating drive 4” (actuator assembly) that may be activated to apply an opening force to the valve needle 3 stronger than the closing force, for moving the valve needle 3 (valve member) to an open position:



(Gottlieb, FIG. 2 (annotated).)

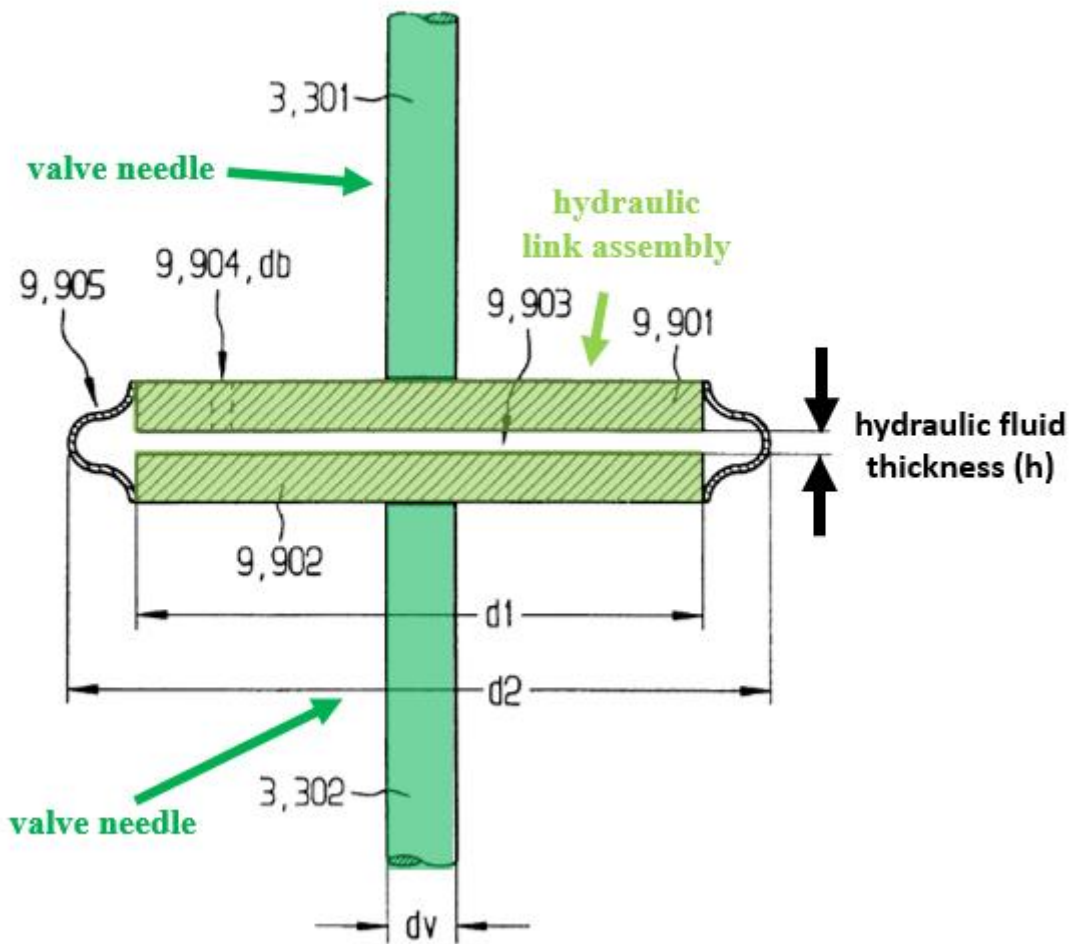
76. Gottlieb explains that the “valve needle 3 [i.e., valve member] at one end is fastened at an actuating drive 4 and leads through the fluid chamber 2. The actuating drive 4 includes a piezo-actuator 401 that is preferably a ceramic multi-layer piezo-actuator.” (Gottlieb, 3:64-67.) Gottlieb also explains that “[d]uring the metering process, the piezo-actuator 401 moves the valve needle 3 a distance or

length that ranges from 10 μm to 100 μm ” by overcoming the closing force of resetting spring 8. (*Id.*, 4:15-18, 4:26-28.) Moreover, Gottlieb discloses that the actuating drive 4 displaces the needle, with transferred by a compensating element 9, in order to open the valve, and that as part of this “the closing force of the resetting spring 8 must be overcome.” (*Id.*, 6:65-7:3, *see also id.*, 8:13-38.)

Claim 1[H]: (e) a hydraulic link assembly comprising a passive hydraulic link having a hydraulic fluid thickness through which said opening and closing forces are transmitted, whereby said hydraulic fluid acts substantially as a solid with said thickness being substantially constant while said actuator assembly is activated and wherein said thickness of said hydraulic link is adjustable while said actuator is not activated in response to changes in the dimensional relationship between components of said injection valve to maintain a desired valve needle lift upon activation of said actuator assembly.

77. In my opinion, Gottlieb discloses Claim 1[H]. With reference to FIG. 1 (below), Gottlieb discloses a hydraulic link assembly comprising a passive hydraulic link, disclosed as compensating element 9, having a hydraulic fluid thickness (h) through which said opening and closing forces are transmitted:

FIG 1



(Gottlieb, FIG. 1 (annotated).)

78. Gottlieb discloses the hydraulic fluid (of the hydraulic link assembly) acts substantially as a solid with said thickness (h) being substantially constant while said actuator assembly is activated and wherein said thickness of said hydraulic link (h) is adjustable while said actuator is not activated in response to changes in the dimensional relationship between components of said injection valve to maintain a desired valve needle 3 lift upon activation of said actuator assembly.

79. In particular, with reference to Figure 1 (above), Gottlieb's passive hydraulic link assembly, compensating element 9, "includes hydraulic chamber 903 that is defined by a first wall 901, a second wall 902 and an outside wall 905" and "[t]he spacing between the first wall 901 and the second wall 902 is referred to as a chamber height h." (Gottlieb, 5:4-14.) Gottlieb discloses the "[t]he outside wall preferably includes a stainless steel bellows," so the chamber height can adjust from "approximately 20 μm to 250 μm " (that is, allowing adjustment while the actuator is inactive). (*Id.*, 5:24-28.) Gottlieb then discloses "the compensating element hydraulic chamber 903 is connected to the fluid chamber 2 via at least one compensating element opening 904 that allows for a fluid exchanged between the hydraulic chamber 903 to the fluid chamber 2. In an exemplary embodiment, the opening 904 is shaped as a micro bore that leads through the first wall 901." (*Id.*, 5:36-42.)

80. Thus, Gottlieb discloses "[t]he hydraulic chamber 903 is . . . filled with a fluid F that is hydrostatically coupled with the surrounding fluid F. In this way, the same static pressure is present in the hydraulic chamber 903 and the fluid chamber 2 in the initial state wherein essentially no forces are acting on the compensating element 9." (*Id.*, 5:51-57.) The diameter of the opening 904 is such that "the compensating element 9 effectively operates to compensate for the shifting or

movement of the various metering device components due to varying thermal loads or other external factors.”

81. “At the same time, the compensating element operates to provide little, if any, lift loss during the delivery of fluid within the metering process” (that is, allowing the hydraulic fluid thickness to be “substantially constant” during actuation). (*Id.*, 5:59-6:2.) “On the other hand, the diameter d_b must be so small that effectively no volume exchange occurs between the hydraulic chamber 903 and the fluid chamber 2 throughout the duration of the metering process, otherwise a lift loss will result as the lift force is transferred between the first 301 and second 302 valve needle parts.” (*Id.*, 6:20-25.) In addition, the fluid “exhibits a high spring constant” so “lift loss does not occur due to the elasticity of the enclosed fluid F wherein the chamber height is preferably maintained at approximately 100 μm .” (*Id.*, 6:28-32.)

82. This hydraulic fluid thickness is used in transmission of the opening and closing forces. In particular, Gottlieb discloses “[t]he forces that are transferred by the compensating element 9 have two components: 1) the closing force of the resetting Spring 8 must be overcome; and 2) the inertial force of the valve needle 3 and the compensating element 9 [i.e., the opening force] must be transferred.” (*Id.*, 7:1-5.) The fluid in “compensating element 9” is involved in this force transfer,

and is accomplished while the fluid “is analogous to an insertion of an optimally stiff spring.” (Gottlieb, 8:14-27.)

b. Dependent Claims 2 and 3

Claim 2: The injection valve of claim 1 wherein said thickness of said hydraulic link is auto-adjustable while said actuator assembly is not activated in response to changes in said dimensional relationship caused by differential thermal expansion.

Claim 3: The injection valve of claim 2 wherein said thickness of said hydraulic link is auto-adjustable while said actuator assembly is not activated in response to changes in said dimensional relationship caused by wear to components of said injection valve.

83. In my opinion, Gottlieb discloses Claims 2 and 3. Gottlieb discloses that “the compensating element . . . acts to compensate for shifting or movement of metering components due to external factors, such as varying thermal loads, aging effects, and settling effects.” (Gottlieb, Abstract, see also *id.*, 1:22-48, 1:63-2:14, 2:32-54, 3:41-43, 4:27-66, 5:58-65, 7:27-8:13.) The compensating element’s movement to compensate for such effects “is at least 100 times slower than the duration of the metering process,” so effectively no lift loss will result as lift force is transferred through the compensating element. (See *id.*, 6:15-25.) One of ordinary skill would understand that the thickness of fluid in Gottlieb’s compensating element (i.e., hydraulic link) is continuously auto-adjusting while

not activated in response to thermal loads (including differential thermal expansion), aging effects, and settling effects.

c. Dependent Claims 6 and 13

Claim 6: The injection valve of claim 1 wherein said actuator assembly comprises a dimensionally responsive member.

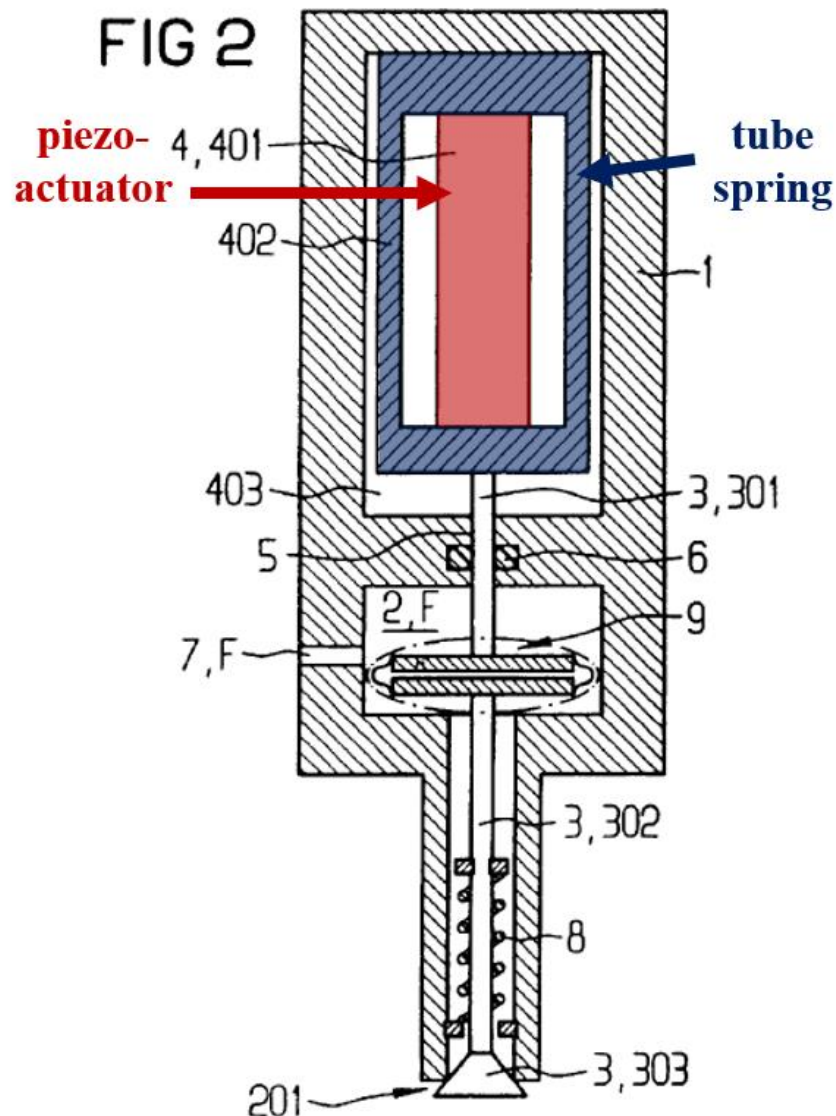
Claim 13: The injection valve of claim 6 wherein said dimensionally responsive member is formed from a piezoelectric material.

84. In my opinion, Gottlieb discloses Claims 6 and 13. The '138 discloses that a dimensionally responsive member is formable from magnetorestrictive or piezoelectric material, and may comprise a compression spring for applying compressive force to said member. ('138, 3:41-4:8.) Gottlieb discloses “actuating drive 4 includes a piezo-actuator 401 [*i.e.*, piezoelectric material] that is preferably a ceramic multi-layer piezo-actuator.” (Gottlieb, 3:65-67.) Gottlieb also describes the piezo-actuator as being held under compressive strain by a tube spring. (*See id.*, 7:28-30.) And Gottlieb describes the actuation distance of the piezo-actuator, which moves the valve needle, at a range from 10 μm to 100 μm (*i.e.*, expanding in dimension by that distance). (*Id.*, 4:25-27.)

d. Dependent Claim 14

Claim 14: The injection valve of claim 6 further comprising a compression spring member for applying a compressive force to said dimensionally responsive member.

85. In my opinion, Gottlieb discloses Claim 14. With reference to FIG. 2 below, Gottlieb discloses “tube spring 402” (compression spring member) for applying a compressive force to the “piezo-actuator 401” (dimensionally responsive member). (Gottlieb, 7:27-30 (“the piezo-actuator 401 is contracted in an axial direction and held under a compressive strain via a tube spring 402”); *see also id.*, 3:67-4:3, 7:28-38.)

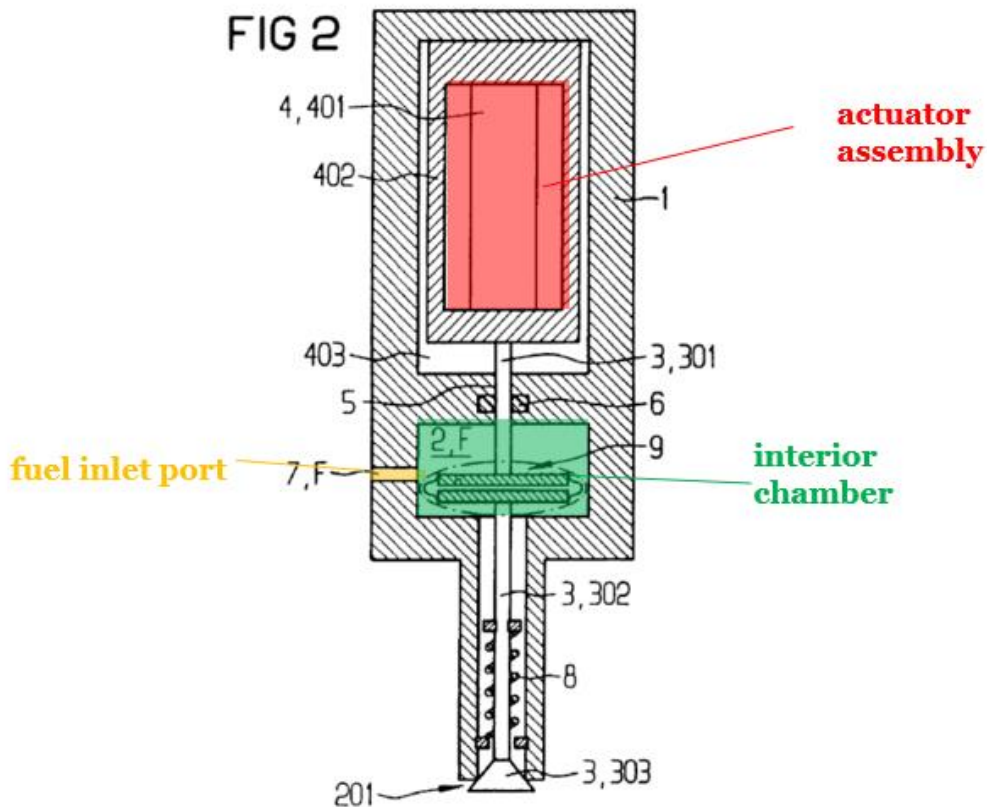


(Id., FIG. 2 (annotated).)

e. Dependent Claim 16

Claim 16: The injection valve of claim 1 wherein said fuel inlet port is position near the valve tip such that fuel flowing through said interior chamber does not contact said actuator assembly.

86. In my opinion, Gottlieb discloses Claim 16. Gottlieb explicitly describes a fuel-injection valve including fuel inlet port, “fluid feeder 7” and actuator assembly “actuating drive 4.” (Gottlieb, 3:62-67.) The fuel from fluid feeder 7 flows into interior chamber “fluid chamber 2” and does not contact said actuator assembly. (Id., 4:20-21.)



(Gottlieb, FIG. 2 (annotated)).

f. Dependent Claim 17

Claim 17: The injection valve of claim 6 wherein when said actuator assembly is controllable to control said desired lift to between 10 and 100 percent of maximum lift.

87. Gottlieb discloses Claim 17. Gottlieb discloses “a piezo-actuator 401 that is preferably a ceramic multi-layer piezo-actuator” and that “[d]uring the metering process, the piezo-actuator 401 moves the valve needle 3 a distance or length that ranges from 10 μm to 100 μm .” (Gottlieb, 1:65-67, 4:25-27.) One of ordinary skill would recognize that the normal operation of a piezo-actuator is dependent on a

quantity of voltage and/or current applied to the piezoelectric stack , where greater voltages (to a point) will lead to greater expansion or contraction of the piezo elements forming the actuator. Thus, a one of ordinary skill would recognize that Gottlieb explicitly discloses an actuator assembly that is controllable to control lift to between 10 and 100 percent of maximum lift.

88. It would also be obvious for one of ordinary skill to control lift between 10 and 100 percent of the maximum lift. Controlling ranges of lift is explicitly taught in Gottlieb and a POSITA would understand, as a design choice or preference, that the control system taught by Gottlieb would be able to control the lift between the range provided in claim 11. This is not a case where the claimed lift range is new, unexpected, or produces some sort of difference in kind. Instead, the operation of Gottlieb's valve is indistinguishable from that of the '138 patent.

g. Dependent Claim 19

Claim 19: The injection valve of claim 6 wherein said valve member is controllable to move between said open and closed positions in less than about 200 microseconds.

89. In my opinion, Gottlieb discloses Claim 19. Gottlieb discloses that the valve needle (3) (valve member) is controllable to move between said open and closed positions in less than about 200 microseconds. Gottlieb discloses that “the separate stages of the metering process, such as the opening and closing of the orifice 201, can occur over time frames ranging from 1 μ s to 10 μ s” (i.e., less than 200 μ s.)

(Gottlieb, 6:8-10, Claim 17.) Gottlieb further discloses an “average duration of a metering process of 100 μ s,” which is again less than 200 μ s. (*Id.*, 6:65-7:20.)

h. Dependent Claim 20

Claim 20: The injection valve of claim 6 further comprising a biasing mechanism for applying a compressive force to said dimensionally responsive member.

90. In my opinion, Gottlieb discloses Claim 20. Gottlieb discloses a tube spring 402 (compression spring member) for applying a compressive force to the piezo-actuator 401 (magnetostrictive or piezoelectric member). (Gottlieb, 7:27-30 (“the piezo-actuator 401 is contracted in an axial direction and held under a compressive strain via a tube spring 402”); *see also id.*, 3:67-4:3, 7:28-38.)

i. Dependent Claim 21

Claim 21: The injection valve of claim 1 wherein said biasing mechanism comprises a spring.

91. In my opinion, Gottlieb discloses Claim 21. Gottlieb discloses a biasing mechanism that applies a closing force to the valve member. (*See supra* Claim 1[F].) This biasing mechanism comprises a spring, namely tube spring 402. (*See supra* Claim 14.)

j. Dependent Claim 26

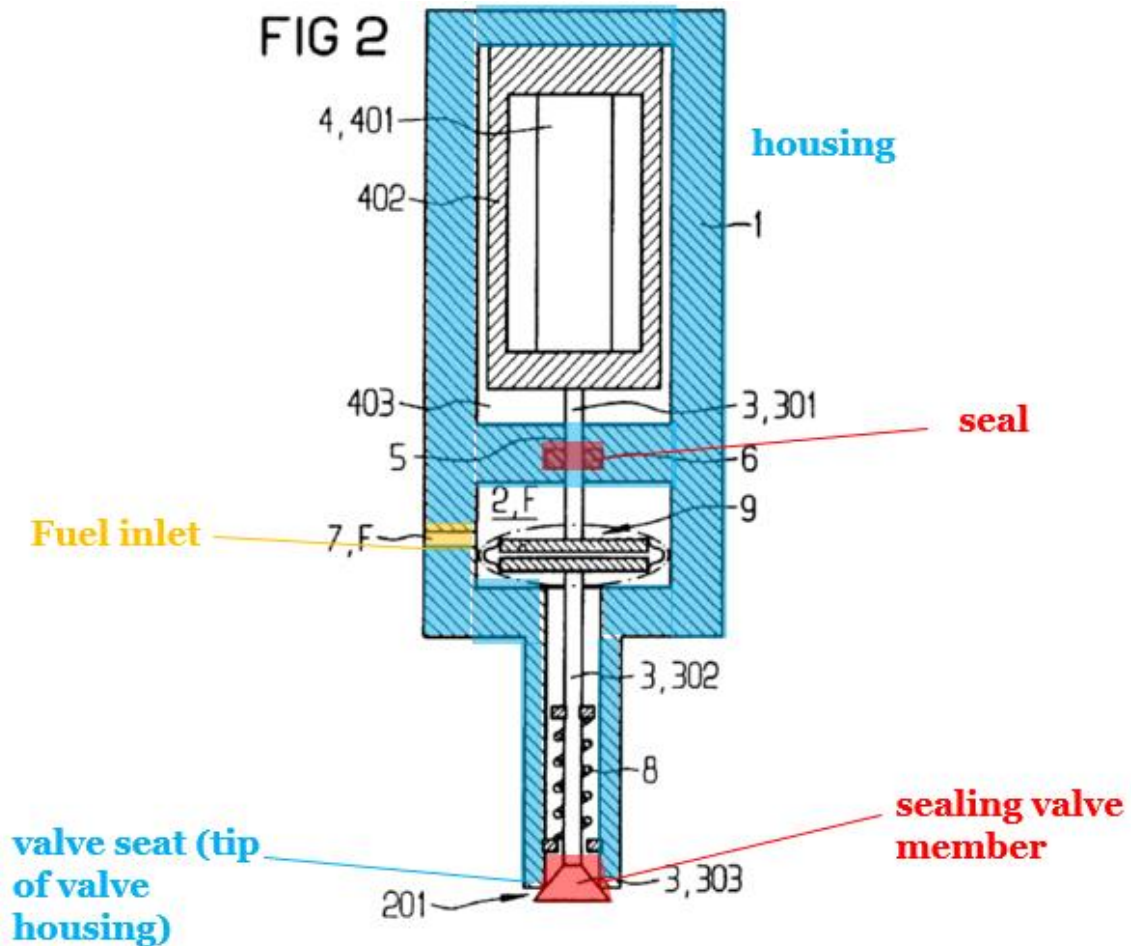
Claim 26: The injection valve of claim 1 wherein said fuel is injected into said combustion chamber at a pressure greater than about 2000 psi (about 13.8 MPa).

92. In my opinion, Gottlieb discloses Claim 26. Gottlieb discloses that fuel (F) is injected into said combustion chamber at a pressure greater than about 2000 psi (about 13.8 MPa). For example, Gottlieb discloses that the pressurized fluid injected from the metering “ includes a fluid pressure, said fluid pressure ranges from approximately 150 bar to approximately 1000 bar.” (Gottlieb, Claim 9.) Gottlieb also describes that “fluid chamber 2 is charged with a fluid F via a fluid feeder 7, typically under a pressure that ranges from 150 bar to 200 bar. The fluid feeder is preferably of a known type such as one that is utilized in a common-rail system.” (*Id.*, 4:20-24.) A POSITA would understand that 150 bar is approximately 2175.6 psi and 1000 bar is 14,503.8 psi (*i.e.*, both greater than 2000 psi), because 1 bar is approximately 14.5038 psi.

k. Dependent Claim 27

Claim 27: The injection valve of claim 1 wherein said valve housing comprises a plurality of parts which are joined with each other to provide a fluidly sealed body.

93. In my opinion, Gottlieb discloses Claim 27.



(Gottlieb, FIG. 2 (annotated).)

94. With reference to FIG. 2 (above), Gottlieb discloses a valve “housing 1” comprising a plurality of parts which are joined with each other to provide a fluidly sealed body, including seal 6 and the sealing end of valve needle 303. (Id.) Gottlieb discloses a housing 1 having a seal 6 that hydraulically seals the fit between valve needle 3 and the housing 1. (Id., 4:6-9.) Gottlieb also describes that the housing 1

is hydraulically sealed by the seal head 303 of the valve needle 3 that presses against the opening of the metering device 201. (Id., 7:33-36.) Gottlieb further explains that “the housing 1 effectively remains hydraulically sealed even though the components of the metering device expand, shift or move due to changing thermal conditions or other external factors, such as aging or settling effects.” (Id., 7:63-67.)

I. Dependent Claim 28

Claim 28: The injection valve of claim 1 wherein said valve housing, said valve needle, and said actuator assembly, are selected from materials having thermal expansion coefficients sufficiently compatible such that changes in the dimensional relationship between said components caused by changes in temperature are reduced.

95. In my opinion, Gottlieb discloses Claim 28. Gottlieb discloses a valve housing, said valve needle, and said actuator assembly, are selected from materials with similar thermal expansion coefficients to reduce changes in the dimensional relationship between said components caused by changes in temperature, and explains that “selecting thermally compatible materials for each of the individual metering device components” was well-known “[t]o compensate for [] shifting or movement due to varying temperature loads.” (Gottlieb, 1:41-45.)

96. Gottlieb also recognizes that the injection valve may be subject to temperature fluctuations. (See *id.*, 4:52-57.) Accordingly, a POSITA would

understand that the selection of thermally compatible materials disclosed by Gottlieb could, in part, address the problems associated with anticipated temperature fluctuations (*i.e.*, by particularly selecting materials having similar thermal expansion coefficients.).

m. Independent Claim 41

Claim 41[A]: A method of operating a fuel injection valve for an internal combustion engine, said injection valve having a longitudinal axis, said method comprising:

97. To the extent the preamble is limiting, in my opinion, Gottlieb discloses Claim 41[A]. (*see supra* Claim 1[A].) Gottlieb discloses a fuel injection valve for an internal combustion engine possessing a longitudinal axis. (*See, e.g.*, Gottlieb Fig. 2.) Gottlieb also discloses that the valve it discloses may be operated. (*See, e.g., id.* Claim 14.)

Claim 41[B]: (a) actuating a dimensionally responsive member comprising at least one of a magnetostrictive material and a piezoelectric material, said dimensionally responsive member expanding in length in the direction of said longitudinal axis upon actuation of said actuator;

98. In my opinion, Gottlieb discloses Claim 41[B]. (*See supra* Claims 6, 13.)

Claim 41[C]: (b) transferring movement caused by said actuated dimensionally responsive member through a passive hydraulic link to cause a corresponding movement of a valve member to open said valve by lifting said valve member away from a valve seat and compressing a biasing mechanism that biases said valve in a closed position, said passive hydraulic link comprising a hydraulic cylinder which

houses a piston and is filled with a hydraulic fluid, wherein said hydraulic fluid forms a layer between said piston and a cylinder head and because of the short duration that said valve is open, said hydraulic fluid does not have time to flow from one side of said piston to the other side and while said injection valve is open, said layer of hydraulic fluid acts as an incompressible solid so that movement caused by the actuation of said dimensionally responsive member is transmitted through said fluid layer;

99. In my opinion, Gottlieb discloses Claim 41[C]. (*See supra* Claims 1[H] (passive hydraulic link); 1[F] (biasing mechanism).)

Claim 41[D]: (c) deactuating said dimensionally responsive member to contract the length of said dimensionally responsive member to unload said biasing mechanism and cause a corresponding movement of said valve member to close said valve;

100. In my opinion, Gottlieb discloses Claim 41[D]. Gottlieb discloses that the injection valve is movable to a closed position. (*See supra* Claim 19.) Gottlieb also discloses a biasing mechanism applying a closing force to a valve member. (*See supra* Claim 1[F].)

Claim 41[E]: (d) providing sufficient time between consecutive valve openings to allow at least some of said hydraulic fluid within said passive hydraulic link to flow from one side of said piston to the other side of said piston.

101. In my opinion, Gottlieb discloses Claim 41[E]. Gottlieb discloses the thickness of its hydraulic link is adjustable, which involves exchange in volume, while said actuator is not activated in response to changes in the dimensional

relationship between components of said injection valve to maintain a desired valve needle 3 lift upon activation of said actuator assembly. (*See supra* Claim 1[H].)

2. Ground 1b – Gottlieb, Alone or In View of Gottlieb (DE) Discloses Claims 14, 18, and 22

a. Dependent Claim 14

Claim 14: The injection valve of claim 6 further comprising a compression spring member for applying a compressive force to said dimensionally responsive member.

102. In my opinion, as discussed above, *see supra* Ground 1a, Claim 14, Gottlieb discloses Claim 14. In the alternative, Gottlieb in view of Gottlieb (DE) discloses claim 14. Gottlieb (DE) is a German Patent Application to which Gottlieb claims priority. Gottlieb (DE) is a foreign equivalent to Gottlieb with a disclosure very similar to that of Gottlieb. A certified translation of Gottlieb (DE) is provided as Exhibit 1006. It would have been obvious to one of ordinary skill to modify the piezo actuator of Gottlieb to include any disclosure in Gottlieb (DE), as both disclosures are similar and are directed to the same invention (or, at minimum, very similar inventions). The disclosures of Gottlieb and Gottlieb (DE) perform the same function, and combination of those disclosures would lead to the same result. Gottlieb (DE) discloses that “a spring element such as a tube spring or a disk spring 100 may be provided for the compressive prestress of the piezo actuator.” (Gottlieb (DE) 2:99-100.)

b. Dependent Claim 18

Claim 18: The injection valve of claim 17 wherein said lift is controllable by varying at least one of the electric current, the electric voltage, and the magnetic field imposed upon said dimensionally responsive member.

103. In my opinion, Gottlieb discloses Claim 18. Gottlieb discloses “a piezo-actuator 401 [*i.e.*, dimensionally responsive member] that is preferably a ceramic multi-layer piezo-actuator.” (Gottlieb, 1:65-67.) A POSITA would understand that the normal operation of any piezo-actuator is dependent on a quantity of voltage and/or current applied to the piezo, where a difference in voltage will lead to greater expansion or contraction of the piezo elements forming the actuator (*i.e.*, controlling the lift).

104. In the alternative, Gottlieb in view of Gottlieb (DE) discloses claim 18. Gottlieb (DE) is a German Patent Application to which Gottlieb claims priority. Gottlieb (DE) is a foreign equivalent to Gottlieb with a disclosure very similar to that of Gottlieb. A certified translation of Gottlieb (DE) is provided as Exhibit 1006. It would have been obvious to one of ordinary skill to modify the piezo actuator of Gottlieb to include any disclosure in Gottlieb (DE), as both disclosures are similar and are directed to the same invention (or, at minimum, very similar inventions). The disclosures of Gottlieb and Gottlieb (DE) perform the same function, and combination of those disclosures would lead to the same result.

Gottlieb (DE) discloses that changes in operating voltage affect the lift of the valve needle. Figure 2 of Gottlieb (DE) (below) describes a “typical operating sequence” on the basis of voltage applied to a piezo actuator. (Gottlieb (DE) 7:15-18.) Figure 3 of Gottlieb (DE) shows “a diagram of deflection A of the piezo actuator 1 in μm plotted as a function of the voltage U in volts applied to it.” (Gottlieb (DE) 7:24-30.) The two figures show that the lift of the Gottlieb piezo actuator is controllable by changes in voltage.

FIG 2

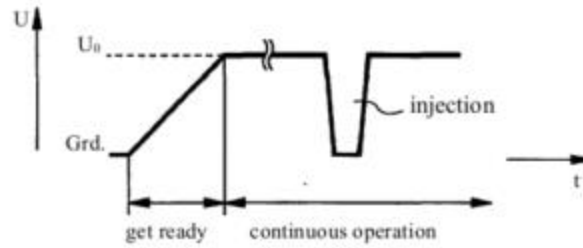
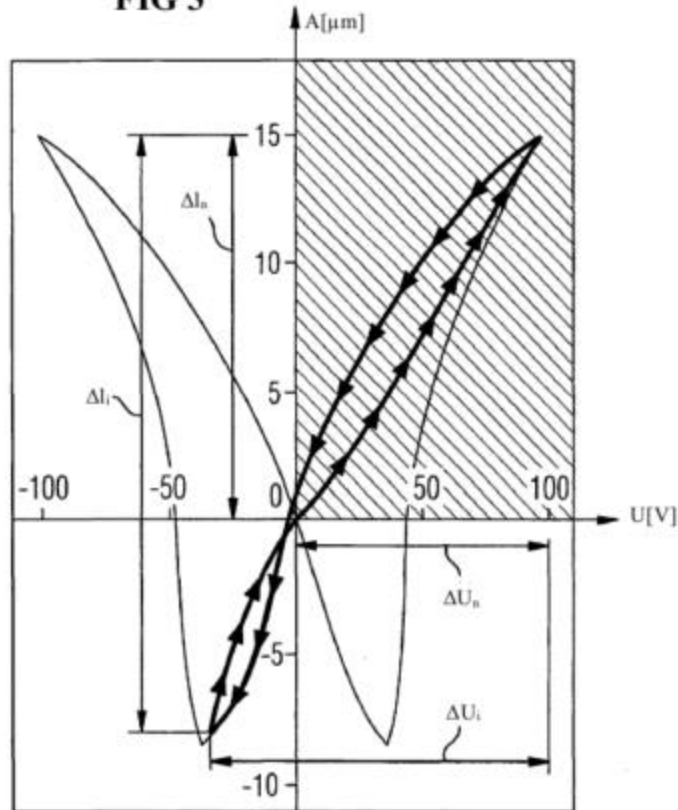


FIG 3



(Gottlieb (DE), Figs. 2-3.)

c. Dependent Claim 22

Claim 22: The injection valve of claim 21 wherein said compression spring member comprises at least one disc spring.

105. In my opinion, Gottlieb discloses Claim 22. Gottlieb discloses compressing a piezo-actuator 401 (piezoelectric member) with a spring member, namely, tube spring 402. See supra Ground 1a, Claim 21. A POSITA would understand that the spring disclosed in Gottlieb could be a tube spring or any equivalent thereof, which includes disc springs. In particular, tube springs and disc springs are both well-known types of springs used in mechanical devices to provide biasing or compression forces, including in actuator assemblies such as described in Gottlieb. (Id.) The substitution of a disc spring for the tube spring in Gottlieb would have been nothing more than the simple substitution of one known spring device for another, that would have continued to operate for its normal and expected functions. (Id.) Thus, a POSITA would have had a reasonable expectation of success that using a disc spring instead of a tube spring would allow the device in Gottlieb to continue to perform its same functions.

106. In the alternative, Gottlieb in view of Gottlieb (DE) discloses claim 22. Gottlieb (DE) is a German Patent Application to which Gottlieb claims priority. Gottlieb (DE) is a foreign equivalent to Gottlieb with a disclosure very similar to that of Gottlieb. A certified translation of Gottlieb (DE) is provided as Exhibit 1006. It would have been obvious to one of ordinary skill to modify the piezo actuator of Gottlieb to include any disclosure in Gottlieb (DE), as both disclosures are similar and are directed to the same invention (or, at minimum, very similar

inventions). The disclosures of Gottlieb and Gottlieb (DE) perform the same function, and combination of those disclosures would lead to the same result. Gottlieb (DE)'s disclosure clarifies, when discussing its compression elements, that "a spring element, . . . **a tube spring or a disk spring**, may be provided." (Gottlieb (DE) 2:99-100.) To the extent Gottlieb itself fails to inherently disclose a compression member comprising a disc spring, it would have been obvious to one of ordinary skill, viewing Gottlieb in view of its foreign equivalent Gottlieb (DE), that the compression member of Gottlieb could be a disc spring.

IV. CERTIFICATION

107. I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and, further, that these statements were made with the knowledge that willful false statements and the like are punishable by fine, imprisonment, or both, under Section 1001 of Title 18 of the U.S. Code.

Dated: 12 Dec 2022



Dr. Glenn Bower

APPENDIX A

Table of Exhibits

Exhibit No.	Description
1001	U.S. Patent No. 6,575,138 (<i>Challenged Patent</i>)
1002	[RESERVED]
1003	Curriculum Vitae of Dr. Glenn Bower
1004	U.S. Patent No. 6,530,273 (“Gottlieb”)
1005	German Patent Application No. DE1938862A1 (“Gottlieb (DE)”)
1006	Certified Translation of Gottlieb (DE)
1007	U.S. Patent Application No. 60/159,691 (“Provisional”)
1008	Redline Comparison of Challenged Patent and Provisional
1009	U.S. Patent No. 3,598,506 (“O’Neill”)
1010	Prosecution History of U.S. Patent No. 6,298,829
1011	U.S. Patent No. 5,630,550 (“Kurishige”)
1012	Prosecution History of U.S. Patent No. 6,575,138

APPENDIX B

Additional Materials Considered

“Internal Combustion Engine Fundamentals, 1st Edition”, John B. Heywood, 1988, McGraw-Hill.

“Internal Combustion Engine Fundamentals, 2nd Edition”, John B. Heywood, 2018, McGraw-Hill.

AUTOMATIONFORUM.COM, What Is a Needle Valve and What Is the Purpose of Needle Valves?,
<https://automationforum.co/what-is-a-needle-valve-and-what-is-the-purpose-of-needle-valves/>
(visited Nov. 18, 2022).