

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD

ROBERT BOSCH LLC, and
MERCEDES-BENZ USA, LLC,
Petitioners,

v.

WESTPORT FUEL SYSTEMS CANADA INC.,
Patent Owner.

U.S. Patent No. 6,575,138
Original Issue Date: Jun. 10, 2003
Title: DIRECTLY ACTUATED INJECTION VALVE

Case No. IPR2023-00293

**ROBERT BOSCH LLC AND MERCEDES-BENZ USA, LLC'S PETITION
FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 6,575,138**

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LISTING OF EXHIBITS

Exhibit	Description
1001	U.S. Patent No. 6,575,138 B2 to Welch et al.
1002	File History of U.S. Patent No. 6,575,138 B2 to Welch et al.
1003	Declaration of Dr. Matt Quinlan
1004	U.S. Patent No. 5,479,902 to Wirbeleit et al.
1005	DE 197 08 304 A1 to Klügl
1006	Certified translation of DE 197 08 304 A1 to Klügl and associated translator's declaration
1007	U.S. Patent No. 5,735,240 to Ito et al.
1008	U.S. Patent No. 6,295,969 B1 to Kato et al.
1009	U.S. Patent No. 5,697,554 to Auwaerter et al.
1010	U.S. Patent No. 4,725,002 to Trachte
1011	U.S. Patent No. 5,630,550 to Kurishige et al.
1012	U.S. Patent No. 4,684,067 to Cotter et al.
1013	EP 0 107 894 A2 to Beck et al.
1014	U.S. Patent No. 4,284,263 to Newcomb
1015	GB 2 318 390 A to Roessler et al.
1016	Docket from <i>Westport Fuel Systems Canada Inc. v. Ford Motor Company</i> , No. 2:21-cv-00453 (E.D. Tex.)
1017	Docket from <i>Westport Fuel Systems Canada Inc. v. Mercedes-Benz USA, LLC</i> , No. 2:21-cv-00454 (E.D. Tex.)
1018	Docket from <i>Westport Fuel Systems Canada Inc. v. Nissan North America, Inc.</i> , No. 2:21-cv-00455 (E.D. Tex.)

1019	Docket from <i>Westport Fuel Systems Canada Inc. v. General Motors, LLC</i> , No. 2:21-cv-00456 (E.D. Tex.)
1020	Docket from <i>Westport Fuel Systems Canada Inc. v. FCA USA LLC d/b/a FCA Group US LLC</i> , No. 2:21-cv-00457 (E.D. Tex.)
1021	Docket from <i>Robert Bosch, LLC v. Westport Fuel Systems Canada Inc.</i> , No. 1:22-cv-00370 (E.D. Va.)
1022	Plaintiff Westport Fuel Systems Canada Inc.’s Disclosure of Asserted Claims and Infringement Contentions, <i>Westport Fuel Systems Canada Inc. v. Ford Motor Company</i> , No. 2:21-cv-00453 (E.D. Tex. April 12, 2022)
1023	U.S. Patent No. 6,148,842 to Kappel et al.
1024	U.S. Patent No. 5,779,149 to Hayes, Jr.

I. Introduction

Petitioners Robert Bosch LLC and Mercedes-Benz USA, LLC (“Petitioners”) respectfully requests IPR of claims 1-3, 6, 13-14, 17-21, 26-28, and 41 of U.S. Patent No. 6,575,138 (“the ’138 patent”), which is assigned to Westport Fuel Systems Canada Inc. (“Westport” or “Patent Owner”). There is more than a reasonable likelihood that Petitioners will prevail with respect to at least one challenged claim.

The ’138 patent is directed to a fuel injector for an engine. According to the patent, this injector has two key features that purportedly serve to distinguish it from other injectors:

First, it is a directly actuated injector. It includes a piezoelectric or magnetostrictive actuator that acts directly on a valve needle that opens a valve into the combustion chamber. The injector does not include any intermediate valves between the actuator and the combustion chamber valve. The ’138 patent explains that this both speeds operation and allows for more precise control over what it calls valve needle “lift” (*i.e.*, the distance the needle moves to open the valve).

Second, the ’138 patent explains that its injector includes a “passive hydraulic link.” This is a volume of hydraulic fluid located between the actuator and valve needle. The “hydraulic link” is “passive” in that force is simply transmitted through the link’s hydraulic fluid. The fluid is not responsible for generating either in whole or in part the force applied to the valve needle. Fluid is not pumped or flowed from

one place to another during actuation. Instead, it acts as a solid with a substantially constant thickness. While this “hydraulic link” is passive during valve actuation, the ’138 patent explains that it is designed in a manner that allows the hydraulic fluid to re-distribute itself about the injector interior during periods of inactivity. According to the ’138 patent, this allows the injector to auto-adjust to account for the effects of thermal expansion and wear.

As of the ’138 patent’s filing date, this very type of fuel injector was well known. This petition discusses two exemplary references showing this: U.S. Patent No. 5,479,902 (Ex. 1004, “Wirbeleit”) and DE 197 08 304 A1 (Exs. 1005-1006, “Klügl”).

Wirbeleit teaches the same type of directly actuated fuel injector required by the ’138 patent. A piezoelectric or magnetostrictive actuator applies force to a valve needle to open a valve into a vehicle’s combustion chamber. There are no intermediate valves. Wirbeleit, like the ’138 patent, explains that this allows for precise control over the lift or distance the valve needle moves which in turn allows for control of the amount of fuel injection. Further, Wirbeleit’s injector includes a hydraulic link—which it refers to as “hydraulic transmission element 22”—that passively transfers force from actuator to valve needle.

While Wirbeleit does not expressly state that its hydraulic link is structured in a way that allows it to compensate for the effects of thermal expansion and wear, a

person having ordinary skill in the art (“POSITA”) would have considered this obvious in view of Klügl. Klügl, like Wirbeleit, teaches a fuel injector. Klügl’s injector also includes a hydraulic link—incompressible hydraulic fluid in a chamber 5 that is part of what Klügl calls a “transmission module 2.” This link transfers force from Klügl’s piezoelectric or magnetostrictive actuator to a valve needle. Klügl explains that its hydraulic link can be passive (*i.e.*, does not generate force) and acts as solid (*i.e.*, does not flow or change thickness) during actuation. But, during times of rest, hydraulic fluid can redistribute itself around Klügl’s transmission module to account for thermal expansion and wear. This is exactly what the ’138 patent claims require. As a result, the combination of Wirbeleit and Klügl render claims 1-3, 6, 13-14, 17-21, 26-27, and 41 obvious as demonstrated in Ground 1. Another reference—U.S. 4,284,263 (Ex. 1014, “Newcomb”)—teaches what claim 28 requires as shown in Ground 2.

Klügl itself also renders many of the ’138 patent’s claims obvious, at least when Patent Owner’s broader, erroneous interpretation of the claims is applied. Patent Owner has taken the position in co-pending district court actions that the claims do not require a directly actuated injector and instead more broadly extend to both directly and indirectly actuated injectors. *See* Section VI, *infra*. Again, unlike a directly actuated injector where the actuator acts on a valve that itself opens into the combustion chamber, an indirectly actuated injector includes an actuator that

operates only on an intermediate valve. This is what Klügl teaches. Applying this interpretation of the claims, Klügl renders claims 1-3, 6, 13-14, 17-21, 26-27, and 41 obvious as shown in Ground 3. Another reference—U.S. Patent No. 5,779,149 (Ex. 1024, “Hayes”)—provides an example of how a POSITA would understand parts of Klügl’s injector referenced in its specification but not shown in its figures to be structured. Newcomb again supplies the teachings required by claim 28 as demonstrated in Ground 4.

II. Mandatory Notices

A. Real Party-in-Interest

Petitioners Robert Bosch LLC and Mercedes-Benz USA, LLC are real parties-in-interest. While not petitioners, Robert Bosch GmbH and its subsidiaries, Mercedes-Benz Intellectual Property GmbH & Co. KG and Mercedes-Benz AG, Ford Motor Company, and General Motors LLC are also real parties-in-interest.

B. Related Matters

Westport is asserting the ’138 patent in the following district court cases:

- *Westport Fuel Systems Canada Inc. v. Ford Motor Company*, No. 2:21-cv-00453, filed in the Eastern District of Texas on Dec. 15, 2021; and
- *Westport Fuel Systems Canada Inc. v. General Motors, LLC*, No. 2:21-cv-00456, filed in the Eastern District of Texas on Dec. 15, 2021.

The ’138 patent was previously at issue in the following cases that have been dismissed:

- *Westport Fuel Systems Canada Inc. v. Mercedes-Benz USA, LLC*, No. 2:21-cv-00454, filed in the Eastern District of Texas on Dec. 15, 2021;
- *Westport Fuel Systems Canada Inc. v. Nissan North America, Inc.*, No. 2:21-cv-00455, filed in the Eastern District of Texas on Dec. 15, 2021; and
- *Westport Fuel Systems Canada Inc. v. FCA USA LLC d/b/a FCA Group US LLC*, No. 2:21-cv-00457, filed in the Eastern District of Texas on Dec. 15, 2021.

In addition to the '138 patent, Westport asserted one other patent in the district court actions referenced above: U.S. Patent No. 6,298,829 ("the '829 patent"). The application underlying the '138 patent identifies itself as a continuation-in-part of the application that led to the '829 patent. Petitioners have also filed a petition seeking *inter partes* review of the '829 patent in IPR2023-00292.

The '138 patent is also at issue in a non-infringement declaratory judgment action: *Robert Bosch, LLC v. Westport Fuel Systems Canada Inc.*, No. 1:22-cv-00370, filed in the Eastern District of Virginia on April 4, 2022.

Petitioner Mercedes will also be filing a second petition (not yet assigned a case number) related to the '138 patent.

C. Counsel, Service, and Fee Information

Petitioners designate the following counsel:

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The USPTO is authorized to charge the filing fee and any other fees incurred by Petitioners to the deposit account of Orrick, Herrington, & Sutcliffe LLP: 15-0665.

III. Requirements for IPR

A. Grounds for Standing

Petitioners certify that the '138 patent is available for IPR, and that Petitioners are not barred or estopped from requesting this IPR. While Petitioner Robert Bosch has initiated a declaratory judgment action relating to the '138 patent, that action seeks only a declaration of non-infringement. It does not challenge the validity of any claim of the '138 patent. *See* 35 U.S.C. § 315(a)(1).

B. Identification of Challenge and Statement of Precise Relief Requested

Petitioners request IPR of claims 1-3, 6, 13-14, 17-21, 26-28, and 41. This petition discusses claim construction, explains why the claims are unpatentable, provides details regarding where the various claim limitations are found in the prior art, and is supported by the accompanying Declaration of Dr. Matt Quinlan (Ex. 1003), a leading expert in the fuel injector field.

The application underlying the '138 patent—U.S. App. 09/863,187 (“the '187 application”)—was filed May 23, 2001. Further, the patent identifies itself as a continuation-in-part of U.S. App. 09/522,130 (“the '130 application”), filed May 9, 2000, and makes a facial claim of priority back to provisional application No. 60/159,791 (“the '791 provisional”), filed October 15, 1999. (Ex. 1001, Cover.) For purposes of this petition only, it has been assumed that the claims of the '138 patent are entitled to the benefit of this October 1999 provisional filing date.

Petitioners rely on the following references: (1) Wirbeleit (Ex. 1004), (2) Klügl (Exs. 1005-1006), (3) Newcomb (Ex. 1014), and (4) Hayes (Ex. 1024). These references are all prior art. (See Section VII.A.) As Klügl published in German, a certified translation and translator's declaration accompanies this petition. (See Ex. 1006.) All citations to Klügl in this petition are to this translation.

Petitioners challenge the claims on the following grounds:

Ground 1: Claims 1-3, 6, 13-14, 17-21, 26-27, and 41 are obvious over Wirbeleit and Klügl.

Ground 2: Claim 28 is obvious over Wirbeleit, Klügl, and Newcomb.

Ground 3: Claims 1-3, 6, 13-14, 17-21, 26-27, and 41 are obvious over Klügl and Hayes.

Ground 4: Claim 28 is obvious over Klügl, Hayes, and Newcomb.

IV. Institution Should Be Granted

Petitioners have established a reasonable likelihood of success on the merits. And, all other requirements for IPR have been met. The Board should institute IPR.

A. There Are No Grounds for a § 314 Discretionary Denial in this Case

There are three pending district court actions involving the '138 patent. In appropriate circumstances, the Board may consider the factors set forth in *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019 Paper 11, (P.T.A.B. Mar. 20, 2020) ("*Fintiv*") when determining whether institution should be granted in light of the pendency of such

actions. But, “the PTAB will not rely on the *Fintiv* factors to discretionarily deny institution in view of parallel district court litigation where a petition presents compelling evidence of unpatentability.” (6/21/22 Interim Procedure for Discretionary Denials, p. 2.) In other words, “compelling, meritorious challenges will be allowed to proceed at the PTAB even where district court litigation is proceeding in parallel.” (*Id.*, pp. 4-5.) Petitioner submits that this is the case here: as explained below, the claims of the ’138 patent are plainly and unambiguously unpatentable in view of the prior art.

Separate from the strength of the petition, all of the co-pending district court litigations involving the ’138 patent are in very early stages. No trial has been scheduled, no claim construction order has issued, no dispositive motions have been filed, and only minimal discovery has been conducted. (*See generally* Exs. 1016-1021.) This also weighs in favor of institution. *See Sand Revolution II, LLC v. Continental Intermodal Group – Trucking LLC*, IPR2019-01393, Paper 24 at 8-9, 11 (PTAB June 16, 2020).

B. Denial Under § 325(d) Would Be Inappropriate

The arguments set forth in this petition are different from those addressed by the Patent Office during prosecution. *Wirbeleit* and *Klügl* were not cited by the applicant or considered by the Examiner. (*See generally* Ex. 1002.) Further, as explained in Section V.B below, the prior art references that were addressed by the

Examiner purportedly failed to teach the claimed “passive hydraulic link.” In contrast, both Wirbeleit and Klügl specifically teach this. Thus, Wirbeleit and Klügl are substantively different from and overcome any purported deficiencies identified in connection with the art considered by the Examiner. For these reasons, and as further explained below, the Board should institute IPR.

V. The ’138 Patent

A. Overview

The ’138 patent relates to fuel “injectors for internal combustion engines” that are “directly controllable” by an actuator. (Ex. 1001, 1:16-20.) The injector also includes a “passive hydraulic link.” (*Id.*, 1:21.)

The patent explains that the prior art recognized that “[d]irect injection,” where fuel is injected directly into an engine’s “combustion chamber” was “desirable” because it improves engine performance and reduces emissions. (*Id.*, 1:23-40.) The patent concedes that “hydraulically actuated” injectors and injectors using “piezoelectric actuator[s]” were known and available. (*E.g., id.*, 2:13-17, 2:52-55.) But, existing hydraulically actuated systems were “bulk[y],” subject to “delayed response” times, and had reduced “controllability of the movement of the injection valve.” (*Id.*, 2:23-46.) Further, the known piezoelectric actuators were purportedly only used to “operate a control valve, which in turn controls the flow of a hydraulic fluid to operate an injection valve....” (*Id.*, 2:52-62.) This also

introduced delay and necessitated hydraulic fluid supply. (*Id.*, 2:58-64.)

The '138 patent proposes a “directly actuated” injector without “an intermediate active hydraulic operator generating any actuating forces.” (*Id.*, 2:64-67.) This injector does include a “passive hydraulic link.” (*Id.*, 3:39-40; 4:10-12; 7:24-36.) Unlike “[c]onventional active hydraulic operators,” this link “merely transmits the actuating forces” (*i.e.*, serves as a “load path”) “but is not employed to generate an actuating force for actuating the valve.” (*Id.*) The “passive hydraulic link” also provides a “further advantage” in that it “may be employed to correct for differential thermal expansion, wear and dimensional variability within permitted manufacturing and assembly tolerances.” (*Id.*, 7:57-60.) It does this by “auto-adjusting itself in response to these effects by allowing movement of hydraulic fluid between opposite sides of [a] hydraulic piston” to “re-zero[] itself to ensure that the desired valve member lift is maintained.” (*Id.*, 7:60-65.)

The below figures provide an example:

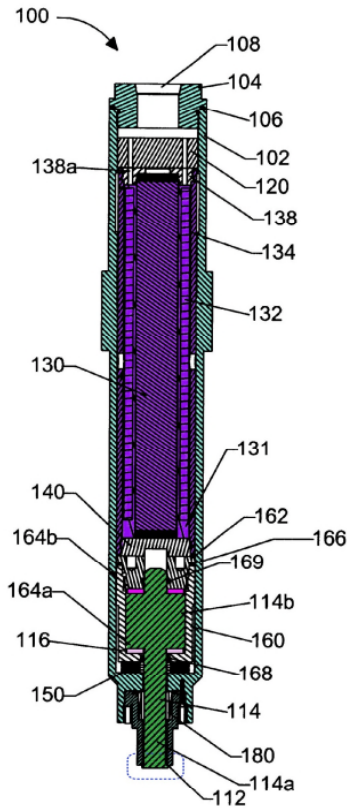


FIG. 1

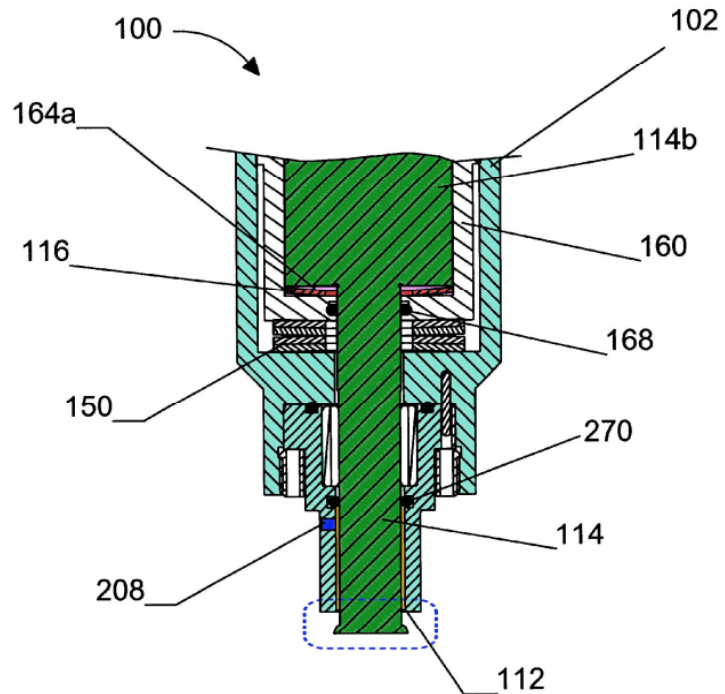


FIG. 2

(*Id.*, Figs. 1-2 (annotated); *see also* Ex. 1003, ¶¶ 46-69.)

These figures depict an “outward[ly] opening directly actuated fuel injection valve.” (Ex. 1001, 8:61-63.) A “valve housing 102” and “cap 104” (teal) “provide a fluidly sealed valve body.” (*Id.*, 9:4-6.) A “fuel inlet 208” (blue) supplies fuel to the injector interior (orange). (*Id.*, 13:33-39.) A “valve member 114” (green) is located within the injector. (*Id.*, 9:23-27.) One end of this member 114 “contacts [a] valve seat 112” (circled in blue) to close the injector. (*Id.*, 9:59-64.) A “valve spring 116” (red) in the form of a “disc or washer spring” (or “coil spring”) “biases” the member 114 “in the closed position.” (*Id.*, 10:13-19.)

A “magnetostrictive actuator” including a member 130, bobbin 131, coil 132, and flux tube 134 (purple) is located within the housing. (*Id.*, 10:41-46.) To open the valve, current is applied to the actuator causing it to “grow[] in length.” (*Id.*, 10:51-60.) This causes the actuator to push an intermediate “sliding pole 140” towards the “valve member 114 to provid[e] a force for opening injection valve 100.” (*Id.*, 10:59-62.) “The opening force generated by the actuator assembly is transmitted to valve member 114 through” “hydraulic fluid 164b” (small area of dark pink) of “a hydraulic link assembly.” (*Id.*, 11:65-67; 14:16-22.) During actuation, this fluid “does not have time to flow” through the “narrow clearance gap” surrounding the top of valve member 114, and instead “acts as a solid.” (*Id.*, 14:26-40.) But, when the injector is closed, “[a]uto-adjustments are accomplished by the migration of hydraulic fluid from chamber 164b on one side of hydraulic piston 114b to chamber 164a” (small area of light pink) “on the other side” of the piston. (*Id.*, 15:14-25.) This allows the injector “to account for the effects of temperature, wear, and any small movements of valve member 114....” (*Id.*; *see also* Ex. 1003, ¶¶ 70-73)

B. Prosecution History

All of the originally filed claims were rejected in a November 2002 office action as obvious over U.S. 5,630,550 (Ex. 1011, “Kurishige”). (*See* Ex. 1002, pp. 123-125.) Fig. 1 of Kurishige is reproduced below:

Applicant responded in February 2003. (Ex. 1002, pp. 128-141.) The Applicant characterized Kurishige as a “conventional ‘dynamic’ hydraulic system, which relies upon the flow of hydraulic fluid” from chamber 10 to the inner cylinder “to actuate a needle valve.” (*Id.*, pp. 134, 136-37.) This is “structurally and functionally distinguished from the applicants’ ‘passive’ hydraulic link. In a ‘dynamic’ hydraulic system, the hydraulic fluid does not ‘act substantially as a solid with the thickness being substantially constant while the actuator assembly is actuated’, as recited in claim 1 ... because the hydraulic fluid must flow from one

chamber to another to cause needle movement.” (*Id.*) This response led to allowance of the claims. (*Id.*, pp. 166-168; *see also* Ex. 1003, ¶¶ 74-80.)

Unlike Kurishige, both Wirbeleit and Klügl employ a passive hydraulic link. Neither employs dynamic hydraulic fluid flow to open an injector valve.

VI. Claim Construction

The Board applies the same *Phillips* claim construction standard used by district courts. *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (*en banc*). For purposes of this petition, Petitioners submit that the terms of the ’138 patent’s claims do not require further construction and can be afforded their plain and ordinary meaning. (*See* Ex. 1003, ¶¶ 82-85.) The below sections comparing the claims to the prior art include further discussion of the plain and ordinary meaning of certain claim terms.

Patent Owner’s district court infringement allegations nonetheless raise an issue of claim scope, although Petitioners submit that an express construction is not needed to reach a decision of unpatentability. Grounds 1 and 2 demonstrate unpatentability applying the plain and ordinary meaning, while Grounds 3 and 4 demonstrate unpatentability if the claims are afforded the scope alleged by Patent Owner in the district court. Specifically, Patent Owner alleges that an indirectly actuated valve—*i.e.*, one where the “valve needle” does not itself open a pathway into the combustion chamber but instead only opens an intermediate valve that

triggers other structure to open this pathway—falls within the scope of the claims. (See, e.g., Ex. 1022, p. 23 (pointing to an alleged “valve seat” and “valve member” that form an intermediate valve that does not open to the combustion chamber).)

This interpretation of the ’138 patent is contrary to the claim language itself. Claim 1 requires a “valve member” that “cooperat[es] with” a “valve seat” “to seal” an “interior chamber from [the] combustion chamber.” (Ex. 1001, claim 1.) Thus, it is the valve member—and not some other structure—that operates to open and close a passage from the injector’s “interior chamber” to the “combustion chamber.” Further emphasizing this, claim 1 also provides that the “valve member” has “one end disposed within said valve housing and an opposite end extendable from said valve seat toward said combustion chamber.” (*Id.*) In other words, the “valve member” must extend from a point inside the housing to a point outside the housing and in the combustion chamber. It is not an intermediate valve located entirely inside the housing.

Even if this were not already clear enough from the claims, the specification further emphasizes that the ’138 patent requires a directly actuated injector. The specification repeatedly and consistently explains that its invention is a “directly actuated injector.” (*Id.*, 8:32-33; see also Abstract, 1:16-21; 2:66-67; 16:37-39.) The patent also contrasts itself with prior art injectors that are indirectly actuated.

(*See, e.g., id.*, 2:52-3:7.) Indeed, the '138 patent is even entitled “Directly Actuated Injection Valve.” (*Id.*, Cover; *see also* Ex. 1003, ¶¶ 86-96.)

The '138 patent cannot be properly interpreted (as Patent Owner attempts to do in district court) to extend to an indirectly actuated valve. Again, *Wirbeleit*—the primary reference at issue in Grounds 1 and 2—teaches a directly actuated valve and thus renders the claims unpatentable when properly interpreted. *Klügl*—the primary reference at issue in Grounds 3 and 4—relates to an indirectly actuated valve. Thus, Grounds 3 and 4 use and are premised on Patent Owner’s erroneous understanding of the claims, notwithstanding Petitioners’ belief that this understanding is incorrect. *See 10X Genomics, Inc. v. Bio-Rad Labs.*, IPR2020-00086, Paper 8 at 18-19, 21 (PTAB Apr. 27, 2020) (explaining that the Board’s claim construction “rule does not prohibit [a p]etitioner from submitting a claim construction it believes is incorrect and relying on that construction to show how the claim is unpatentable.”); *Western Dig. Corp. v. SPEX Techs., Inc.*, IPR2018-00084, Paper 14 (PTAB Apr. 25, 2018).

VII. How the Challenged Claims Are Unpatentable

A. Prior Art Overview

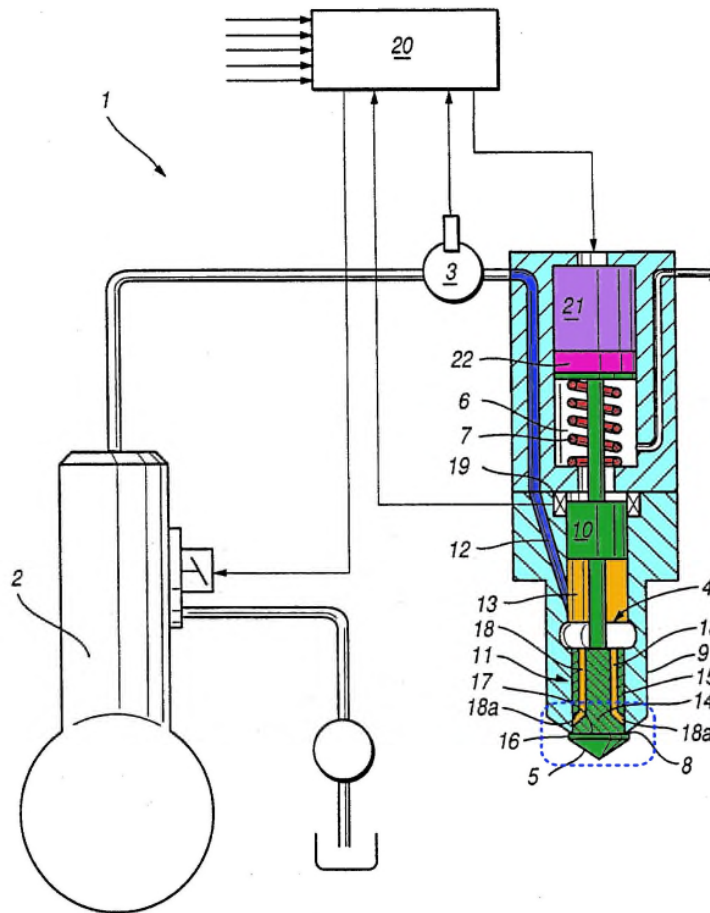
The prior art teaches the same fuel injector the '138 patent requires.

1. Wirbeleit

Wirbeleit issued January 2, 1996. (Ex. 1004, Cover.) It is prior art under § 102(b). *Wirbeleit* was not considered during prosecution.

Werbeleit teaches a “fuel injection system for a Diesel engine.” (*Id.*, 1:45-46.) Werbeleit’s injector has a “control needle” with fuel injection orifices that can be “exposed to a degree controllable ... depending on engine operating parameters.” (*Id.*, 1:52-57.)

Werbeleit’s injector is shown in the below:



(*Id.*, Fig. (annotated); see also Ex. 1003, ¶¶ 103-110.) The injector includes an outer “body 9” (teal). (Ex. 1004, 2:31-35.) A “spring 7” (red) forces the tip of a “control needle 5” (green) onto a “valve seat 8” (circled) to close the injector. (*Id.*) To open the injector, a “piezo” or “magnetostrictive actuator 21” (purple) applies force to the

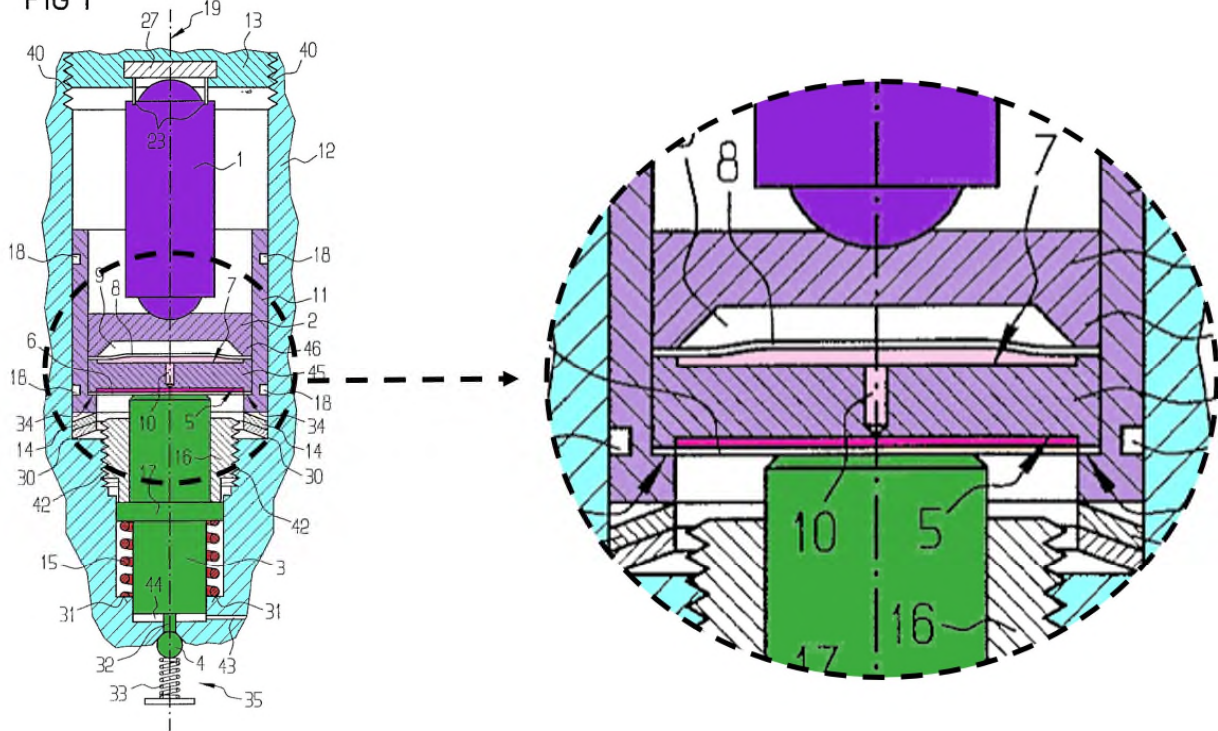
needle “by way of a hydraulic transmission element 22” (pink). (*Id.*, 2:60-65.) This allows fuel to flow through “fuel admission passage 12” (blue) to “pressure chamber 13,” grooves 18, and orifices 18a (orange), and into the combustion chamber. (*Id.*, 2:35-39.) The desired needle lift—and the corresponding orifice size—“is maintained by way of voltage control of the actuator 21.” (*Id.*, 3:1-7; *see also* Ex. 1003, ¶¶ 99-111.)

2. Klügl

Klügl published September 10, 1998. (*See* Ex. 1006, Cover.) Klügl is prior art under § 102(b). Klügl was not considered during prosecution.

Klügl teaches a “power transmission device” to “transmit the movement of a piezoelectric actuator” to open and close a fuel injector. (*Id.*, 1:7-12.) Klügl’s injector is shown in the below. The central portion of the figure has been expanded to the right:

FIG 1



(*Id.*, Fig. 1 (annotated); *see also* Ex. 1003, ¶¶ 117-124.) The injector includes an “upper stop 13” and outer “housing 12” (teal) surrounding its components. (Ex. 1006, 1:47-51.) A “spring 15” (red) forces a “drive piston 3”—along with connected “control needle 32” and “ball 4” (all green)—upwards to close the injector. (*Id.*, 2:35-39, 50-57.) To open the injector, a signal is applied to a “piezoelectric actuator 1” (dark purple) causing it to expand and press a “transmission module 2” (light purple) downwards toward the piston 3 against the force exerted by disk spring 14. (*Id.*, 3:23-33.) Force is transmitted from the actuator to the piston through incompressible hydraulic fluid “located in [a] pressure chamber 5” (dark pink). (*Id.*, 3:26-29.) This chamber is defined and sealed by a membrane

6. (*See id.*) Moving the piston's ball 4 off its seat causes the pressure in a "pressure chamber" at the bottom of Klügl's injector to drop, an "injection needle" to open, and fuel to be injected. (*Id.*, 3:30-38.)

During actuation, no hydraulic fluid flows out of chamber 5. (*Id.*, 4:11-22.) But, during idle periods, hydraulic fluid can move from chamber 5 through bore 10 to chamber 7 (light pink) to "automatic[ally] adjust[]" for "thermal expansion differences and gradual wear" and keep the "drive piston 3" in contact with "transmission module 2." (*Id.*, 3:50-4:33.) The hydraulic fluid is completely captured and contained within the transmission module. (*See id.*; Fig. 1.) There is no external fluid source. (*See id.*; *see also* Ex. 1003, ¶¶ 112-125.)

3. Newcomb

Newcomb issued August 18, 1981. (*See* Ex. 1014, Cover.) It is prior art under § 102(b). Newcomb was not considered during prosecution.

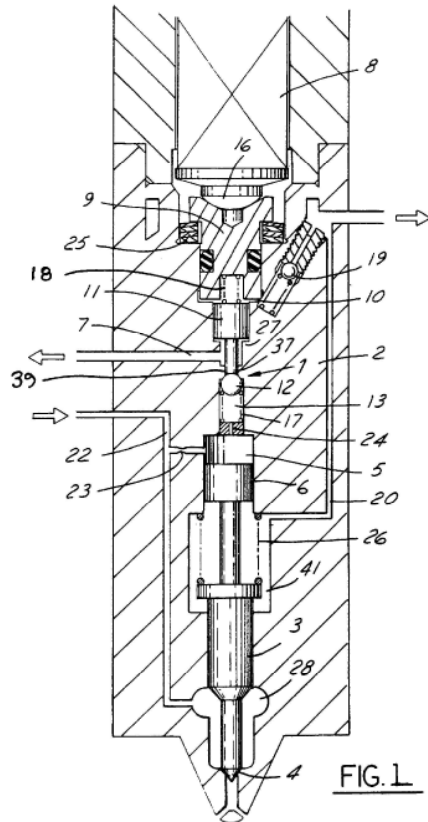
Newcomb teaches a "control valve such as a ... fuel injection valve." (*Id.*, 1:5-7.) The valve employs materials with matching thermal expansion coefficients to "enable[] the effects of thermal expansion to be reduced...." (*Id.*, 1:45-49; *see also* Ex. 1003, ¶¶ 126-129.)

4. Hayes

Hayes issued July 14, 1998. (*See* Ex. 1024, Cover.) Hayes is prior art to the '138 patent under § 102(b). Hayes is cited on the face of the '138 patent but was not

specifically discussed by the Examiner.

Hayes teaches an indirectly actuated fuel injector. (*Id.*, 1:7-9.) Hayes explains that such an injector includes an intermediate “control valve 1” sealed by a ball-shaped “component 12.” (*Id.*, 2:7-15, 30-33.) Actuating the injector opens the control valve. (*Id.*, 3:24-45.) Hayes also explains how this in turn opens a valve into the combustion chamber. In particular, opening the intermediate control valve lowers the pressure in a “chamber 5” which causes a separate “valve needle 3” to lift and open a passage into combustion chamber. (*Id.*, 3:52-63.) Fuel supplied by a “feeding line 22, which feeds the fuel at high pressure,” is then injected through the passage opened by the needle. (*Id.*, 2:45-48, 3:52-63.) Figure 1 of Hayes shows these various components:



(*Id.*, Fig. 1; see also Ex. 1003, ¶¶ 130-137.)

B. Level of Ordinary Skill in the Art

A POSITA in the technology 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. (See Ex. 1003, ¶¶ 37-39, 41.) 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. (*Id.*, ¶ 40.)

C. Ground 1: Claims 1-3, 6, 13-14, 17-21, 26-27, and 41 Are Obvious Over Wirbeleit and Klügl

The combination of Wirbeleit (Ex. 1004) and Klügl (Exs. 1005-1006), when considered in view of the knowledge of a POSITA, render claims 1-3, 6, 13-14, 17-21, 26-27, and 41 obvious. (See Ex. 1003, ¶¶ 138-140.)

Wirbeleit teaches the claimed directly actuated fuel injector: a piezoelectric actuator 21 generates force that is transferred through a passive hydraulic transmission element 22 to an injector orifice control needle 5 to open a valve and start injection. While Wirbeleit does not expressly state that its element 22 adjusts to account for thermal expansion and wear, it would have been obvious to design it to do so in view of the teachings of Klügl. Klügl also teaches a fuel injector. And, its injector includes a transmission module 2 with chamber 5 filled with hydraulic fluid that not only passively transfers force during valve actuation, but also adjusts to account for thermal expansion and wear during idle periods.

1. Claim-by-Claim Analysis

a. Claim 1

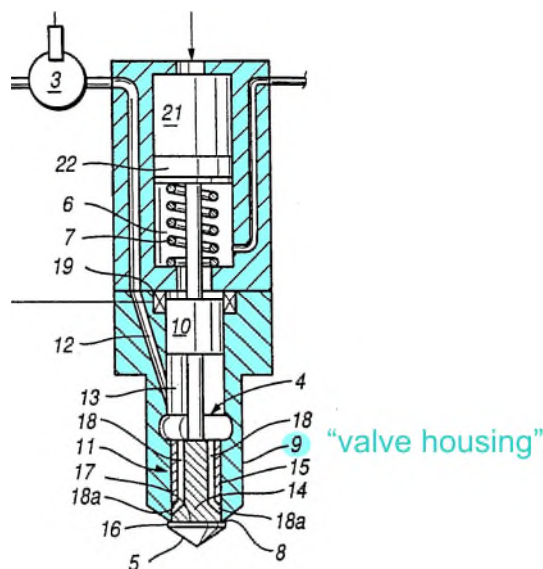
[1-p] “An injection valve for injecting fuel into a combustion chamber of an internal combustion engine, said injection valve comprising:”

To the extent the preamble is limiting, Wirbeleit teaches an **“injection valve.”** Wirbeleit relates to fuel injectors for “direct-injection Diesel engines.” (Ex. 1004, 1:7-12, 30-37.) Direct injection entails injecting fuel directly into the combustion chamber (as opposed to injection into the manifold). (See Ex. 1007, 2:7-10 (in a

“direct ... injection system,” “the fuel injector ... sprays ... into the cylinder bore”);
Ex. 1008, 1:16-24 (similar); *see also* Ex. 1003, ¶¶ 141-148.)

[1(a)] “(a) a valve housing comprising:”

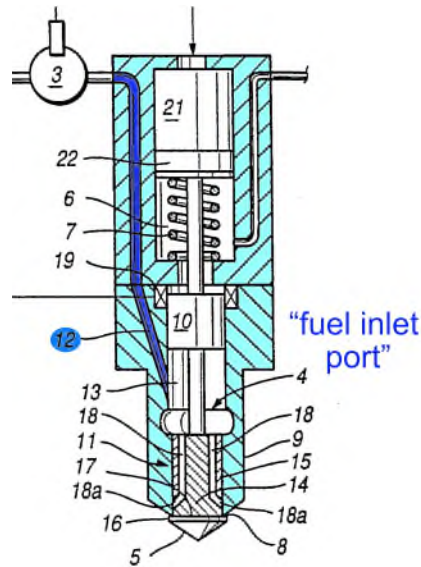
Wirbeleit’s “injector” includes an “injector body 9” that surrounds and contains the other injector components. (Ex. 1004, 1:31-35.) This body 9—the claimed “**valve housing**”—is shown in teal below. This figure has been cropped throughout this petition to better focus on the depicted injector:



(*Id.*, Fig. (annotated); *see also* Ex. 1003, ¶¶ 149-151.)

[1(a)-1] “a fuel inlet port;”

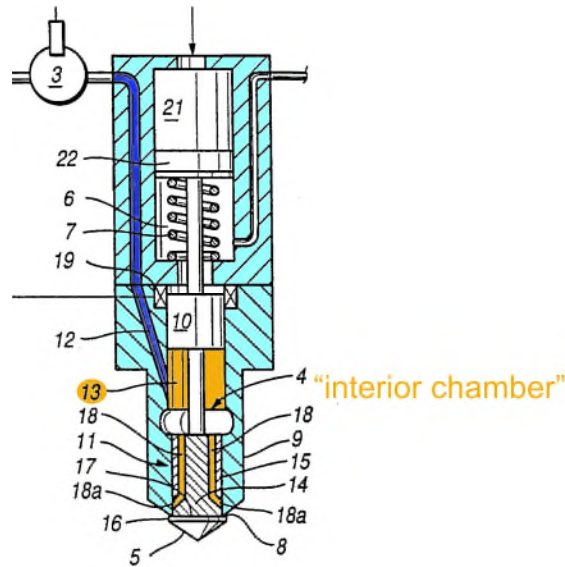
Wirbeleit’s “valve housing” (body 9) includes the claimed “**fuel inlet port.**”
A “fuel admission passage 12” in “communication with the common supply conduit 3” to allow fuel to enter the injector. (Ex. 1004, 2:35-40.) This is shown below in blue:



(*Id.*, Fig. (annotated); see also Ex. 1003, ¶¶ 152-155.)

[1(a)-2] “an interior chamber fluidly connected to said fuel inlet port; and”

Wirbeleit explains that its “control needle 5” “delimits a pressure chamber 13 ... in communication with” the “fuel admission passage 12.” (Ex. 1004, 2:35-40.) The chamber 13 also connects to grooves 18 and orifices 18a that form “fuel injector passages.” (*Id.*, 2:45-55.) Again, passage 12 is Wirbeliet’s “fuel inlet port.” The pressure chamber 13, grooves 18, and orifices 18a—Wirbeleit’s “*interior chamber*”—are connected to this passage and are shown below in orange:



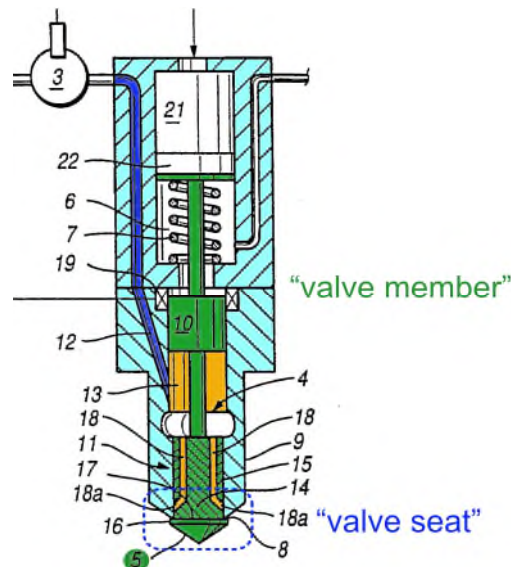
(*Id.*, Fig. (annotated); *see also* Ex. 1003, ¶¶ 156-160.)

[1(a)-3] “a valve seat for cooperating with a valve member to seal said interior chamber from said combustion chamber when said injection valve is closed;”

[1-b] “(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 liftably away from said valve seat when said injection valve is open;”

Wirbeleit’s injector satisfies both limitations. Wirbeleit includes “an injector orifice control needle 5” within its “injector body 9.” (Ex. 1004, 2:31-32; *see also* Abstract ; 1:48-49.) Among other parts, this needle includes a “piston-like needle tip 11” with a “collar 16 ... disposed outside the injector body 9....” (*Id.*, 2:35-37, 40-45.) The “rear side 17” of the “collar 16” “forms the valve seating surface.” (*Id.*, 2:43-45.) It is “forced onto the valve seat 8 on the injector body 9” to close the injector. (*Id.*, 2:31-35; *see also* Abstract; 1:48-52.) Wirbeleit’s needle—the claimed

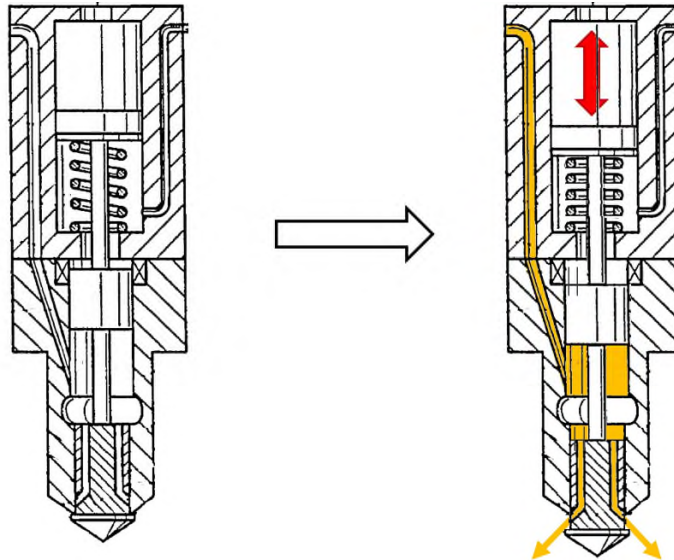
“valve member”—is shown in green below. The valve seating surface—the **“valve seat”** with which Wirbeleit’s “valve member” **“cooperat[es] ... to seal”**—is circled:



(*Id.*, Fig. (annotated); Ex. 1003, ¶¶ 161-165.)

Wirbeleit also explains that its “needle 5 is” “movable outwardly for opening the orifice[s]” to start fuel injection, and can be “forced onto the valve seat 8 on the injector body 9” to stop injection. (Ex. 1004, 2:31-35; *see also* Abstract; 1:52-58; 3:5-11.) Thus, the needle is **“extendable from said valve seat toward said combustion chamber,”** and can both **“fluidly seal[] against said valve seat”** to close Wirbeleit’s injector, and **“lift[] away from said valve seat”** to open the injector.

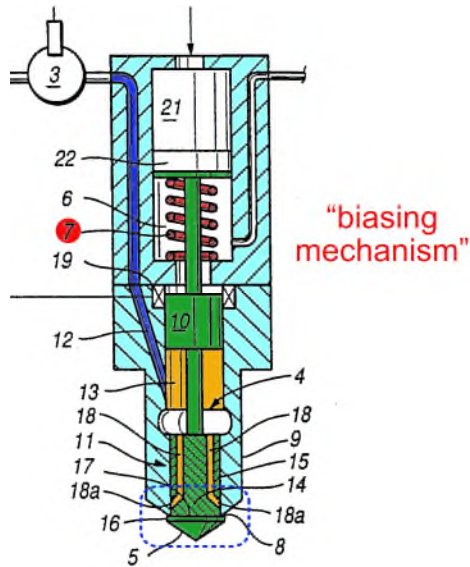
This is shown below. In the left demonstrative, Wirbeleit’s needle is forced against the valve seat closing the injector. In the right demonstrative, Werbeliet’s needle has moved out of the injector body and lifted off the valve seat exposing the slot orifices and allowing fuel (shown in yellow) to be injected:



(Ex. 1003, ¶¶ 166-172.)

[1(c)] “(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;”

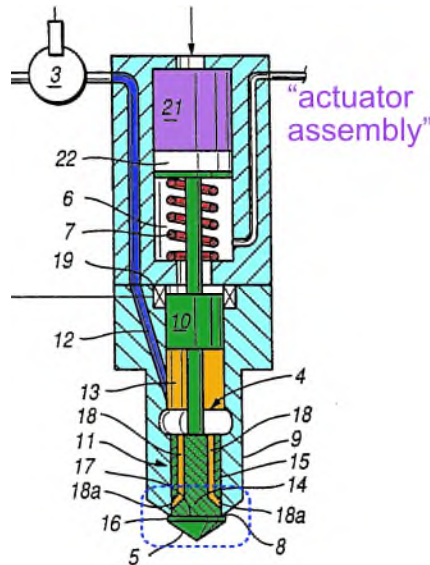
Wirbeleit includes the claimed “*biasing mechanism.*” Wirbeleit’s injector includes a “return spring 7.” (Ex. 1004, 2:35-36.) The spring “force[s]” the “injector orifice control needle 5 ... onto the valve seat 8 on the injector body 9” to close the injector. (*Id.*, 2:31-36; *see also* Abstract; 1:48-30; 3:7-11.) Spring 7 is shown in red below:



(*Id.*, Fig. (annotated); Ex. 1003, ¶¶ 173-176.)

[1(d)] “(d) an actuator assembly associated with said valve member, wherein said actuator assembly may be actuated to apply an opening force to said valve member stronger than said closing force, for moving said valve member to said open position; and”

Wirbeleit’s injector includes the claimed “*actuator assembly.*” A “magnetostrictive actuator 21” (or “piezo actuator”) is located “[a]t the rear end of the orifice control needle 5 opposite its tip 11....” (Ex. 1004, 2:60-65.) “Opening of the slot-injection orifices can be controlled by energizing” the “actuator which acts on the injector needle ... against a compression spring with a voltage-dependent force.” (*Id.*, 2:1-4; *see also* Abstract; 1:50-52.) Wirbeleit’s actuator is shown in purple below:



(*Id.*, Fig. (annotated); see also Ex. 1003, ¶¶ 177-180.)

[1(e)] “(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 actuated and wherein said thickness of said hydraulic link is adjustable while said actuator assembly is not actuated in response to changes in the dimensional relationship between components of said injection valve to maintain a desired valve lift upon actuation of said actuator assembly.”

Wirbeleit’s injector employs a *“hydraulic link assembly” “through which ... opening and closing forces are transmitted.”* Wirbeleit’s “actuator 21 ... operates the orifice control needle 5 by way of a hydraulic transmission element 22....” (Ex. 1004, 2:60-64; see also 2:1-4 (the actuator “acts on the injector needle by way of a hydraulic transmission element against a compression spring....”).) Thus, during valve opening, force is exerted from the actuator through the hydraulic transmission element to the needle. During valve closing, force is exerted from the spring, to the needle, and back through the hydraulic transmission element until a rest position is

189.) Wirbeleit's hydraulic transmission element is shown below in pink:



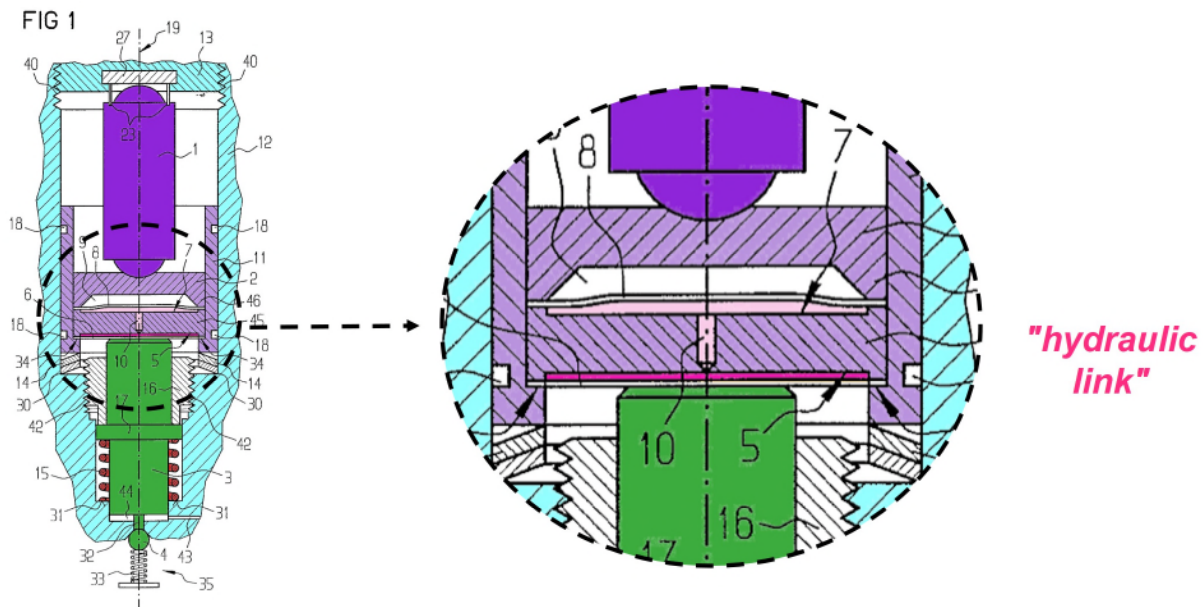
(Ex. 1004, Fig. (annotated); *see also* Ex. 1003, ¶ 190.)

Section VII.C.2, *infra*.) Klügl relates to a device that can be used in an “automotive”

fuel injector “to transmit the movement of a piezoelectric actuator in an injection valve....” (Ex. 1006, 1:7-12.) Klügl’s injector, like Wirbeleit’s, has an outer “housing 12.” (*Id.*, 1:47-51.) A “piezoelectric actuator 1” is located within this housing. (*Id.*) A “transmission module 2” is located between the actuator and a “drive piston 3.” (*Id.*, 1:48-51; 2:23-41; Fig. 1.) The drive piston is attached to needle 32 and ball 4 (also referred to as a “closing element 4”) forming a “servo valve” that serves to activate “an injection needle.” (*Id.*, 2:50-57, 3:11-13.) A “spring 15” exerts force on the drive piston to close the valve. (*Id.*, 2:35-36.) The intermediate transmission module includes a “pressure chamber 5” filled with “hydraulic fluid” with “low compressibility.” (*Id.*, 1:60-2:4.) The transmission module also includes a “throttl[e]” or “connecting bore 10” that connects the “pressure chamber 5 to a compensating chamber 7.” (*Id.*) The compensating chamber is filled with the same incompressible hydraulic fluid as the pressure chamber 5. (*Id.*) The hydraulic fluid is completely captured, contained, and sealed within the transmission module. (*See id.*; Fig. 1.) There is no external fluid source. (*See id.*)

These components are shown below. The same coloring scheme used when comparing Wirbeleit to claim 1 has been employed. The housing 12 (Klügl’s “valve housing”) is shown in teal. The piezoelectric actuator 1 and transmission module 2 (Klügl’s “actuator assembly”) are respectively shown in dark and light purple. The

drive piston, needle, and ball (Klügl’s “valve member”) are shown in green. The valve-closing spring (Klügl’s “biasing mechanism”) is shown in red. The pressure chamber 5 (Klügl’s “hydraulic link”) is shown in dark pink, while throttle 10 and compensation chamber 7 are shown in light pink. The region of the figure showing these chambers has been expanded to the right for emphasis purposes:



(*Id.*, Fig. 1 (annotated); *see also* Ex. 1003, ¶¶ 192-206.)

During operation, when the “piezoelectric actuator 1 is ... controlled,” “pressure is exerted on the drive piston 3 via ... the transmission medium located in the pressure chamber 5....” (Ex. 1006, 3:23-29.) In Figure 1, the dimensions of chamber 5—including its thickness—remain constant so that the movement of the actuator results in the same amount of movement of the piston. (*See id.*, Fig. 1; 3:23-29; *see also* Ex. 1003, ¶¶ 207-215.) In contrast, in the different embodiment of

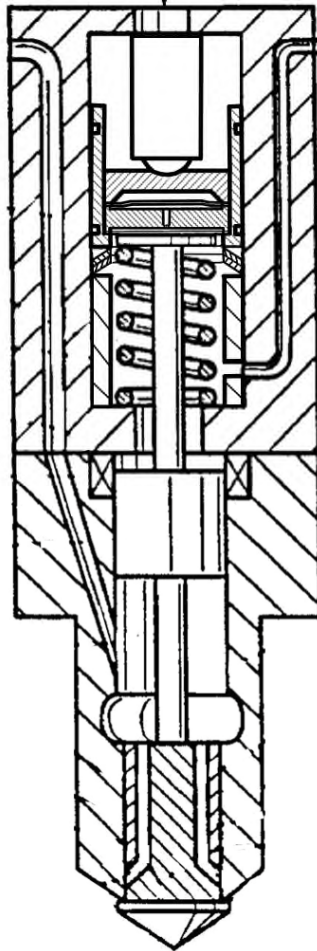
Figure 3, the dimensions of chamber 5 change during actuation resulting in movement amplification from the actuator to the piston. (See Ex. 1006, 1:41-46 (noting that Fig. 1 is “without stroke translation” while Fig. 3 is “with stroke translation”); 7:12-14 (noting that Fig. 3, unlike Fig. 1, “achieves a stroke ratio between the deflection of the piezoelectric actuator 1 and the deflection of the drive piston 3”); *see also* Ex. 1003, ¶¶ 208-215.)

Klügl also explains that the transmission module’s “throttle 10” is “dimensioned in relation to the transmission medium such that during normal activation” “only an insignificant amount of transmission medium flows into the compensat[ion] chamber.” (Ex. 1006, 4:11-22.) But, during periods of rest, “if there are long-lasting pressure differences between the pressure chamber 5 and the compensation chamber 7[,] ... transmission medium is exchanged between the compensation chamber 7 and the pressure chamber 5 via the throttle 10.” (*Id.*, 4:25-31.) This allows Klügl’s injector to account for “thermal expansion differences and gradual wear” and ensures that the “drive piston 3” remains in contact with the transmission module. (*Id.*, 3:50-4:31; *see also* Ex. 1003, ¶¶ 216-217.)

Again, Wirbeleit already employs a hydraulic transmission element 22 to transfer the movement of its actuator 21 to needle 5. While the structure of this element 22 “is not shown in detail” in Wirbeleit (Ex. 1004, 2:64), Klügl supplies this detail and confirms what a POSITA would understand from Wirbeleit’s teachings.

In Klügl, as in Wirbeleit, force from an actuator passes through the hydraulic fluid in chamber 5 (which is also sealed within transmission module 2) to the piston 3 for purposes of opening a valve. Further, Klügl explains that fluid does not flow into or out of chamber 5 during actuation. Thus, this chamber and the fluid it contains—like Werbeliet’s own hydraulic transmission element 22—is a **“passive hydraulic link.”** Per Klügl, the fluid also has a low compressibility. And, in the embodiment of Figure 1 (unlike the embodiment of Figure 3), no stroke amplification occurs and chamber 5 does not change dimension. As a result, the hydraulic link simply transmits force rather than generating it and its **“thickness”** is **“substantially constant.”** (See Ex. 1003, ¶¶ 218-222.) Finally, fluid flows between chambers 5 and 7 through the throttle 10 during times of rest to account for thermal expansion or wear and keep the injector components in contact. Thus, its **“thickness ... is adjustable while said actuator is not activated in response to changes in the dimensional relationship between components.”** (See *id.*, ¶ 223.) As Wirbeleit’s system is meant to facilitate control of the amount of “needle lift” (*e.g.*, Ex. 1004, 2:1-12), a POSITA would have understood that when applied to Wirbeleit, Klügl’s transmission module 2 would be structured so as to maintain the intended needle lift or position range (*i.e.*, the claimed **“desired valve lift upon actuation”**). (Ex. 1003, ¶¶ 224-225.) An example application of Klügl to Wirbeleit—with Wirbeleit’s

hydraulic transmission element 22 replaced with Klügl's transmission module—is shown in the demonstrative below:



(*Id.*, ¶ 226.)

b. Claim 2

Claim 2 depends on claim 1 and further requires:

“wherein said thickness of said hydraulic link is auto-adjustable while said actuator assembly is not actuated in response to changes in said dimensional relationship caused by differential thermal expansion.”

The combination of Wirbeliet and Klügl teach the claimed ***“auto-adjustable”*** ***“hydraulic link.”*** When Klügl’s actuator is “in the rest position,” “if there are long-

lasting pressure differences between the pressure chamber 5 and the compensation chamber 7, ... transmission medium is exchanged between the compensation chamber 7 and the pressure chamber 5 via the throttle 10.” (Ex. 1006, 3:50-4:31.) According to Klügl, this accounts for the effects of “thermal expansion differences and gradual wear” of its components, and operates to ensure that the “drive piston 3” remains in contact with the transmission device even if the piston or actuator change in size. (*Id.*, 3:52-62; 4:25-31; Ex. 1003, ¶¶ 227-231.)

c. Claim 3

Claim 3 depends on claim 2 and further requires:

“wherein said thickness of said hydraulic link is auto-adjustable while said actuator assembly is not actuated in response to changes in said dimensional relationship caused by wear to components of said injection valve.”

This is taught by the combination of Wirbeliet and Klügl for the same reasons discussed for claim 2: Klügl’s transmission module 2 allows for fluid flow between chambers 5 and 7 during periods of non-activation to account not only for thermal expansion, but also component wear. (*See supra* Sections VII.C.1.b; Ex. 1003, ¶¶ 232-234.)

d. Claim 6

Claim 6 depends on claim 1 and further requires:

“wherein said actuator assembly comprises a dimensionally responsive member.”

This is taught by Wirbeleit: Wirbeleit employs either a “magnetostrictive actuator 21” or “piezo actuator” that expands in length in response to a control signal. (Ex. 1004, 2:60-65; *see also* 2:1-4, 13-17; Ex. 1003, ¶¶ 235-238.)

e. Claim 13

Claim 13 depends on claim 6 and further requires:

“wherein said dimensionally responsive member is formed from a piezoelectric material.”

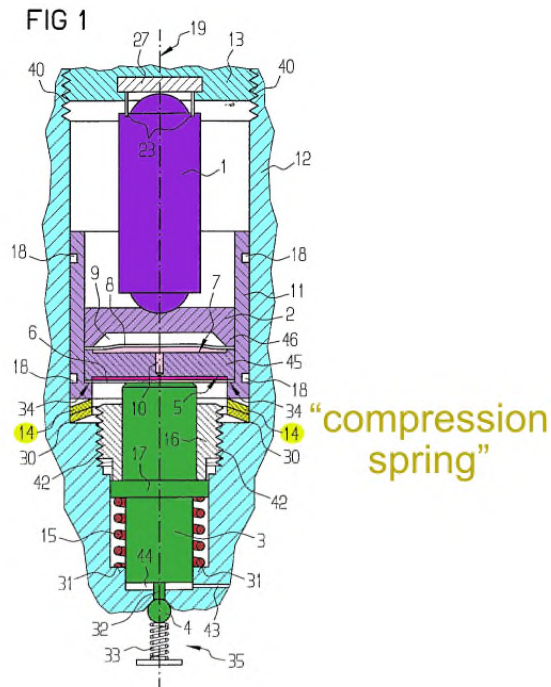
This is taught by Wirbeleit for the same reasons discussed for claim 6: Wirbeleit includes a piezoelectric actuator 21. (*See supra* Section VII.C.1.d; Ex. 1003, ¶¶ 239-241.)

f. Claim 14

Claim 14 depends on claim 6 and further requires:

“a compression spring member for applying a compressive force to said dimensionally responsive member.”

This is taught by the combination of Wirbeleit and Klügl. Klügl’s injector includes a “disk spring 14” that “pre-stress[es]” the piezoelectric actuator 1 “against” the valve housing via the “transmission module 2.” (Ex. 1006, 2:11-21; 3:16-19.) This disk spring 14—the claimed **“compressing spring member”**—is shown in yellow below:



position of the orifice needle”). (*Id.*, 2:4-12.) In other words, in Wirbeleit, different, controllable amounts of needle lift are employed to allow “the injection orifice cross-section of the injector” to be “variable and ... controlled depending on the requirements” for “engine performance...” (*Id.*, 1:59-63; *see also* 3:5-7 (noting that “[a]n appropriate injector slot orifice cross-section” can be “maintained by way of voltage control of the actuator”); 3:13-14 (the “orifice cross-section of the fuel injector can be controlled”); *see also* Ex. 1003, ¶¶ 248-253.)

While Wirbeleit does not specifically reference adjustment of its valve needle **“between 10 and 100 percent of maximum lift,”** it nonetheless teaches a valve needle that allows for a controllable amount of lift. And, “where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation.” *EI DuPont de Nemours & Co. v. Synvina C.V.*, 904 F.3d 996, 1006 (Fed. Cir. 2018) (*quoting In re Aller*, 220 F.2d 454, 456 (CCPA 1955)). The general conditions of claim 17 are present in the prior art: Wirbeleit teaches a valve with controllable needle lift that can be varied between 100% lift and amounts less than 100%. Moreover, the ’138 patent identifies no importance or significance to the use of a range of “10 to 100 percent of maximum lift.” Instead, the patent explains that the purpose of the claimed actuator is simply to “provide for” some degree of “partial lifting.” (Ex. 1001, 8:19-21.) Thus, 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 Wirbeleit's valve is indistinguishable from that of the '138 patent: both allow for either full or partial needle lift. (See Ex. 1003, ¶¶ 254-259.)

h. Claim 18

Claim 18 depends on claim 17 and further requires:

“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.”

This is taught by Wirbeleit: needle “lift position” and the corresponding “[o]pening of the slot-injection orifices can be controlled by energizing a piezo actuator which acts on the injector needle ... with a voltage-dependent force.” (Ex. 1004, 2:1-6; *see also* 2:10-12; 3:1-7; *see also* Ex. 1003, ¶¶ 260-263.)

i. Claim 19

Claim 19 depends on claim 6 and further requires:

“wherein said valve member is controllable such that said valve member moves between said open and closed positions in less than about 200 microseconds.”

This is taught by Wirbeleit and Klügl. Wirbeleit explains that its valve “injection time is adjustable depending on engine operating parameters.” (Ex. 1004, 3:15-16.) And, Klügl explains that the “actuation times” of an injection valve should be “in the range of milliseconds, preferably between 0 ms and 10 ms. Fast actuation times are 0.1 to 1 ms” (or 100 to 1000 microseconds). (Ex. 1006, 4:22-24.) This range—which a POSITA would consider to be standard at the time the '138 patent

was filed—includes valve actuation times that overlap the claimed range. (*See* Ex. 1003, ¶¶ 265-269.)

j. Claim 20

Claim 20 depends on claim 6 and further requires:

“a biasing mechanism for applying a compressive force to said dimensionally responsive member.”

This claim requires a further “biasing mechanism” in addition to the “biasing mechanism associated with said valve member” already required by claim 1. This is taught by Klügl for the same reasons explained for claim 14: Klügl includes an additional disk spring 14 that applies a pre-loading force to its piezoelectric actuator 1. (*See supra* Section VII.C.1.f; *see also* Ex. 1003, ¶¶ 270-272.)

k. Claim 21

Claim 21 depends on claim 1 and further requires:

“wherein said biasing mechanism comprises a spring.”

This claim limits the “biasing mechanism associated with said valve member” of claim 1 to “a spring.” This is taught by Wirbeleit: as explained when discussing claim 1, Wirbeleit’s injector includes a return spring 7 that applies force to close the injector. (*See supra* Section VII.C.1.a.[1(c)]; *see also* Ex. 1003, ¶¶ 273-275.)

l. Claim 26

Claim 26 depends on claim 1 and further requires:

“wherein said fuel is injected into said combustion chamber at a pressure greater than about 2000 psi (about 13.8 Mpa).”

Wirbeleit explains that its injection valve is meant for use with a “high pressure” fuel injection system. (Ex. 1004, 2:27-30.) A POSITA would have recognized that in such a system, injection pressure varies with engine speed, from “relatively low pressure ... of ... 2000 psi” at lower idle speeds, to pressures as high as 15,000 psi at higher engine speeds. (*E.g.*, Ex. 1012, 5:48-52, 7:1-14; *see also* Ex. 1013, 11:25-31 (“a typical pressure in the supply line ... may be on the order of 103.4 bars”—about 1500 psi—while the pressure at the “injection nozzle” may be as high as “1,550.9 bars”—about 20,000 psi); *see also* Ex. 1003, ¶¶ 276-281.)

m. Claim 27

Claim 27 depends on claim 1 and further requires:

“wherein said valve housing comprises a plurality of parts which are joined with each other to provide a fluidly sealed body.”

Both Wirbeleit and Klügl teach sealed valve housings with a **“plurality”** of **“joined” “parts.”** As shown in its figure, the “injector body 9” of Wirbeleit’s injector valve can include an upper and lower piece that together form an interior, sealed “slot orifice 4.” (*See* Ex. 1004, 2:31-36; Fig.) Klügl confirms that injectors were routinely designed to have housings with multiple parts and that Wirbeleit’s injector would have been understood to be no different. In particular, in Klügl, an “upper stop 13 is connected to the housing 12 via a screw thread 40” to form a closed interior space. (Ex. 1006, 1:57-60; *see also* Ex. 1003, ¶¶ 282-287.)

n. **Claim 41**

Claim 41 is an independent claim. It is directed to a ***“method of operating a fuel injection valve”*** like that required by claim 1. The combination of Wirbeleit and Klügl teach everything required by this method for the same reasons explained for claim 1. (*See also* Ex. 1003, ¶¶ 289-291.)

In particular, the injector taught by the references ***“(a) actuat[es] a dimensionally responsive member”*** and ***“(c) deactuat[es] said dimensionally responsive member”*** to open and close an injector: Wirbeleit includes a piezoelectric actuator 21 that expands in length along the injector’s longitudinal axis when voltage is applied, and contracts in length when voltage is removed. (*See supra* Section VII.C.1.a.[1-d].) A spring 7 facilitates valve closing during deactuation. (*See supra* Section VII.C.1.a.[1(c)]; *see also* Ex. 1003, ¶¶ 292-294.)

The references’ injector also ***“(b) transfer[s] movement caused by said actuated dimensionally responsive member through a passive hydraulic link”*** to move a ***“valve member”*** and cause it to lift from a ***“valve seat.”*** In Wirbeleit, the force exerted by an actuator is passed through a hydraulic transmission element 22 to a valve needle 3 causing it to unseat. (*See supra* Section VII.C.1.a.[1(e)].) Further, in view of Klügl, a POSITA would understand that this element would act as a solid and maintain its thickness during actuation. (*See id.*; *see also* Ex. 1003, ¶¶ 295-297.) Klügl also includes the claimed ***“hydraulic cylinder which houses a***

piston”: its transmission module 2 is surrounded by a cylindrical “guide sleeve 11” located within the hollow interior of the injector’s housing 12. (See Ex. 1006, 2:7-16; Fig. 1; *see also* Ex. 1003, ¶¶ 298-300.)

Finally, the references teach “**(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.**” In particular, Klügl teaches that its transmission module 2 includes a bore 10 which allows the fluid from chamber 5 on one side of the module to flow to chamber 7 on the other side of the module during injector idle periods. (*See supra* Section VII.C.1.a.[1(e)]; *see also* Ex. 1003, ¶¶ 301-302.)

2. Motivation to Combine

A POSITA would have considered it obvious and would have been motivated to combine the teachings of Wirbeleit and Klügl. (*See* Ex. 1003, ¶¶ 303-349.)

Again, while Wirbeleit employs a “hydraulic transmission element 22,” it states that this element is purposefully “not shown in detail.” (Ex. 1004, 2:60-64.) Thus, POSITA would have been required to look elsewhere—including to other available designs known in the art at the time the ’138 patent was filed—to determine how to best implement this particular element of Wirbeleit’s fuel injector. (*See* Ex. 1003, ¶¶ 304-305.) Klügl provides an example of one such design. (*Id.*, ¶ 306.)

Not only was Klügl an available design, but a POSITA would have considered its “transmission module 2” particularly suitable for use with Wirbeleit. Like Wirbeleit’s “hydraulic transmission element 22,” Klügl’s “transmission module 2” is hydraulic-based and is meant to transfer force in an engine’s fuel injection valve. (*E.g.*, Ex. 1006, 1:60-2:10, 3:23-29; *see also* Ex. 1003, ¶¶ 307-309.) Further, Wirbeleit’s “hydraulic transmission element 22” and Kleugl’s “transmission module 2” are incorporated into injectors that are structurally and functionally analogous. (*Id.*, ¶¶ 307-312.) Both employ a piezoelectric (or magnetostrictive) actuator that applies force to a piston through a hydraulic element for purposes of opening an injection valve. (*Id.*, ¶ 310.) Further, both employ a spring that applies force to the piston for purposes of closing the valve. (*Id.*, ¶ 311.) This structural and functional similarity would have provided a POSITA with a strong motivation to use Klügl’s transmission module 2 with Wirbeleit. (*Id.*, ¶ 312.)

Klügl also explains that the design of its “transmission module 2,” including the use of an incompressible hydraulic fluid that that does not flow out of a chamber 5 during actuation but can move between a chamber 5 and chamber 7 during periods of rest, allows for “automatic adjustment” of its injector to account for the effects of “wear,” “aging,” and “thermal expansion.” (Ex. 1006, 3:50-4:31.) When the ’138 patent was filed, a POSITA would have recognized that one “known” “aim” when designing an injection valve should be to “compensat[e]” for the “effects of

temperature changes, wear and manufacturing tolerances” on the valve’s “actuating displacement.” (*E.g.*, Ex. 1009, 1:9-16; *see also* Ex. 1010, 1:41-52 (noting that an injector “valve needle and its valving element” must “always perform the same opening stroke” regardless of “temperature fluctuations,” “wear,” or “manufacturing tolerances”); *see also* Ex. 1003, ¶¶ 313-318.) The same design considerations apply to Wirbeleit: a POSITA would have understood that temperature changes, wear, or manufacturing issues could cause its components to also become misaligned, inefficient, or even non-functional. (*See id.*, ¶¶ 319-321.) Use of Klügl’s “transmission module 2” would address this problem: force would still be transmitted between Wirbeleit’s actuator and its needle. But, during periods of rest, hydraulic fluid could flow between chambers 5 and 7 to account for any dimensional changes resulting from thermal expansion and wear. (*Id.*, ¶¶ 322-325.) A POSITA would have recognized that this would substantially improve Wirbeleit’s valve by rendering it more able to account for and automatically adapt to the types of conditions routinely encountered by a fuel injector. (*Id.*, ¶ 325.)

Klügl also identifies numerous other benefits provided by its “transmission module 2” that would have further motivated application of its teachings to Wirbeleit. For instance, Klügl explains that its device—including module 2—is “particularly compact and easy-to-assemble.” (Ex. 1006, 1:20-22; *see also* 1:26-38 (noting that device has a “compact housing,” is “simple [to] manufacture,” and can

be “pre-assembled”).) A POSITA would have recognized that this would serve to further improve Wirbeleit. (Ex. 1003, ¶¶ 326-334.) Wirbeleit’s “hydraulic transmission element 22” would be more compact, leading to an overall smaller injector allowing it to be more readily integrated into an engine. (*Id.*, ¶ 329-330.) A smaller sized element 22 would also allow for further design flexibility elsewhere in the injector. (*Id.*, ¶ 331.) Further, because a separate, preassembled component would be used in place of built-in “hydraulic transmission element 22,” the overall process of manufacturing Wirbeleit’s injector would be simplified. (*Id.*, ¶¶ 330, 333-334.) Klügl’s “transmission module 2” also completely houses and contains the hydraulic fluid. A POSITA would recognize that this would further improve Wirbeleit by reducing the possibility of hydraulic fluid leaks. (*Id.*, ¶ 334.)

Klügl’s “transmission module 2” and the injector that contains it also facilitates the use of other components that improve valve operation. For example, an “upper stop 13” and a “lower stop 16” are both attached via “screw” connections and can be used to set the tension of the piezoelectric actuator, disk spring 14, and spring 15. (Ex. 1006, 1:57-60; 2:35-39.) This allows “the piezoelectric actuator 1,” “transmission module 2,” and “drive piston 3” to be “pre-adjusted” “[d]uring ... production of the injection valve.” (*Id.*, 3:1-10.) This would have further motivated application of Klügl to Wirbeleit as it would allow Wirbeleit’s injector—at the time of manufacture—to be adjusted to account for slight variations of component size,

or to refine the tension of the injector's components for purposes of improving operation. (Ex. 1003, ¶¶ 335-338.)

A POSITA would also have been motivated to retain Wirbeleit's directly actuated and controllable valve design when applying the teachings of Klügl. Wirbeleit explains that this is an important feature of its injector as it allows for the injection amount to be controlled "depending on engine operating parameters." (Ex. 1004, 1:52-58, 2:1-12.) A POSITA would have recognized this to be a highly beneficial feature. (See Ex. 1003, ¶¶ 339-345.) For instance, it was known that controlling injection in this manner allows the "opening stroke of the valve member and the injection time" to be adjusted based on the engine's current operating conditions to "optimize[]" fuel "consumption" and minimize "emission." (*E.g.*, Ex. 1015 at 3; *see also id.* at 1 (explaining that adjusting valve lift allows for "low fuel consumption and emissions ... over [a] wide range[]" of engine operating conditions).) Engaging in the type of control taught by Wirbeleit also allows injector performance to be tailored to ensure "smooth running of the internal combustion engine." (*Id.* at 3.) And, it allows for valve adjustment "dynamically" during operation allowing for even further refinement of engine performance. (*Id.*) These benefits would have not only led a POSITA with a strong motivation to use Wirbeleit in the first place, but would also have led a POSITA to maintain the ability to control

valve lift even if making other changes (such as applying Klügl's transmission module) to Wirbeleit's injector. (See Ex. 1003, ¶ 345.)

Next, a POSITA would have considered the use of Klügl's "transmission module 2" with Wirbeleit to be nothing more than a routine design choice. (See *id.*, ¶¶ 346-349.) "[W]hen a patent 'simply arranges old elements with each performing the same function it had been known to perform' and yields no more than one would expect from such an arrangement, the combination is obvious." *KSR Int'l Co. v. Teleflex Inc.*, 550 US 398, 417 (2007) (citation omitted). This is all the '138 patent does here. Wirbeleit teaches a fuel injector with controllable valve lift that allows the injection amount to be tailored to engine operation. It already includes a hydraulic force transmission element. Klügl teaches a hydraulic transmission element like that employed by Wirbeleit that can be designed to automatically adjust to account for the effects of thermal expansion and wear. A POSITA would have understood that combining these two references' teachings results in an injector that continues to exhibit these very same benefits. (See Ex. 1003, ¶ 349.)

A POSITA would also have had a reasonable expectation of success when combining Wirbeliet and Klügl. As discussed above, a POSITA would have recognized that both Wirbeleit and Klügl are directed not only to injector valves, but injector valves that are structurally and functionally similar. (See *id.*, ¶¶ 350-352.) This similarity would have led a POSITA to conclude that Klügl's "transmission

module 2” and the other injector components associated with this module could be readily incorporated into Wirbeleit. (*See id.*)

While Klügl does provide an example where a piezoelectric actuator is employed to open a “servo valve” (which in turn opens injection valve), a POSITA would have understood that Kleugl’s “transmission module 2” could also be successfully used in other types of injectors. This includes injectors like Wirbeleit’s, where the actuator directly controls a valve that opens into an engine’s combustion chamber. (*See id.*, ¶¶ 353-358.) In fact, Klügl itself explains that use of its transmission module in connection with a servo valve is intended to be just an “example.” (Ex. 1006, 1:7-12.) But, its teachings are not limited to this context and can instead be more broadly applied to the transmission of “movement of a piezoelectric actuator in an injection valve to” any “control element.” (*Id.*)

D. Ground 2: Claim 28 Is Obvious Over Wirbeleit, Klügl, and Newcomb

Claim 28 is obvious over Wirbeleit (Ex. 1004) and Klügl (Exs. 1005-1006) in further view of Newcomb (Ex. 1014). (*See* Ex. 1003, ¶¶ 359-360.) Claim 28 depends on claim 1 and further requires:

“wherein said valve housing, said valve member 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.”

As explained above, Wirbeleit and Klügl teach everything claim 1 requires. (See *supra* Section VII.C.1.a.) A POSITA would have considered the additional limitation of claim 28 to be obvious in view of the teachings of Newcomb (Ex. 1014).

Newcomb—like both Wirbeleit and Klügl—relates to a “control valve such as a ... fuel injection valve...” (*Id.*, 1:5-7.) Newcomb explains that when such a valve employs a “piezoelectric element” as an actuator, “the potential stroke of the valve is usually small, for example of the order to 10 or 20 micrometers.” (*Id.*, 1:31-34.) Newcomb goes on to explain that “[i]t is therefore essential to minimize the effect of thermal expansion on the valve parts so that the flow through the valve will vary only slightly with changes of ambient temperature.” (*Id.*, 1:34-38.) “One solution to [this] problem is to choose a material” (like “a nickel-iron alloy”) “for the valve housing” that “has a similar thermal expansion coefficient to that of the piezoelectric element.” (*Id.*, 1:38-42.) Alternatively, different materials can be used so long as those materials have “coefficient[s] of thermal expansion” and dimensions that result in “equal” “linear expansion.” (*Id.*, 1:50-59.) For instance, in one embodiment, a “valve body 21” and valve opening “end piece 2a” are made from “steel having a thermal expansion coefficient of $12 \mu\text{m K}^{-1}$,” while the piezoelectric “actuating member 2” is formed from a ceramic that “has a thermal expansion

coefficient of $4 \mu\text{m K}^{-1}$.” (*Id.*, 3:38-44.) Use of these materials allows the valve pieces to “be maintained in a substantially fixed position ... even though changes in the temperature of the valve may take place.” (*Id.*, 3:64-68; *see also* Ex. 1003, ¶¶ 362-371.)

A POSITA would have been motivated to combine Newcomb’s teachings with the injector of Werbeleit and Klügl. Klügl itself already recognizes that injector valves should be designed to account for the effects of thermal expansion. (Ex. 1006, 3:52-55, 4:25-31, 6:29-33.) Similarly, Newcomb explains that it is “essential” that a fuel injector be designed to “minimize the effect of thermal expansion.” (Ex. 1014, 1:34-38; *see also* Ex. 1003, ¶¶ 372-376.) Indeed, Patent Owner itself has conceded in the co-pending district court litigation that a POSITA would have been motivated to choose materials with matching thermal expansion coefficients when designing a valve. (*E.g.*, Ex. 1022, p. 19 (“In order to minimize dimensional variations from changes in temperature expected in internal combustion engine applications, a reasonable engineer would select materials with similar thermal expansion coefficients for use in an injection valve.”).) Moreover, Newcomb explains that its valve design approach “enable[s] the effects of thermal expansion to be reduced without requiring the use of comparatively costly ... materials.” (Ex. 1014, 1:45-49.) This potential for cost reduction through the use of less expensive materials would have served to further motivate a POSITA to apply Newcomb’s teachings.

(Ex. 1003, ¶¶ 377-378.) Applying Newcomb’s above teachings to the injector of Wirbeleit and Klügl therefore results in an injector where the injector’s housing, needle, and actuator are made from materials with sufficiently similar thermal expansion coefficients such that any change in relative dimension would be minimized. (*See id.*, ¶ 371.)

A POSITA would also have had a reasonable expectation of success. Newcomb explains that it—and its material proposals—is specifically intended for use with a “control valve such as a ... fuel injection valve.” (Ex. 1014, 1:5-7.) This is exactly what Wirbeleit and Klügl teach: a fuel injection valve. (*See* Ex. 1003, ¶¶ 379-380.)

E. Ground 3: Claims 1-3, 6, 13-14, 17-21, 26-27, and 41 Are Obvious Over Klügl and Hayes

This Ground applies Patent Owner’s interpretation of the claims from the district court action, although as noted above Petitioners do not agree with this interpretation. (*See supra* Section VI.) Under this interpretation, the claims encompass indirectly actuated injectors and therefore Klügl (Exs. 1005-1006)—when considered in view of the knowledge of a POSITA as evinced by Hayes (Ex. 1024)—itself renders claims 1-3, 6, 13-14, 17-21, 26-27, and 41 obvious. (*See* Ex. 1003, ¶¶ 381-382.)

Again, Klügl teaches a fuel injector with the claimed passive hydraulic link (a chamber 5 filled with incompressible hydraulic fluid that is part of a transmission

module 2). This link transfers force from a piezoelectric actuator 1 to an interconnected drive piston 3, drive needle 32, and ball/closing element 4 during valve opening, and can adjust to account for thermal expansion and wear during idle periods. While Klügl provides an example of an indirectly actuated injector, according to Patent Owner this is within the claim scope. Hayes provides elaboration regarding how a POSITA would have understood the parts of Klügl's injector not shown in its figures to be structured.

1. Claim-by-Claim Analysis

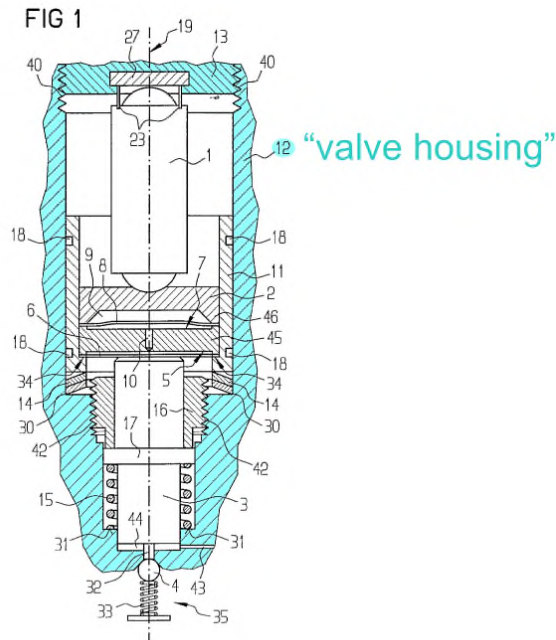
a. Claim 1

[1-p] “An injection valve for injecting fuel into a combustion chamber of an internal combustion engine, said injection valve comprising:”

To the extent the preamble is limiting, Klügl teaches an “automotive” “injection valve.” (Ex. 1006, 1:7-12.) This valve controls injection into an “internal combustion engine.” (*Id.*, 2:54-57; Ex. 1003, ¶¶ 383-385.)

[1(a)] “(a) a valve housing comprising:”

Klügl's injector includes the claimed “**valve housing**” formed from an “upper stop 13” and an outer “housing 12” that surrounds the valve components. (Ex. 1006, 1:47-51.) This housing is shown in teal below:



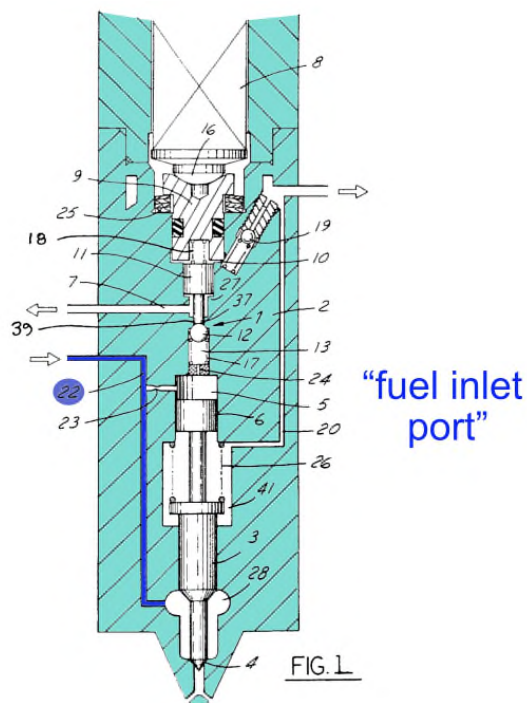
(*Id.*, Fig. 1 (annotated); Ex. 1003, ¶¶ 386-388.)

[1(a)-1] “a fuel inlet port;”

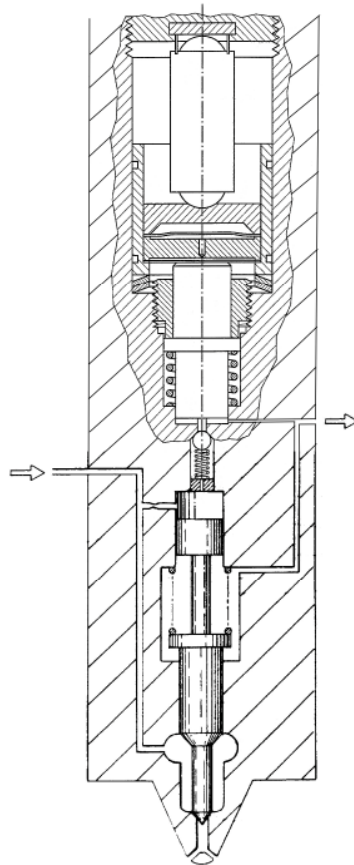
Klügl explains that a “servo valve” formed by “ball 4” (or “closing member 4”) “control[s] an injection needle, which controls the injection of an internal combustion engine.” (Ex. 1006, 2:54-57.) This needle is lifted or lowered to “begin[]” or “end[]” “injection.” (*Id.*, 3:23-38, 39-49.)

While Klügl’s figures do not show the structure around its “injection needle,” a POSITA would nonetheless have understood that there would be a passage, conduit, line or other similar structure to supply fuel to the space adjacent to the “injection needle” such that fuel can be injected when the needle opens. (*See* Ex. 1003, ¶¶ 389-396.) Other prior art, including, for instance, Hayes (Ex. 1024), exemplifies how a POSITA would understand Klügl to be structured and operated.

(See Ex. 1003, ¶ 397.) Like Klügl, Hayes relates to an indirectly actuated fuel injector. (Ex. 1024, 1:7-9.) Hayes' injector includes an intermediate "control valve 1" sealed by a ball-shaped "component 12" that is analogous to the servo valve sealed by ball 4 in Klügl. (*Id.*, 2:7-15, 30-33.) As in Klügl, actuating Hayes' injector opens the control valve. (*Id.*, 3:24-45.) Also like Klügl, this lowers the pressure in a "chamber 5" which in turn and causes a separate valve "needle 3" to lift and open a passage into combustion chamber. (*Id.*, 3:53-63.) Fuel supplied by a "feeding line 22 which feeds the fuel at high pressure" is then injected through the passage opened by the needle. (*Id.*, 2:45-48, 3:53-63.) A POSITA would have understood that a similar "feeding line"—the claimed **"fuel inlet port"**—would also be present in Klügl. This line is shown in blue below:



(Fig. 1 (annotated); Ex. 1003, ¶¶ 398-402.) The below demonstrative provides an example of how a POSITA would understand Klügl’s injector to be structured in the area below the ball 4 shown in its figures:

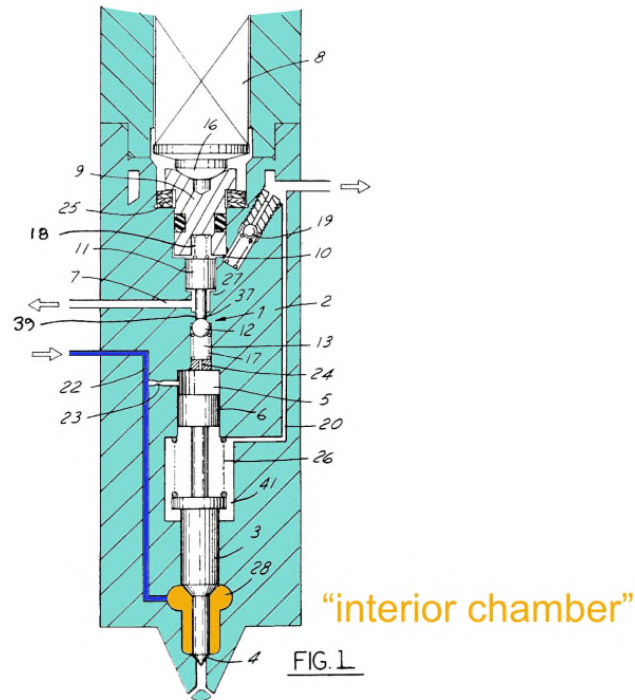


(*Id.*, ¶ 403.) As can be seen, a “feeding line” like that shown in Figure 1 of Hayes is still present. (*See id.*)

[1(a)-2] “an interior chamber fluidly connected to said fuel inlet port; and”

Klügl explains that its injector includes an “injection needle” that controls injection. (Ex. 1006, 3:33-38.) Again, Hayes provides an example of how a POSITA would have understood the portion of Klügl’s injector around this needle

to be structured. And, in Hayes, fuel feed line 22 terminates in an “injection valve pressure chamber 28” located within the injector interior. (Ex. 1024, 2:45-49.) This chamber 28, shown in orange below, is the claimed **“interior chamber”**:

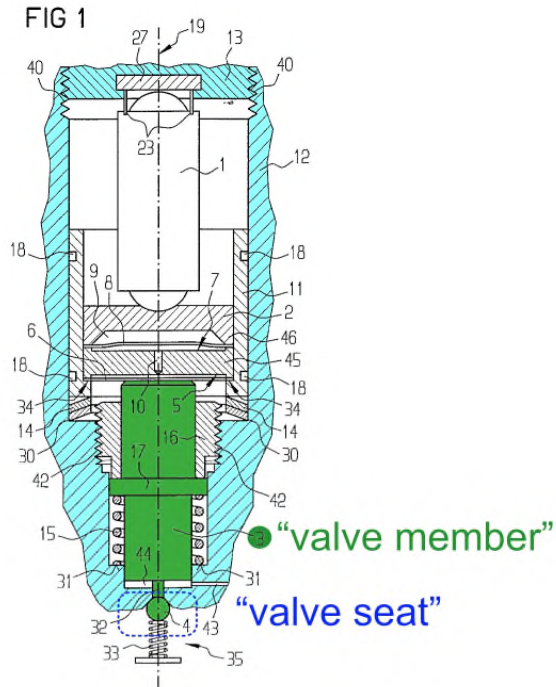


(*Id.*, Fig. 1 (annotated); Ex. 1003, ¶¶ 404-408.) A POSITA would have understood that Klügl would include a similar interior space adjacent to its injection needle. (See *id.*, ¶ 409.)

[1(a)-3] “a valve seat for cooperating with a valve member to seal said interior chamber from said combustion chamber when said injection valve is closed;”

[1-b] “(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;”

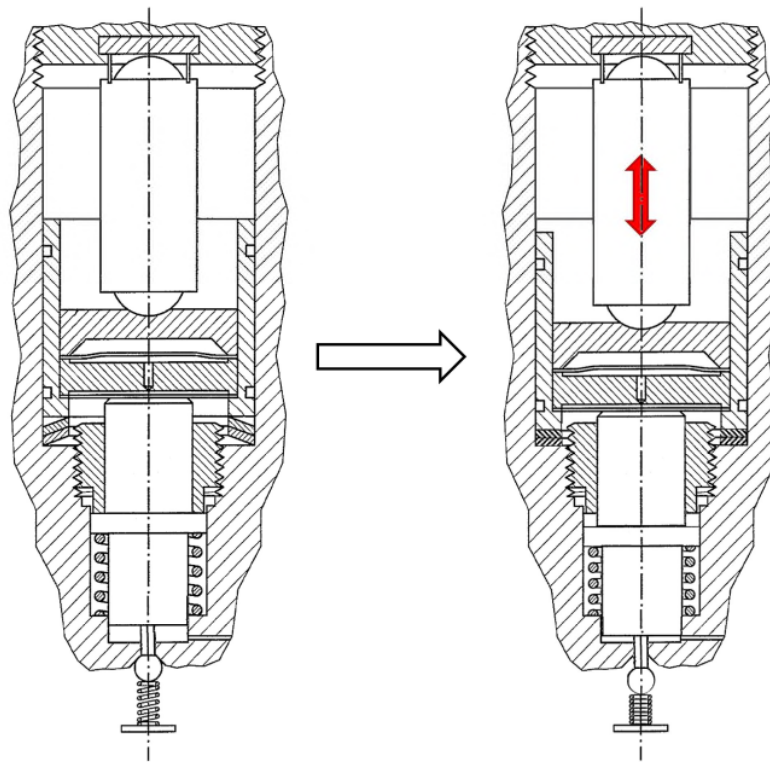
Klügl teaches what these two limits require and includes the claimed **“valve seat”** and **“valve member,”** at least when Patent Owner’s understanding of claim 1 is applied. In particular, Klügl’s injector includes a “drive piston 3” within its housing that “merges into a control needle 32” at its lower end. (Ex. 1006, 2:50-53.) The “control needle 32 ... extends ... to a valve seat 35....” (*Id.*) There is a “ball 4” (also called a “closing element 4”) attached to this control needle 32 that acts as a “closing element” when “pressed against the valve seat.” (*Id.*, 2:54-57.) The piston 3, control needle 32, and ball 4 together form Klügl’s **“valve member.”** These components are shown in green below. Klügl’s valve seat 35 is the claimed **“valve seat.”** This component is circled in blue:



(*Id.*, Fig. 1 (annotated); *see also* Ex. 1003, ¶¶ 410-412.)

This valve member also ***“extendable from said valve seat toward said combustion chamber”*** such that it ***“lift[s] away from said valve seat”*** to open the injector. And, it ***“cooperat[es] with”*** the valve seat ***“to seal said interior chamber from said combustion chamber”*** to close the injector. To open the injector, “[t]he drive piston 3” is pressed downward or displaced due to the expansion of Klügl’s actuator causing “closing element 4” to be “lifted off the valve seat 35 by the control needle 32.” (Ex. 1006, 3:23-33.) This in turn causes “the pressure in the pressure chamber [to] drop[]” and “the injection needle” to “lift[]” so that injection from the pressure chamber to the combustion chamber can begin. (*Id.*, 3:33-38.) Then, when the “closing element 4” is again “pushed ... back onto the assigned valve seat 35[,]”

the pressure in the “pressure chamber” returns to a high level lowering the injection needle and ending injection. (*Id.*, 3:39-49.) The closed position is shown to the left in the below demonstrative, while the open position is shown to the right:



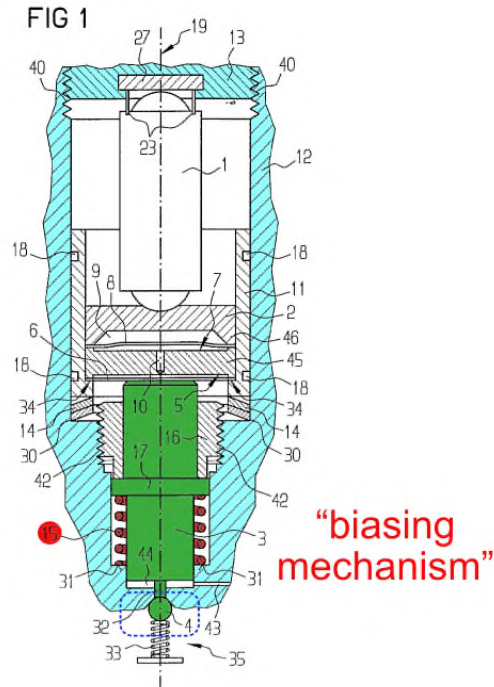
(Ex. 1003, ¶¶ 413-418.)

As noted above, movement of Klügl’s piston 3, control needle 32, and ball/closing element 4 does not directly open a passage to the combustion chamber. Regardless, it indirectly does so by lowering the pressure in Klügl’s pressure chamber causing Klügl’s injection needle to unseat so that fuel can be injected. While Petitioners believe that this type of indirect actuation is not what claim 1 requires, Patent Owner has taken the opposite position in its district court claim

construction, which Petitioners apply in this Ground. (*See supra* Section VI.) And, applying Patent Owner’s understanding of claim 1, Klügl teaches what the claim requires: it includes a **“valve member”** (its piston 3, control needle 32, and ball/closing element 4) that operates (albeit indirectly) to either **“fluidly seal[]”** with a **“valve seat”** (valve seat 35) to stop injection, or **“lift[]”** from that seat to start injection. (*See* Ex. 1003, ¶¶ 419-424.)

[1(c)] “(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;”

Klügl includes the claimed **“biasing mechanism.”** In particular, the injector includes a “spring 15” that “bias[es]” the “drive piston 3 ... against a lower stop 16” located within the injector housing. (Ex. 1006, 2:35-36.) The force exerted by this spring through the piston—along with cooperating force exerted by a “valve spring 33”—causes “closing element 4” to be “seated on the valve seat 35” when the injector is in its “rest” state. (*Id.*, 3:11-13, 19-22, 39-45.) Spring 15 is shown in red below:



(*Id.*, Fig. 1 (annotated); see also Ex. 1003, ¶¶ 425-428.)

[1(d)] “(d) an actuator assembly associated with said valve member, wherein said actuator assembly may be actuated to apply an opening force to said valve member stronger than said closing force, for moving said valve member to said open position; and”

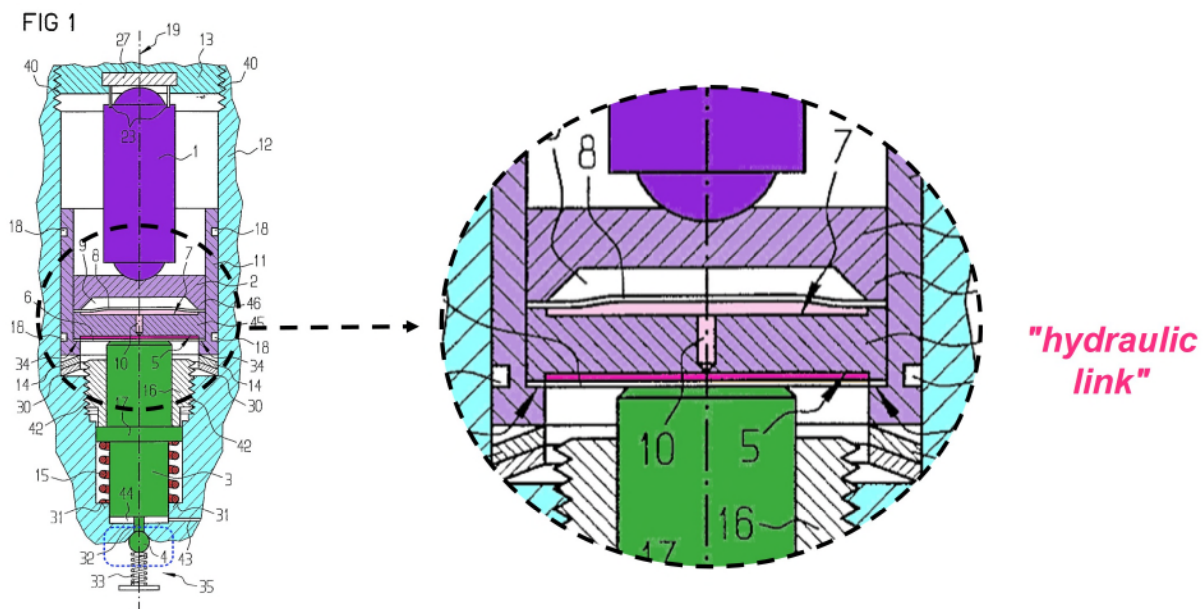
Klügl’s injector includes the claimed “*actuator assembly*.” According to Klügl, a “piezoelectric actuator 1 is placed in” its “housing 12” “between an upper stop 13 and a transmission module 2....” (Ex. 1006, 1:47-51.) The “length” of this actuator can be “adjusted” via application of a voltage over “control lines 23.” (*Id.*, 1:51-56.) To open the valve, “the piezoelectric actuator 1 is ... controlled” “press[ing] the entire transmission module 2 ... in the direction of the drive piston 3” so as to “move[]” the piston “against the spring force of the tension spring 15....” (*Id.*, 3:23-33.) To close the valve, “activation of the piezoelectric actuator 1 ends”

[illegible]

[1(e)] “(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 actuated and wherein said thickness of said hydraulic link is adjustable while said actuator assembly is not actuated in response to changes in the dimensional relationship between components of said injection valve to maintain a desired valve lift upon actuation of said actuator assembly.”

-66-

incompressible hydraulic fluid through which force from the piezo actuator 1 is transmitted to piston 3 to open the valve. Then, the closing force of the spring 15 is transmitted back through this same chamber 5 during valve closing. (See *supra* Section VII.C.1.a.[1(e)].) As explained, the fluid in this chamber passively transmits force from the actuator 1 to the piston 3 and acts as solid with constant thickness during valve opening. (See *id.*) But, during periods of rest and valve inactivity, fluid can move from the chamber 5 through bore 10 to chamber 7 to automatically adjust and compensate for effects of thermal expansion and wear. (See *id.*) This fluid-filled chamber 5—which corresponds to claimed “*hydraulic link*”—is highlighted dark pink below. The bore 10 and chamber 7 that allow for auto-adjustment during idle periods are shown in light pink:



(Ex. 1006, Fig. 1 (annotated); Ex. 1003, ¶¶ 435-439.)

b. Claim 2

Claim 2 depends on claim 1 and further requires:

“wherein said thickness of said hydraulic link is auto-adjustable while said actuator assembly is not actuated in response to changes in said dimensional relationship caused by differential thermal expansion.”

This is taught by Klügl for the same reasons discussed above: fluid can move from Klügl’s chamber 5 to chamber 7 when the injector is at rest to account for the effects of thermal expansion. (*See supra* Section VII.E.1.a.[1(e)]; *see also* Ex. 1003, ¶¶ 440-442.)

c. Claim 3

Claim 3 depends on claim 2 and further requires:

“wherein said thickness of said hydraulic link is auto-adjustable while said actuator assembly is not actuated in response to changes in said dimensional relationship caused by wear to components of said injection valve.”

This is taught by Klügl for the same reasons discussed above: fluid can move from Klügl’s chamber 5 to chamber 7 when the injector is at rest to account for the effects of wear. (*See supra* Section VII.E.1.a.[1(e)]; *see also* Ex. 1003, ¶¶ 443-445.)

d. Claim 6

Claim 6 depends on claim 1 and further requires:

“wherein said actuator assembly comprises a dimensionally responsive member.”

This is taught by Klügl: Klügl employs a “piezoelectric actuator 1” that “preferably consists of a stack of piezoelectric elements” that expand in length in

response to an applied voltage to open Klügl's injector. (Ex. 1006, 1:54-56; *see also* Ex. 1003, ¶¶ 446-448.)

e. Claim 13

Claim 13 depends on claim 6 and further requires:

“wherein said dimensionally responsive member is formed from a piezoelectric material.”

This is taught by Klügl for the same reasons discussed for claim 6: Klügl includes a piezoelectric actuator 1. (*See supra* Section VII.D.1.d; Ex. 1003, ¶¶ 449-451.)

f. Claim 14

Claim 14 depends on claim 6 and further requires:

“a compression spring member for applying a compressive force to said dimensionally responsive member.”

This is taught by Klügl: as noted above, Klügl's injector includes a “disk spring 14” to “pre-stress[]” its piezoelectric actuator 1. (Ex. 1006, 2:11-21; 3:16-19; *see also supra* Section VII.C.1.f; Ex. 1003, ¶¶ 452-454.)

g. Claim 17

Claim 17 depends on claim 6 and further requires:

“wherein when said actuator assembly is controllable to maintain said desired lift between 10 and 100 percent of maximum lift.”

This is rendered obvious by Klügl, at least under Patent Owner's claim interpretation, which Petitioners disagree with but nevertheless applies. (*See supra*

Section VI.) In particular, Klügl explains that “the length” of its “piezoelectric actuator 1 can be adjusted” via a signal sent over “control lines 23” by a “control means 27.” (Ex. 1006, 1:51-56.) As Klügl teaches the general conditions of this claim—an injector with a valve (*albeit* an intermediate one) with adjustable and controllable lift—it renders the claimed range obvious and non-inventive. (See *supra* Section VII.C.1.g; see also Ex. 1003, ¶¶ 455-460.)

h. Claim 18

Claim 18 depends on claim 17 and further requires:

“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.”

This is taught by Klügl for the same reasons discussed for claim 17: Klügl teaches a valve with lift that can be adjusted by controlling the voltage supplied to a “piezoelectric actuator.” (See *supra* Section VII.E.1.g; see also Ex. 1003, ¶¶ 461-463.)

i. Claim 19

Claim 19 depends on claim 6 and further requires:

“wherein said valve member is controllable such that said valve member moves between said open and closed positions in less than about 200 microseconds.”

This is taught by Klügl for the same reasons discussed above: Klügl’s valve can transition from an open to closed state in as little as 100 microseconds. (See *supra* Section VII.C.1.i; see also Ex. 1003, ¶¶ 464-466.)

j. Claim 20

Claim 20 depends on claim 6 and further requires:

“a biasing mechanism for applying a compressive force to said dimensionally responsive member.”

This is taught by Klügl for the same reasons explained for claim 14: Klügl includes a disk spring 14 that applies a pre-loading force to its piezoelectric actuator 1. (*See supra* Section VII.E.1.f; *see also* Ex. 1003, ¶¶ 467-469.)

k. Claim 21

Claim 21 depends on claim 1 and further requires:

“wherein said biasing mechanism comprises a spring.”

This is taught by Klügl: as explained when discussing claim 1, Klügl’s injector includes a spring 15 that applies force to close the injector. (*See supra* Section VII.E.1.a.[1(c)]; *see also* Ex. 1003, ¶¶ 470-472.)

l. Claim 26

Claim 26 depends on claim 1 and further requires:

“wherein said fuel is injected into said combustion chamber at a pressure greater than about 2000 psi (about 13.8 Mpa).”

Klügl’s injector employs a “high pressure” chamber to facilitate injection from its injector into an engine’s combustion chamber. (*E.g.*, 1006, 3:33-38.) As explained above, a POSITA would have recognized that in such a high-pressure system, injection pressure would greatly exceed 2000 psi. (*See supra* Section VII.C.1.l; *see also* Ex. 1003, ¶¶ 473-476.)

m. Claim 27

Claim 27 depends on claim 1 and further requires:

“wherein said valve housing comprises a plurality of parts which are joined with each other to provide a fluidly sealed body.”

This is taught by Klügl. In particular, Klügl’s injector housing includes at least a “housing 12” and an “upper stop 13” that together cooperate to form a sealed interior space. (Ex. 1006, 1:49-51; Fig. 1; *see also* Ex. 1003, ¶¶ 477-479.)

n. Claim 41

Claim 41 is an independent claim directed to a **“method of operating a fuel injection valve”** like that required by claim 1. The combination of Klügl and Hayes teach everything required by this method for the same reasons explained for claim 1. (See Ex. 1003, ¶¶ 480-483.)

In particular, the injector taught by the references **“(a) actuate[es] a dimensionally responsive member”** and **“(c) deactuat[es] said dimensionally responsive member”** to open and close an injector: Klügl includes a piezoelectric actuator 1 that expands in length along the injector’s longitudinal axis when voltage is applied, and contracts in length when voltage is removed. (*See supra* Section VII.E.1.a.[1-d].) A spring 15 facilitates valve closing during deactuation. (*See supra* Section VII.E.1.a.[1(c)]; *see also* Ex. 1003, ¶¶ 484-486.)

The references’ injector also **“(b) transfer[s] movement caused by said actuated dimensionally responsive member through a passive hydraulic link”** to

move a **“valve member”** and cause it to lift from a **“valve seat.”** Klügl teaches that the force exerted by its actuator is passed through incompressible hydraulic fluid in chamber 5 that is part of transmission module 2 to a piston 3 / needle 32 / ball 4 causing it to unseat. (See *supra* Section VII.E.1.a.[1(e)].) The fluid in this chamber acts as a solid and maintains its thickness during actuation. (See *id.*; see also Ex. 1003, ¶¶ 487-489.) Klügl also includes the claimed **“hydraulic cylinder which houses a piston”**: its transmission module 2 is surrounded by a cylindrical “guide sleeve 11” located within the hollow interior of the injector’s housing 12. (See Ex. 1006, 2:7-16; Fig. 1; see also Ex. 1003, ¶¶ 490-492.)

Finally, the references teach **“(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.”** In particular, Klügl teaches that its transmission module 2 includes a bore 10 which allows the fluid from chamber 5 on one side of the module to flow to chamber 7 on the other side of the module during injector idle periods. (See *supra* Section VII.E.1.a.[1(e)]; see also Ex. 1003, ¶¶ 493-494.)

2. Motivation to Combine

This ground points to Hayes as an example of what a POSITA would understand Klügl to already teach. In other words, Hayes simply provides elaboration. Klügl is not being modified or changed in view of Hayes’s teachings.

Regardless, a POSITA would have been motivated to look to Hayes—and would have had a reasonable expectation of success when doing so—not only because of the structural and functional similarity of Hayes and Klügl, but also because Hayes teaches that its injector is designed to be “simple,” and “compensate[s] for tolerances and shifts due to temperature and wear.” (Ex. 1024, 1:32-35.) Klügl’s injector is designed with similar goals in mind. (See Ex. 1003, ¶¶ 495-496.)

F. Ground 4: Claim 28 is Obvious Over Klügl, Hayes, and Newcomb

Claim 28 is obvious over Klügl (Exs. 10015-1006) and Hayes (Ex. 1024) in further view of Newcomb (Ex. 1014). (See Ex. 1003, ¶¶ 497-498.) Claim 20 depends on claim 1 and further requires:

“wherein said valve housing, said valve member 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.”

As explained above, Klügl and Hayes teach everything claim 1 requires. (See *supra* Section VII.E.1.a.) A POSITA would have considered the additional limitation of claim 28 to be obvious in view of the teachings of Newcomb (Ex. 1014) for the same reasons discussed in Section VII.D: Klügl already recognizes that an injector should be designed to account for the effects of thermal expansion. And, Newcomb teaches that these effects can be minimized by employing materials with matching thermal expansion coefficients. (See *supra* Section VII.D; see also Ex. 1003, ¶¶ 499-502.)

G. Secondary Considerations of Non-Obviousness

Petitioners are unaware of any applicable secondary considerations of non-obviousness. None were identified or asserted during prosecution. (*See generally* Ex. 1002.) Regardless, even if such considerations existed, none would overcome the strong *prima facie* showing of obviousness. (*See* Ex. 1003, ¶¶ 503-504.)

VIII. Conclusion

For the foregoing reasons, Petitioners respectfully request institution of IPR and cancellation of claims 1-3, 6, 13-14, 17-21, 26-28, and 41.

Respectfully submitted,

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CERTIFICATE OF WORD COUNT

The undersigned certifies that the foregoing PETITION FOR *INTER PARTES* REVIEW complies with the type volume limitation in 37 C.F.R. § 42.24(a). According to the utilized word-processing system's word count, the petition—excluding the caption, table of contents, table of exhibits, mandatory notices, certificate of word count, and certificate of service—contains 13,669 words.

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CERTIFICATE OF SERVICE

The undersigned hereby confirms that the foregoing PETITION FOR IPR and associated exhibits were caused to be served on 12/14/2022 via overnight courier upon the following counsel of record for Patent Owner:

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