

**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.**

**Case Nos. IPR2023-00292 and -00293
U.S. Patent Nos.
6,298,829
6,575,138**

**PETITIONERS' JOINT HEARING DEMONSTRATIVES
November 14, 2024**

Ex. 1041

Overview of Argument

Introduction

Patent Owner's Translation Arguments Lack Merit

Wirbeleit and Klügl Teach the Claimed “Hydraulic Link”

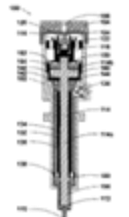
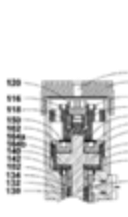
Motivation to Combine Wirbeleit and Klügl

Wirbeleit and Klügl: Other Claim Limitations

Motivation to Apply Newcomb

Klügl and Hayes Also Render the Claims Obvious

The '829 and '138 Patents

 US00629829B1	
(12) United States Patent Welch et al.	(10) Patent No.: US 6,298,829 B1 (45) Date of Patent: Oct. 9, 2001
(54) DIRECTLY ACTUATED INJECTION VALVE	
(75) Inventors: Alan B. Welch; Irawan Rahardja; Mike Hebbers, all of Vancouver (CA)	
(73) Assignee: Westport Research Inc., Vancouver (CA)	
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.	
(21) Appl. No.: 09/522,130 (22) Filed: Mar. 9, 2000	
Related U.S. Application Data (60) Provisional application No. 60/159,791, filed on Oct. 15, 1999.	
(51) Int. Cl. ⁷ F02M 41/00 (52) U.S. Cl. 123/467; 123/472 (50) Field of Search 123/468, 497, 123/467, 472, 476; 251/129.06; 230/533.2, 533.9; 293/102.2	
(56) References Cited U.S. PATENT DOCUMENTS 3,598,506 * 8/1971 O'Neill 417/383 4,022,896 * 3/1977 Bart 123/52 4,104,056 * 5/1978 Bart 230/534 4,158,368 6/1979 Clark 137/467.5 4,725,002 2/1988 Tsuchie 230/102.2 4,726,389 2/1988 Masaru et al. 4,803,303 * 2/1989 Takahashi 320/326 4,813,601 3/1989 Schwartz et al. 230/91 5,031,841 7/1991 Schuler 230/585 5,035,360 7/1991 Green et al. 230/585 5,097,534 12/1997 Amantez et al. 230/38 5,779,149 7/1998 Hayes, Jr. 230/124 5,819,710 10/1998 Huber 123/496 5,821,671 * 10/1998 Trembl 320/326 5,845,852 12/1998 Waldman et al. 230/533.8 5,875,564 3/1999 Kappel et al. 123/467 5,917,682 6/1999 Schmitz et al. 6,062,533 5/2000 Kappel et al. 251/57	
FOREIGN PATENT DOCUMENTS 197 27 902 1/1999 (DE) .	
(57) ABSTRACT A directly actuated injection valve comprises a hollow valve housing, a valve needle disposed within the hollow interior, a needle spring, an actuator assembly, and a hydraulic link assembly. The valve needle is movable between a closed position and an open position for governing the flow of fuel into the combustion chamber of an internal combustion engine. The displacement of the valve needle from the closed position is defined as the lift. The a needle spring biases the valve needle in the closed position. The actuator assembly generates an opening force that acts against the needle spring to open the valve. The hydraulic link assembly is interposed between the valve needle and the needle spring and the actuator assembly. The hydraulic link assembly transmits respective closing and opening forces to the valve needle. The hydraulic link preferably comprises a piston disposed within a cylinder that is filled with a hydraulic fluid. The opening and closing forces are transmitted through a thickness of the hydraulic fluid that is trapped between the planar surfaces of the piston and the head and base of the hydraulic cylinder. In the preferred embodiment, the thickness of the hydraulic fluid trapped between the piston and cylinder head or base is automatically adjustable in response to changes in the dimensional relationship between components of the injection valve to maintain a desired valve needle lift when the actuator assembly is activated. When the actuator assembly comprises a magnetostrictive or piezoelectric member, the movements of the valve needle can be controlled by the application of a shaped control pulse or waveform to improve the speed of the opening and closing motion of the valve needle, and to reduce the impact of the valve needle on the valve seat upon closing.	
32 Claims, 5 Drawing Sheets	
 	

- Filed in the 1999-2000 time-frame
- Relate to various embodiments of a “***directly actuated injection valve***” with a “***hydraulic link assembly***”

Ex. 1001 (829 Patent), Cover, Abstract;
 see also IPR2023-00292, Paper 1 (Petition) at 10-13

'829 Patent – Claim 1

1. An injection valve for injecting fuel into a combustion chamber of an internal combustion engine, said injection valve comprising:
- (a) a valve housing comprising:
 - a fuel inlet port;
 - an interior chamber fluidly connected to said fuel inlet port;
 - a nozzle comprising a nozzle orifice providing a fluid passage from said interior chamber to said combustion chamber;
 - (b) a valve needle disposed within said valve housing wherein said valve needle is movable between a closed position at which a sealing end of said valve needle contacts a valve seat to fluidly seal said interior chamber from said nozzle orifice, and an open position at which said sealing end of said valve needle is spaced apart from said valve seat whereby said interior chamber is fluidly connected with said nozzle orifice, wherein valve needle lift equals the distance traveled by said sealing end away from said valve seat;
 - (c) a needle spring associated with said valve needle, wherein said needle spring applies a closing force to said valve needle for biasing said valve needle in said closed position;
 - (d) an actuator assembly associated with said valve needle, wherein said actuator assembly may be activated to apply an opening force to said valve needle stronger than said closing force, for moving said valve needle to said open position; and
 - (e) a hydraulic link assembly comprising a passive hydraulic link having a hydraulic fluid thickness through which said opening and closing forces are transmitted, whereby **said hydraulic fluid acts substantially as a solid with said thickness being substantially constant while said actuator assembly is activated** and wherein **said thickness of said hydraulic link is adjustable while said actuator is not activated** in response to changes in the dimensional relationship between components of said injection valve to maintain a desired valve needle lift upon activation of said actuator assembly.

Ex. 1001 (829 Patent), Claim 1;
see also IPR2023-00292, Paper 1 (Petition) at 10-13

Grounds At Issue

	'829 Patent	'138 Patent
Ground 1: Wirbeleit + Klügl	Claims 1-3, 6, 11-12, 14-15, and 18-19 obvious	Claims 1-3, 6, 13-14, 17-21, 26-27, and 41 obvious
Ground 2: Wirbeleit + Klügl + Newcomb	Claim 20 obvious	Claim 28 obvious
Ground 3: Klügl + Hayes	Claims 1-3, 6, 11-12, 14-15, and 18-19 obvious	Claims 1-3, 6, 13-14, 17-21, 26-27, and 41 obvious
Ground 4: Klügl + Hayes + Newcomb	Claim 20 obvious	Claim 28 obvious

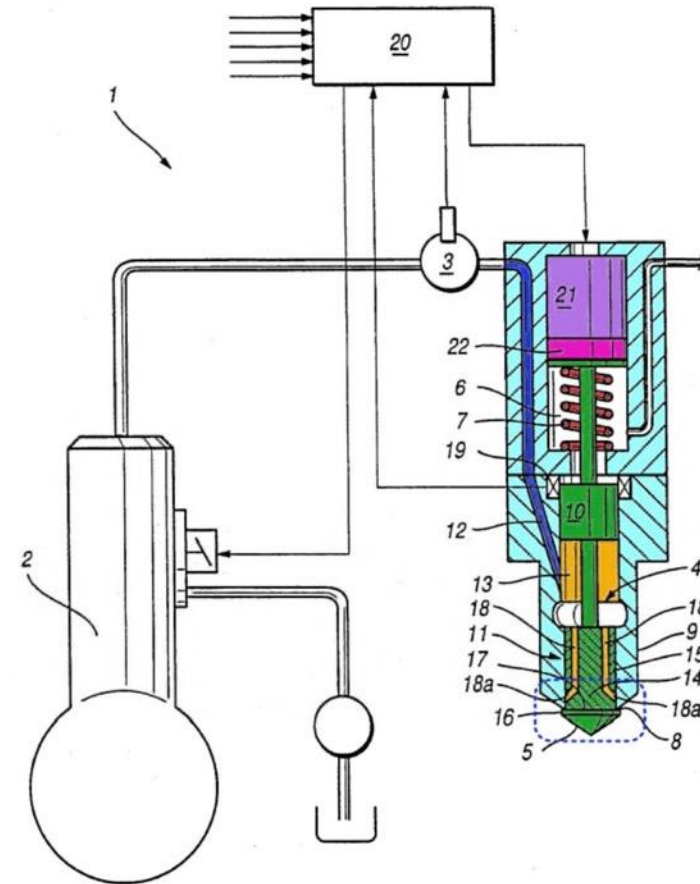
IPR2023-00292, Paper 1 (Petition) at 8;
IPR2023-00293, Paper 1 (Petition) at 8

Wirbeleit

In a fuel injection system for a Diesel engine with a high pressure fuel pump supplying fuel under pressure to a

control of an electronic control unit, the needle includes a cylindrical needle body movable within a cylinder and has slot-shaped orifices formed in its outer surface which are fully covered when the control needle is seated but which are exposed to a degree controllable by the needle actuator for adjustment of the orifice sizes depending on engine operating parameters.

At the rear end of the orifice control needle 5 opposite its tip 11 there is a magnetostrictive actuator 21 which is addressed by the control unit 20 and which operates the orifice control needle 5 by way of a hydraulic transmission element 22 which is not shown in detail. Instead of the magnetostrictive actuator, a piezo actuator may be utilized.



Ex. 1004 (Wirbeleit), 1:45-46, 1:52-57, 2:60-65;
see also IPR2023-00292, Paper 1 (Petition) at 18-20

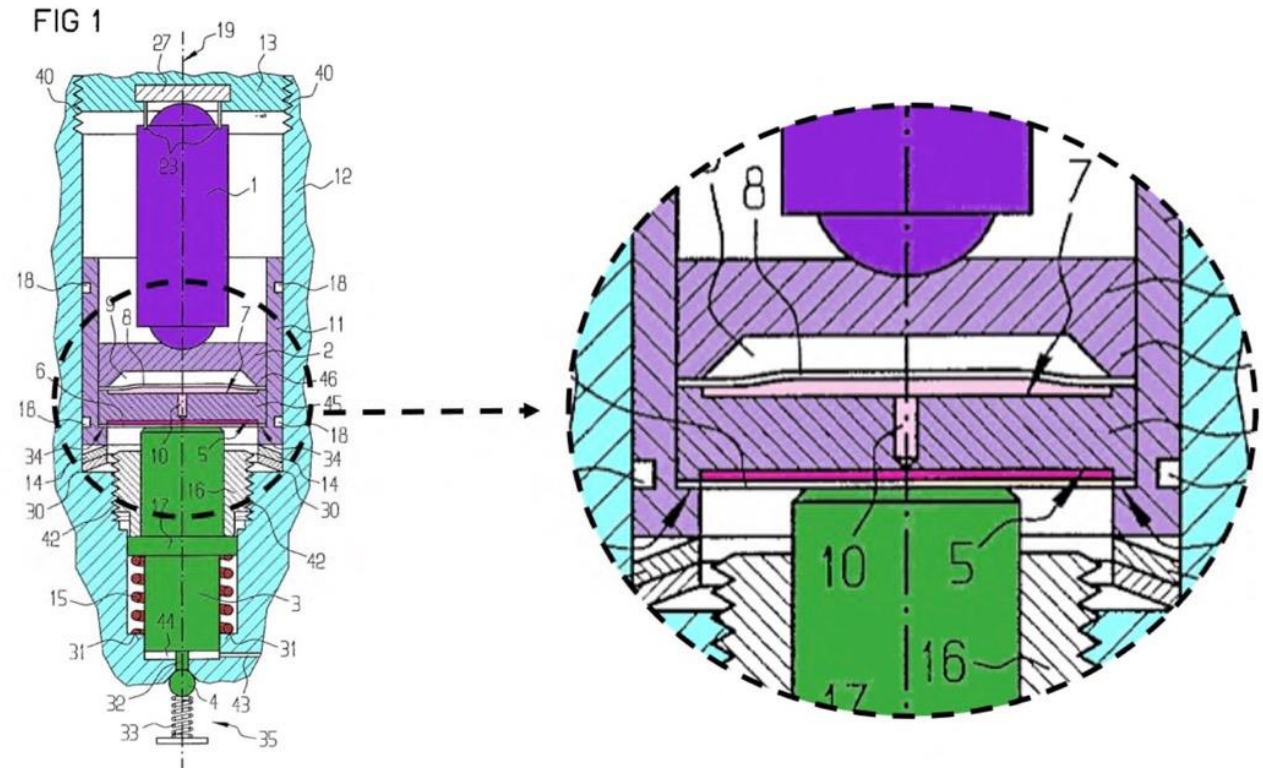
A power transmission device is used, for example, in automotive engineering to transmit the movement of a piezoelectric actuator in an injection valve to a control element, the control element opening a servo valve, for

Fig. 1 shows a device for power transmission without stroke translation,

If the piezoelectric actuator **1** is now controlled, the piezoelectric actuator **1** presses the entire transmission module **2** against the spring force of the disk spring **14** in the direction of the drive piston **3**, so that pressure is exerted on the drive piston **3** via the first membrane **6** and the transmission medium located in the pressure chamber **5** is exercised.

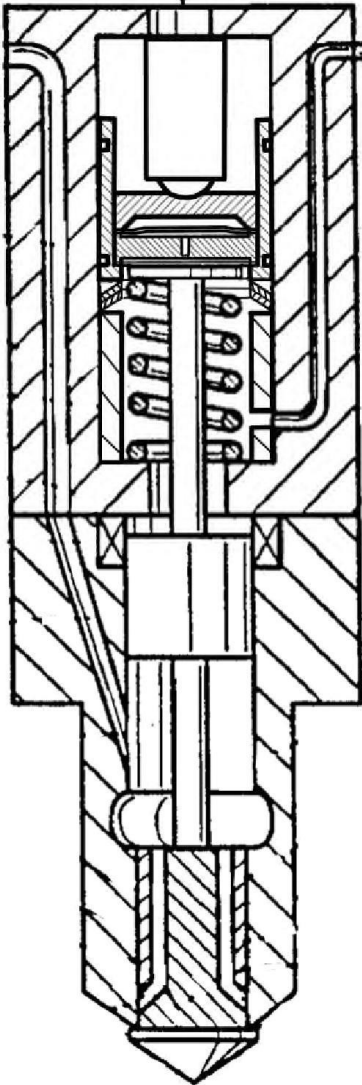
This moves the drive piston **3** against the spring force of the tension spring **15** in the direction of the closing element **4** so that the closing element **4** is lifted off the valve seat **35** by the control needle **32**. As a result, a pressure chamber which

However, if there are long-lasting pressure differences between the pressure chamber **5** and the compensation chamber **7** lasting from one second to minutes, the transmission medium is exchanged between the compensation chamber **7** and the pressure chamber **5** via the throttle **10**. This is especially the case in terms of thermal expansion differences and gradual wear.



Ex. 1006 (Klühl), 1:7-12 1:42-43, 3:23-33, 4:25-31;
see also IPR2023-00292, Paper 1 (Petition) at 20-21, 37

Combination of Wirbeleit and Klügl



A POSITA would have been motivated to use Klügl's transmission module 2 when implementing Wirbeleit's hydraulic transmission element 22 because:

- Wirbeleit does not show element 22 in detail, directing a POSITA to other references.
- Klügl's transmission module is structured and functions in a way that makes it well suited for use with Wirbeleit.
- Klügl's transmission module improves Wirbeleit by allowing it to better account for temperature changes, wear, or manufacturing issues.
- Klügl's transmission module is compact and easy to assemble.
- Klügl's transmission module allows for more pre-use adjustment.
- Using Klügl's transmission module would be considered a straight-forward design choice.

IPR2023-00292, Paper 1 (Petition) at 38-40, 47-52

Newcomb

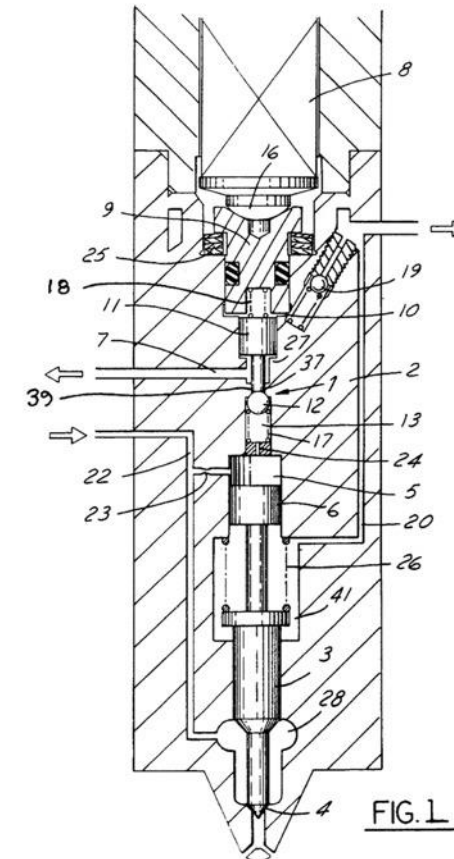
The invention relates to a control valve such as a servovalve or fuel injection valve for controlling flow of a medium. The valve comprises a housing which is

example, of the order to 10 or 20 micrometers. It 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. One solution to the problem is to choose a material for the valve housing which material has a similar thermal expansion coefficient to that of the piezoelectric element. An example of such a material is

Ex. 1014 (Newcomb), 1:5-7, 1:30-41;
see also IPR2023-00292, Paper 1 (Petition) at 21-22, 53-54

Hayes

This invention is related to means of controlling a common rail injector with an electrical device, especially a piezoelectric actuator.



Ex. 1024 (Hayes), 1:7-9, Fig. 1;
see *also* IPR2023-00292, Paper 1 (Petition) at 22-23

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Patent Owner Tried—But Failed—To Create Confusion

Petitioner:

- ✓ Filed certified translation + declaration
- ✓ Petitioner's technical expert considered full context provided by Klügl
- ✓ Deposed Patent Owner's translator
- ✓ Determined that Patent Owner's translator queried other translators via the Internet regarding the meaning of "Hubübersetzung" before submitting her declaration
- ✓ Filed excerpt from Patent Owner submitted dictionary translating "Hub" and "Übersetzung"
- ✓ Identified multiple examples of industry patents consistently translating "Hubübersetzung"

Patent Owner:

- ✗ ***Did not*** depose Petitioner's translator
- ✗ Translator declarant just ***conclusorily*** stated that Ex. 1006 includes "error"
- ✗ Translator declarant ***did not*** translate Klügl
- ✗ Translator declarant ***did not*** take a position on meaning of "Hubübersetzung"
- ✗ Translator declarant was aware of multiple translations of "Hubübersetzung" but ***failed to mention*** this in her declaration

IPR2023-00292, Paper 23 (Reply) at 3-5

Petitioner's Certified Translation of Klügl

Fig. 1 eine Vorrichtung zur Kraftübertragung **ohne Hub-übersetzung**.

Fig. 2 eine Vorrichtung zur Kraftübertragung mit einer Feder als Druckmittel und

Fig. 3 eine Vorrichtung zur Kraftübertragung **mit Hub-übersetzung**.

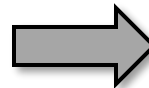


Fig. 1 shows a device for power transmission **without stroke translation**,

Fig. 2 shows a device for power transmission with a spring as a pressure medium and

Fig. 3 shows a device for power transmission **with stroke translation**.

Die Stempelfläche **38**, mit der der Stempel **29** an der dritten Membran **26** anliegt, ist vorteilhafter Weise größer als die Kolbenfläche **37**, mit der der Antriebskolben **3** an der ersten Membran **6** anliegt. Auf diese Weise wird **eine Hub-übersetzung zwischen** der Auslenkung des Piezoaktors **1** und der Auslenkung des Antriebskolbens **3** erreicht. Zudem ist es vorteilhaft, wenn die Fläche der dritten Membran **26** größer ist, als die Fläche der ersten Membran **6**, so daß schon über die unterschiedlich großen Flächen der ersten Membran **6** und der dritten Membran **26** **eine Hubübersetzung zwischen** der Auslenkung des Piezoaktors **1** und der Auslenkung des Antriebskolbens **3** erreicht wird.



The die surface **38** with which the die **29** bears against the third membrane **26** is advantageously larger than the piston surface **37** with which the drive piston **3** bears against the first membrane **6**. This way, it achieves **a stroke ratio between** the deflection of the piezoelectric actuator **1** and the deflection of the drive piston **3**. In addition, it is advantageous if the surface of the third membrane **26** is larger than the surface of the first membrane **6**, so that over the different sized surfaces of the first membrane **6** and the third membrane **26** **a stroke transmission is already achieved between** the deflection of the piezoelectric actuator **1** and the deflection of the drive piston **3**.

IPR2023-00292, Ex. 1005 (Klügl), 1:44-49, 7:8-19
Ex. 1006 (Klügl Translation), 1:41-45, 7:9-20

Dr. Quinlan Testified That The Translation Makes Sense Given Klügl's Overall Teachings

Q. Do you believe the Klügl reference is accurately translated?

...

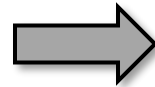
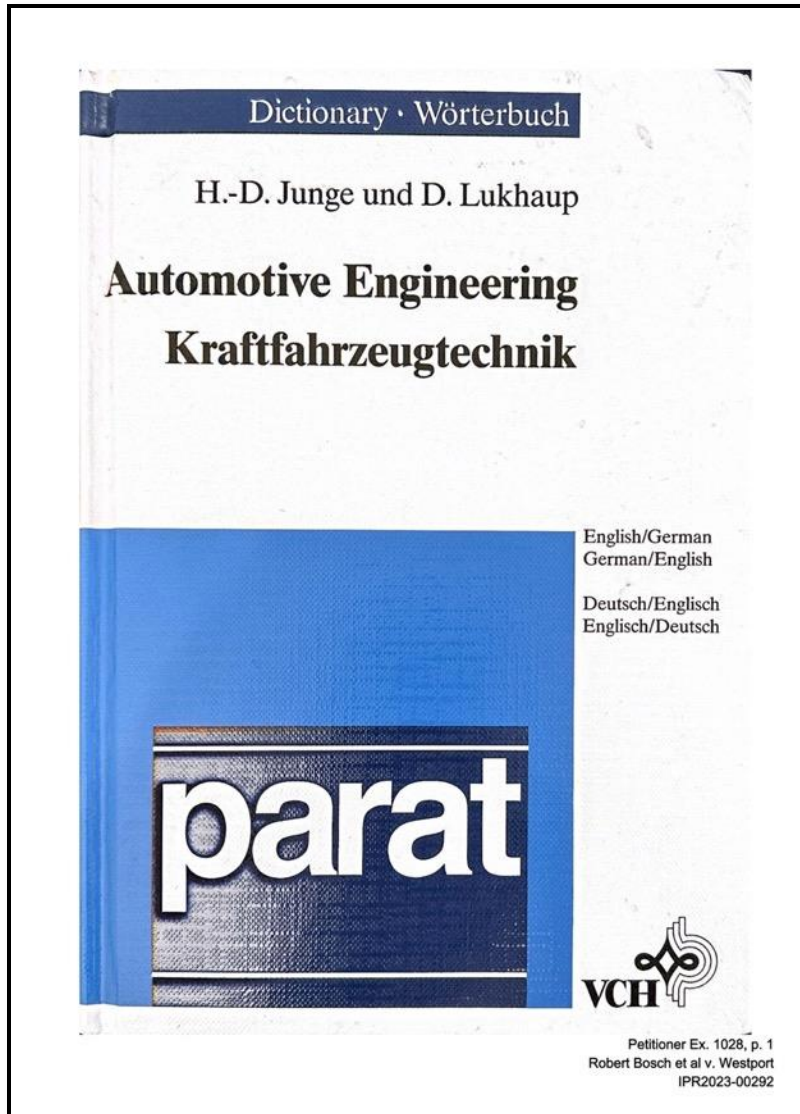
A. I'm sure that there is always alternate translations that could be done, but the translation seemed consistent and, you know, we could surely discuss word choice issues, but I think that the -- taken on a whole, it seemed -- it seemed like it would be an accurate translation from what I could see.

Q. (BY MR. PHILBIN) What does stroke translation mean to you in the context of the Klügl reference?

A. So -- so, how Klügl uses stroke translation is the relationship between the motion of one piece on one side of the hydraulic link versus the motion on the other side of the hydraulic link and the -- essentially, whether that is the same or different.

Ex. 2025 (Quinlan Depo), 13:23-14:6, 17:22-18:3
see also IPR2023-00292, Paper 23 (Reply) at 5

Patent Owner's German-to-English Dictionary Confirms the Accuracy of Ex. 1006



Hub m stroke

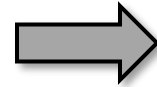
**Übersetzung f gear ratio, gearing,
transmission**

Ex. 1028 (German-English Dictionary), pp. 293, 364
see also IPR2023-00292, Paper 23 (Reply) at 4

Translations in Industry Player Patents **Also** Confirm the Accuracy of Ex. 1006

Robert Bosch:

160. Auf diese Weise kann, beispielsweise durch eine im Vergleich zur hydraulischen Fläche des ersten Kopplerkolbens 150 verringerte hydraulische Fläche des zweiten Kopplerkolbens 160 eine Hubübersetzung mit einem Übersetzungsverhältnis größer als Eins herbeigeführt werden, wodurch auch mit einem geringen Hub des Piezo-Aktors 140 ein größerer Hub des Einspritzventilglieds 128 bewirkt werden kann. Dadurch lässt sich die Baulänge des Piezo-Ak-

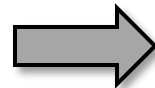


160. In this way, by means for instance of a reduced hydraulic area of the second coupler piston 160 in comparison with the hydraulic area of the first coupler piston 150, a stroke boost can be brought about with a step-up ratio greater than one, and as a result even with a short stroke of the piezoelectric actuator 140, a greater stroke of the injection valve member 128 can be accomplished. As a result, the

Ex. 1029, [0025]; Ex. 1030, [0025]

Siemens:

nerhalb der Spieltoleranz räumlich bewegen kann. Diese Beweglichkeit kann kinematische Veränderungen und somit Streuungen der Hubübersetzung verursachen.



move spatially within the play tolerance. This moveability may cause kinematic variations and therefore dispersions in the stroke step-up.

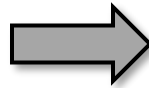
Ex. 1031, [0006]; Ex. 1032, [0006]

see also IPR2023-00292, Paper 23 (Reply) at 4-5

Translations in Industry Player Patents **Also** Confirm the Accuracy of Ex. 1006

Continental:

und der Düsennadel ermöglicht. Diese hydraulische Kopplung bewirkt vorteilhafterweise einen Spielausgleich und eine Hubübersetzung. Dadurch können

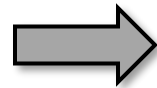


between the two control chambers. Said hydraulic coupling advantageously effects play compensation and a stroke boosting action. In this way, temperature effects, wear at contact

Ex. 1033, [0008]; Ex. 1034, [0022]

Siemens:

liche Hebel, eingesetzt. Bei der Direkteinspritzung von CNG (komprimiertes Erdgas) wird beispielsweise eine Hubübersetzung von 1:6 verwendet.



levers, are used in gas injectors in most cases. A stroke transmission ratio of 1:6 is used for example in the case of direct injection of CNG (compressed natural gas).

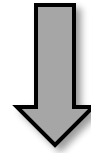
Ex. 1035, [0006]; Ex. 1036, [0007]

see also IPR2023-00292, Paper 23 (Reply) at 4-5

Translations in Industry Player Patents **Also** Confirm the Accuracy of Ex. 1006

Daimler:

Nach dem Verdrängerprinzip arbeitende Vorrichtung zur Kraft- und Hubübersetzung bzw. -übertragung



**DEVICE FOR STEPPING UP OR
TRANSMITTING FORCES AND STROKES**

Ex. 1037, Title; Ex. 1038, Title

see also IPR2023-00292, Paper 23 (Reply) at 4-5

Patent Owner's Translator Declaration Is Conclusory

3. I have evaluated the accuracy of passages of the English translation (Exhibit 1006) of the German patent DE 197 08 304 A1 (Exhibit 1005), namely the paragraphs appearing at Column 1, lines 42–49 and Column 7, lines 8–19 of Exhibit 1005.

4. The word “Hubübersetzung” is used four times in Exhibit 1005, as follows (emphasis added):

- “Fig. 1 eine Vorrichtung zur Kraftübertragung ohne **Hubübersetzung**” (Exhibit 1005 at 1:44–45.)
- “Fig. 3 eine Vorrichtung zur Kraftübertragung mit **Hubübersetzung**.” (Exhibit 1005 at 1:48–19.)
- “Auf diese Weise wird eine **Hubübersetzung** zwischen der Auslenkung des Piezoaktors 1 und der Auslenkung des Antriebskolbens 3 erreicht.” (Exhibit 1005 at 7:11–13.)
- “Zudem ist es vorteilhaft, wenn die Fläche der dritten Membran 26 größer ist, als die Fläche der ersten Membran 6, so daß schon über die unterschiedlich großen Flächen der ersten Membran 6 und der dritten Membran 26 eine **Hubübersetzung** zwischen der Auslenkung des Piezoaktors 1 und der Auslenkung des Antriebskolbens 3 erreicht wird.” (Exhibit 1005 at 7:13–19.)

5. In the English translation (Exhibit 1006), the source word was not translated consistently throughout the document. “Hubübersetzung” was translated as “stroke translation” the first two times, as “stroke ratio” the third time, and as “stroke transmission” the fourth time.

6. In my experience, the best practice when translating a patent document is to translate a source term consistently with the same target term throughout the document, unless there is some context that imbues the word with a different meaning. Only if there is a difference in meaning should the same source term be translated differently within the document.

7. Here the word “Hubübersetzung” in Exhibit 1005 should be translated the same all four places in which it appears. There is no context which gives “Hubübersetzung” a different meaning between its use in column 1 and column 7. Accordingly, it was a translation error for it to have been translated differently in Exhibit 1006.

Patent Owner's Translator Neither Translated Klügl Nor Defined "Hubübersetzung"

Q And you have not generated your own translated version of Klugl in this proceeding, correct?

A No, I have not.

Q Now, in this declaration, you do not express an opinion regarding whether or not hubübersetzung means stroke translation, stroke ratio, stroke transmission, or something else, do you?

A No, I don't express an opinion on the final translation or what would be the single term that should have been used.

Ex. 1026 (Holthaus Depo.), 12:18-21, 15:2-9
see also Reply (Paper 23) at 3

Patent Owner's Translator Posted on the Internet to Determine the Meaning of "Hubübersetzung"

German term

48 viewers * Feb 22 16:00
3 mos ago

Hubübersetzung

German to English

Tech/Engineering

Automotive / Cars & Trucks

Fuel injector

Auf diese Weise wird eine ***Hubübersetzung*** zwischen der Auslenkung des Piezoaktors 1 und der Auslenkung des Antriebskolbens 3 erreicht. Zudem ist es vorteilhaft, wenn die Fläche der dritten Membran 26 größer ist, als die Fläche der ersten Membran 6, so daß schon über die unterschiedlich großen Flächen der ersten Membran 6 und der dritten Membran 26 eine ***Hubübersetzung*** zwischen der Auslenkung des Piezoaktors 1 und der Auslenkung des Antriebskolbens 3 erreicht wird.

This from a patent on a fuel injector.
I found:
stroke translation
<https://patents.google.com/patent/WO2006108741A1/en> (looks machine translated)
stroke step-up
<https://worldwide.espacenet.com/patent/search/family/0079290>.
..

and was also offered stroke ratio

What does "Übertragung" mean here?
I was unable to find any other source for "stroke step-up"



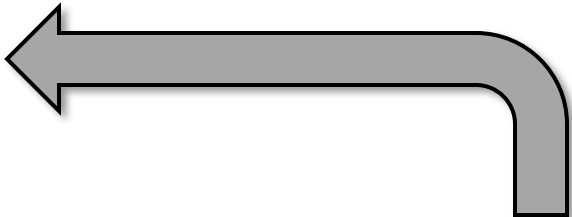
P

Heike Holthaus

United States

318 questions

More...



Proposed translations (English)		
3	Amplification/amplified actuation	thefastshow
3	stroke transformation	Darin Fitzpatrick
3	Amplification ratio	Alexandra Timms
3	stroke transmission or transfer	Peter Ward

Ex. 1025 (Holthaus Post),
see also Reply (Paper 23) at 3-4

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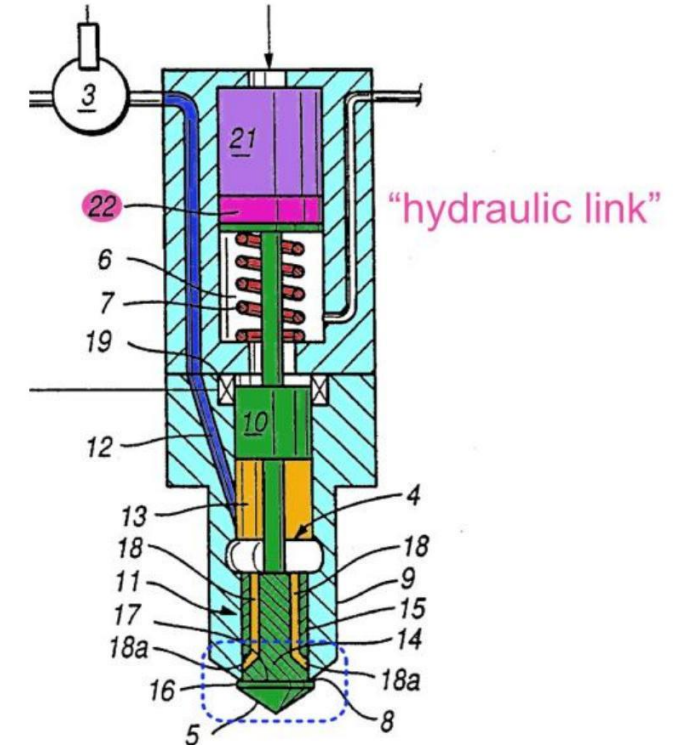
Wirbeleit Teaches a “Passive” “Hydraulic Link”

198. According to Wirbeleit, during valve opening, force is exerted by the actuator and imparted through the hydraulic transmission element to the needle. In contrast, during valve closing, force is exerted from the spring, to the needle, and back through the hydraulic transmission element until a rest position is reached. (See *id.*; see also 3:5-11.)

199. Moreover, a POSITA would, in my opinion, understand this hydraulic link to be “*passive*” as required. There are two primary reasons for this.

200. First, Wirbeleit characterizes its “hydraulic transmission element” as a simple force pathway through which force from the actuator passes to the needle. (*Id.*, 2:1-3.) The hydraulic transmission element does not generate or amplify the force.

201. Second, the “hydraulic transmission element” is located in an enclosed cylindrical space between the actuator and needle. It has nowhere to flow during actuation and thus can only serve to passively transmit force. (See *id.*, see also Fig.)



Ex. 1003 (Quinlan Dec.), 198-201
see also IPR2023-00292, Paper 1 (Petition) at 34-35

Figure 1 of Klügl Operates *Without* Stroke Translation

Fig. 1 shows a device for power transmission without stroke translation,

If the piezoelectric actuator **1** is now controlled, the piezoelectric actuator **1** presses the entire transmission module **2** against the spring force of the disk spring **14** in the direction of the drive piston **3**, so that pressure is exerted on the drive piston **3** via the first membrane **6** and the transmission medium located in the pressure chamber **5** is exercised.

This moves the drive piston **3** against the spring force of the tension spring **15** in the direction of the closing element **4** so that the closing element **4** is lifted off the valve seat **35** by the control needle **32**. As a result, a pressure chamber which

The throttle **10** should preferably be dimensioned in relation to the transmission medium such that during normal activation of the drive piston **3** only so little of the transmission medium flows into the compensation chamber **7** that the activation of the drive piston is not impaired. For

*Ex. 1006 (Klügl), 1:41-42, 3:23-28, 4:11-15
see also IPR2023-00292, Paper 23 (Reply) at 6-7*

Figure 3 of Klügl Operates *With* Stroke Translation

Fig. 3 shows a device for power transmission with stroke translation.

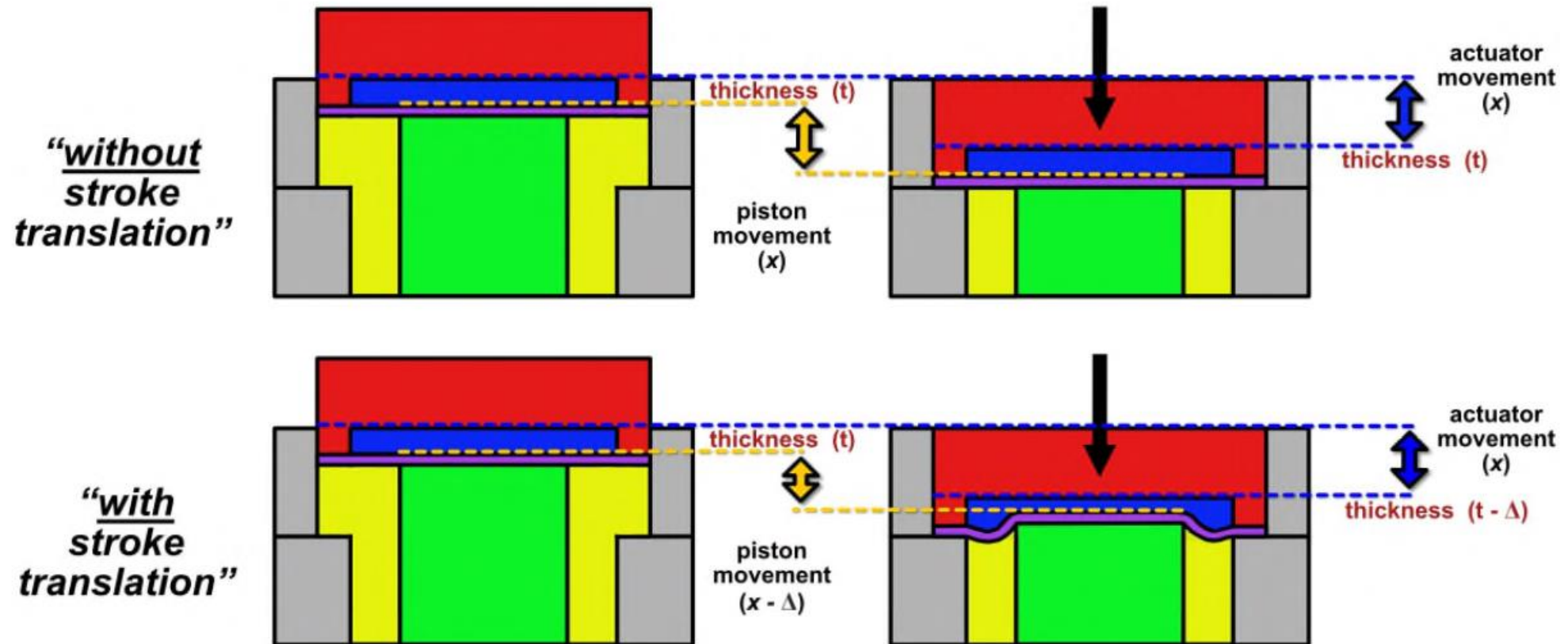
If the piezoelectric actuator 1 is now controlled by the control means 27 via the control lines 23, the piezoelectric actuator 1 lengthens, so that as a result the die 29 is deflected against the spring force of the disk spring 14 in the direction of the transmission module 2. However, the transmission module 2 is fixed in position by the lower stop 16 preventing it from following the longitudinal movement of the die 29. As a result, the third membrane 26 is pushed downwards by the die 29 with the circular plunger surface 38 causing the transmission medium located in the second pressure chamber 28 to be pushed into the pressure chamber 5 via the lines 25. This deflects first membrane 6 in the direction of the drive piston 3 and the drive piston 3 is thus moved against the spring force of the spring 15 in the direction of the closing element 4. As a result of this, the closing element 4 is lifted off the valve seat 35 by the actuating needle 32 against the force of the valve spring 33.

Although there is a connection between the pressure chamber 5 and the compensation chamber 7 via the connecting bore 10, this is designed as a throttle causing brief pressure increases in the pressure chamber 5 to only a very small outflow of transmission medium into the compensation chamber 7. At least the throttle 10 and the

The die surface 38 with which the die 29 bears against the third membrane 26 is advantageously larger than the piston surface 37 with which the drive piston 3 bears against the first membrane 6. This way, it achieves a stroke ratio between the deflection of the piezoelectric actuator 1 and the deflection of the drive piston 3. In addition, it is

*Ex. 1006 (Klügl), 5:51-6:6, 7:9-14
see also IPR2023-00292, Paper 23 (Reply) at 6-7*

Patent Owner Improperly Conflates Figures 1 and 3 of Klügl



Ex. 1040 (Quinlan Reply Dec.), ¶¶ 26-29
see also IPR2023-00292, Paper 23 (Reply) at 9

Other Prior Art Confirms that Figure 1 of Klügl Does Not Apply a Stroke Ratio

components in the injection valve, DE 197 08 304 A1 proposes a hydraulic transmission element which transmits

aging processes. When the actuator is actuated, the deflection of this actuator is transmitted via the transmission element essentially unchanged to the drive plunger of the servo valve or the guide shaft of the valve needle. In this case, the

Ex. 2012, 1:50-51, 1:70-2:6

particular to an injection valve with such an element. Such an element is known from DE 197 08 304 A1.

chamber fast enough, so that when the piezo actuator is actuated electrically, for which the actuation times are in the millisecond range, the movement of the piezo actuator via the transmission module is transmitted via the transmission module virtually unchanged to the drive plunger for the servo valve.

Ex. 2008, 1:9-10, 1:48-54

drive plunger of the servo valve, DE 197 08 304 A1 discloses a transmission module which is essentially

When the actuator is actuated, the deflection of this actuator is transmitted by the transmission module essentially unchanged to the drive plunger of the servo

[0005] Since the hydraulic fluid in the transmission module used in DE 197 08 304 A1 is enclosed in the

...

transmission module, the deflection of the actuator is transmitted to the drive plunger of the servo valve virtually undamped and without a time delay. This in

Ex. 2010, ¶¶ [0003]-[0005]

see also IPR2023-00292, Paper 23 (Reply) at 11-12

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Motivation to Combine Wirbeleit and Klügl

Wirbeleit and Klügl: Other Claim Limitations

Motivation to Apply Newcomb

Klügl and Hayes Also Render the Claims Obvious

Wirbeleit *Requires* Teachings From a Reference Like Klügl

Wirbeleit:

At the rear end of the orifice control needle 5 opposite its tip 11 there is a magnetostrictive actuator 21 which is addressed by the control unit 20 and which operates the orifice control needle 5 by way of a hydraulic transmission element 22 which is not shown in detail. Instead of the magnetostrictive actuator, a piezo actuator may be utilized.

Ex. 1004 (Wirbeleit), 2:60-65

Klügl:

A power transmission device is used, for example, in automotive engineering to transmit the movement of a piezoelectric actuator in an injection valve to a control element, the control element opening a servo valve, for

stressing of the piezoelectric actuator 1. The transmission module 2 is essentially cylindrical and has a pressure chamber 5 which is delimited by a first membrane 6. In the . . . spring plate 8. The pressure chamber 5 is at least partially filled with a transmission medium, for example a hydraulic fluid, which has low compressibility. The pressure chamber

If the piezoelectric actuator 1 is now controlled, the piezoelectric actuator 1 presses the entire transmission module 2 against the spring force of the disk spring 14 in the direction of the drive piston 3, so that pressure is exerted on the drive piston 3 via the first membrane 6 and the transmission medium located in the pressure chamber 5 is exercised.

This moves the drive piston 3 against the spring force of the tension spring 15 in the direction of the closing element 4 so that the closing element 4 is lifted off the valve seat 35 by the control needle 32. As a result, a pressure chamber which

Ex. 1006 (Klügl), 1:7-10, 1:60-2:2, 3:23-33

see also IPR2023-00292, Paper 1 (Petition) at 20, 47

Klügl's Hydraulic Transmission Element Provides Many Benefits

Accounts for wear / thermal changes:

with a new injection valve and at a specified temperature. If, due to wear or a change in temperature, the adjustment no longer fits, the transmission module 2 achieves an automatic adjustment.

Compact, easy to manufacture:

An essential advantage of the invention is that the pressure chamber and the compensation chamber are incorporated in a compact housing, and that the housing is located between the actuator and the controlling element. This way it allows for a particularly simple manufacture of the device, in particular for an injection valve. The housing with the power transmission device is pre-assembled and is inserted into the housing of the injection valve during manufacture.

Allows for pre-adjustment:

During the production of the injection valve, the piezoelectric actuator 1, the transmission module 2 and the drive piston 3 are pre-adjusted via the upper stop 13 and the lower stop 16. The piezoelectric actuator 1, the transmission

Ex. 1006 (Klügl), 3:52-55, 1:26-39, 3:1-10
see also IPR2023-00292, Paper 1 (Petition) at 48-50

Patent Owner's Arguments Are Contrary to Both the Fact and the Law

- ✗ Klügl does not add “needless” complexity. Wirbeleit lacks required detail, ***necessitating*** a reference like Klügl.
- ✗ Patent Owner’s “visual inspection” of the figures in the Petition—and purported identification of issues with the figures’ designs—ignores that those figures are meant to be ***schematic***.
- ✗ The Petition was not required to include “set-in-stone” engineering drawings detailing a fully functional, ready to manufacture injector to prove obviousness.
- ✗ Purported “disadvantages” with membranes do not lead away from combination. The art merely expresses other ***alternatives***.

IPR2023-00292, Paper 23 (Reply) at 20-21

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Wirbeleit and Klügl: Other Claim Limitations

Motivation to Apply Newcomb

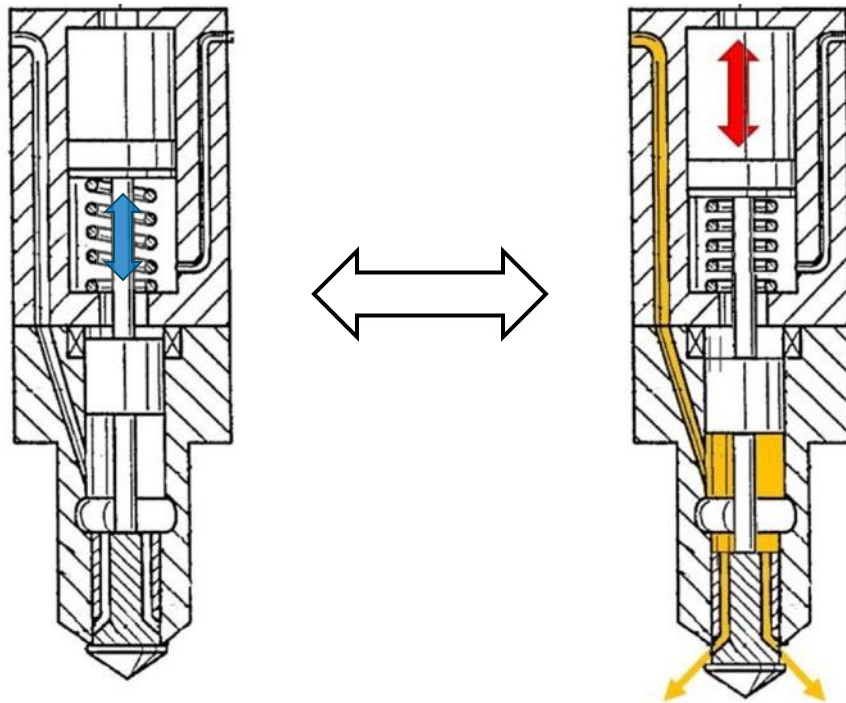
Klügl and Hayes Also Render the Claims Obvious

Claim 1's "Opening" and "Closing" Forces

1. An injection valve for injecting fuel into a combustion chamber of an internal combustion engine, said injection valve comprising:
 - (a) a valve housing comprising:
 - a fuel inlet port;
 - an interior chamber fluidly connected to said fuel inlet port;
 - a nozzle comprising a nozzle orifice providing a fluid passage from said interior chamber to said combustion chamber;
 - (b) a valve needle disposed within said valve housing wherein said valve needle is movable between a closed position at which a sealing end of said valve needle contacts a valve seat to fluidly seal said interior chamber from said nozzle orifice, and an open position at which said sealing end of said valve needle is spaced apart from said valve seat whereby said interior chamber is fluidly connected with said nozzle orifice, wherein valve needle lift equals the distance traveled by said sealing end away from said valve seat;
 - (c) a needle spring associated with said valve needle, wherein **said needle spring applies a closing force** to said valve needle for biasing said valve needle in said closed position;
 - (d) an actuator assembly associated with said valve needle, wherein **said actuator assembly may be activated to apply an opening force** to said valve needle stronger than said closing force, for moving said valve needle to said open position; and
 - (e) a hydraulic link assembly comprising **a passive hydraulic link having a hydraulic fluid thickness through which said opening and closing forces are transmitted**, whereby said hydraulic fluid acts substantially as a solid with said thickness being substantially constant while said actuator assembly is activated and wherein said thickness of said hydraulic link is adjustable while said actuator is not activated in response to changes in the dimensional relationship between components of said injection valve to maintain a desired valve needle lift upon activation of said actuator assembly.

Ex. 1001 ('829 Patent), Claim 1

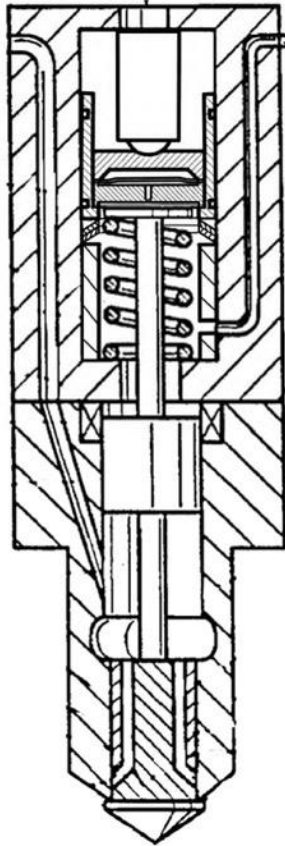
The Petition Explained How “Opening” and “Closing” Forces Are Transmitted Through Wirbeleit/Klügl’s “Hydraulic Link” (’829 Patent, Claim 1)



hydraulic transmission element 22....” (Ex. 1004, 2:60-64.). Wirbeleit similarly explains that either a “magnetostrictive actuator” or a “a piezo actuator” can “act[] on the injector needle by way of a hydraulic transmission element against a compression spring....” (*Id.*, 2:1-4.) Thus, during valve opening, force is exerted from the actuator through the hydraulic transmission element to the needle. In contrast, during valve closing, force is exerted from the spring, to the needle, and back through the hydraulic transmission element until a rest position is reached. (See *id.*; see also 3:5-11.) According to the ’829 patent, the claimed “passive hydraulic

IPR2023-00292, Paper 1 (Petition) at 31, 34-35;
Paper 23 (Reply) at 15-16

The Petition Explained How “Opening” and “Closing” Forces Are Transmitted Through Wirbeleit/Klügl’s “Hydraulic Link” (’829 Patent, Claim 1)



Again, Wirbeleit already employs a hydraulic transmission element 22 to transfer the movement of its actuator 21 to its 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.

claimed “*desired valve needle lift upon activation*”). (Ex. 1003, ¶¶ 236-237.) 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:

IPR2023-00292, Paper 1 (Petition) at 38, 39-40;
see also Paper 23 (Reply) at 15-16

Claim 1's "Hydraulic Link" With an "Adjustable" "Thickness"

1. An injection valve for injecting fuel into a combustion chamber of an internal combustion engine, said injection valve comprising:
 - (a) a valve housing comprising:
 - a fuel inlet port;
 - an interior chamber fluidly connected to said fuel inlet port;
 - a nozzle comprising a nozzle orifice providing a fluid passage from said interior chamber to said combustion chamber;
 - (b) a valve needle disposed within said valve housing wherein said valve needle is movable between a closed position at which a sealing end of said valve needle contacts a valve seat to fluidly seal said interior chamber from said nozzle orifice, and an open position at which said sealing end of said valve needle is spaced apart from said valve seat whereby said interior chamber is fluidly connected with said nozzle orifice, wherein valve needle lift equals the distance traveled by said sealing end away from said valve seat;
 - (c) a needle spring associated with said valve needle, wherein said needle spring applies a closing force to said valve needle for biasing said valve needle in said closed position;
 - (d) an actuator assembly associated with said valve needle, wherein said actuator assembly may be activated to apply an opening force to said valve needle stronger than said closing force, for moving said valve needle to said open position; and
 - (e) a hydraulic link assembly comprising a passive hydraulic link having a hydraulic fluid thickness through which said opening and closing forces are transmitted, whereby **said hydraulic fluid acts substantially as a solid with said thickness being substantially constant while said actuator assembly is activated** and wherein **said thickness of said hydraulic link is adjustable while said actuator is not activated** in response to changes in the dimensional relationship between components of said injection valve to maintain a desired valve needle lift upon activation of said actuator assembly.

Ex. 1001 ('829 Patent), Claim 1

Wirbeleit/Klügl's "Hydraulic Link" Behaves Differently During Actuation and Rest

Actuation:

If the piezoelectric actuator 1 is now controlled, the piezoelectric actuator 1 presses the entire transmission module 2 against the spring force of the disk spring 14 in the direction of the drive piston 3, so that pressure is exerted on the drive piston 3 via the first membrane 6 and the transmission medium located in the pressure chamber 5 is exercised.

This moves the drive piston 3 against the spring force of the tension spring 15 in the direction of the closing element 4 so that the closing element 4 is lifted off the valve seat 35 by the control needle 32. As a result, a pressure chamber which

The throttle 10 should preferably be dimensioned in relation to the transmission medium such that during normal activation of the drive piston 3 only so little of the transmission medium flows into the compensation chamber 7 that the activation of the drive piston is not impaired. For

Ex. 1006 (Klügl), 3:23-33, 4:11-15

Rest:

However, if there are long-lasting pressure differences between the pressure chamber 5 and the compensation chamber 7 lasting from one second to minutes, the transmission medium is exchanged between the compensation chamber 7 and the pressure chamber 5 via the throttle 10. This is especially the case in terms of thermal expansion differences and gradual wear.

Ex. 1006 (Klügl), 4:25-31

see also IPR2023-00292, Paper 1 (Petition) at 38;
Paper 23 (Reply) at 16-18

Dr. Quinlan Explained That Patent Owner Mis-Reads Klügl: There Is No “Design Flaw”

43. First, “if ... actuator 1 shortens ... due to thermal influences or signs of aging[,]” fluid is pushed into “pressure chamber 5, so that the first membrane 6 is moved in the direction of the drive piston 3” and “drive piston 3” continues to “bear[] against first membrane 6 despite the shortening” of the “actuator.” Klügl, 3:63-4:3.

44. In my opinion, a POSITA would have recognized this adjustment to be important: if the membrane did not bear against the piston due to shortening of the actuator resulting from thermal influences or aging, the piston would move by less during actuation (since the separating space would first need to be cleared before the piston moves). This would in turn reduce needle lift.

45. Second, “if the distance between the ... actuator 1 and the drive piston 3 is reduced, the first membrane 6 is pushed in by the drive piston 3 so that the transmission medium is pressed through the throttle 10 into the compensation chamber 7.” Klügl, 4:4-10.

46. In my opinion, a POSITA would also have recognized that this adjustment is important. If thermal influences or aging results in increases in the size of the actuator (resulting in a reduced distance between the actuator and the piston) closing element 4 would be pushed too far off its seat during actuation resulting in too much needle lift.

47. So, per Klügl, transmission module 2 is meant to account for thermal effects and aging that cause the actuator to either increase or decrease in size. This in turn would cause the piston to be pushed either too little or too much during actuation. The rest of Klügl—in particular the movement of fluid within transmission module 2 during times of rest—operates to avoid this and ensure that a consistent amount of lift is provided even if components change size.

Ex. 1040 (Quinlan Reply Dec.), ¶¶ 43-44, 45-46, 47;
see also IPR2023-00292, Paper 23 (Reply) at 16-17

Wirbeleit/Klügl's "Hydraulic Link" Does "Adjust[]" to Account for Component Size Changes and Maintain Lift

If the piezoelectric actuator 1 shortens in the rest position without being actuated due to thermal influences or signs of aging in relation to the housing 12, the spring plate 8 pushes the transmission medium from the compensation chamber 7 via the throttle 10 into the pressure chamber 5, so that the first membrane 6 is moved in the direction of the drive piston 3 and, as a result, the drive piston 3 bears against the first membrane 6 despite the shortening of the piezoelectric actuator 1.

However, if the distance between the piezoelectric actuator 1 and the drive piston 3 is reduced, the first membrane 6 is pushed in by the drive piston 3 so that the transmission medium is pressed through the throttle 10 into the compensation chamber 7 against the spring force of the spring plate 8. As a result, the drive piston 3 is always in contact with the first membrane 6 in this case as well.

Ex. 1006 (Klügl), 3:63-4:10;
see also IPR2023-00292, Paper 1 (Petition) at 38;
Paper 23 (Reply) at 16-18

Dr. Quinlan Explained Why Patent Owner's Position Is Wrong: *Different Forces* Applied to Klügl's Membrane 6 at Different Times Result in Different Behavior

49. Dr. Atkinson posits that Klügl's membrane 6 "will not have different properties during actuation and while at rest (e.g., the membrane will be pliable and flexible in both circumstances)." Ex. 2022, ¶ 67.

50. While I agree that the membrane 6 has the same structure and physical properties at all times, this does not mean that it *behaves* the same during both actuation and periods of rest.

51. The forces applied to the membrane differ during these periods. As Klügl itself explains, during periods of rest, there may be "long-lasting pressure differences between the pressure chamber 5 and the compensation chamber 7" that cause "transmission medium" to be "exchanged between the compensation chamber 7 and the pressure chamber 5 via the throttle 10." Klügl, 4:25-30.

52. It is these long-lasting differences—which are present only during much longer rest periods and not very short actuation periods—that cause the same membrane to behave differently during actuation and rest.

Ex. 1041 (Quinlan Reply Dec.), ¶¶ 49-52;
see also IPR2023-00292, Paper 23 (Reply) at 16-18

Wirbeleit and Klügl Teach Injectors Employing the Claimed Type of Actuator ('829 Patent, Claim 6)

6. The injection valve of claim 1 wherein said actuator assembly comprises a magnetostrictive member or a piezo-electric stack.

It is particularly advantageous to use a magnetostrictive actuator for the controlled opening of the injector orifice in place of a piezo actuator since it requires substantially lower electrical voltages than are necessary for operating a piezo actuator.

At the rear end of the orifice control needle 5 opposite its tip 11 there is a magnetostrictive actuator 21 which is addressed by the control unit 20 and which operates the orifice control needle 5 by way of a hydraulic transmission element 22 which is not shown in detail. Instead of the magnetostrictive actuator, a piezo actuator may be utilized. Also, as a transmission element one with elastomer or with mechanical force transmission can be utilized.

Ex. 1004 (Wirbeleit) at 2:13-17, 2:60-64
see also IPR2023-00292, Paper 1 (Petition) at 41-42;
Paper 23 (Reply) at 18

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

The electronic control unit 20 which receives the engine operating parameters such as rotational speed, load, charge air temperature and similar data, constantly compares the actual needle lift position with desired values present in a performance graph. An appropriate injector slot orifice cross-section 18a of the grooves 18 is maintained by way of voltage control of the actuator 21. At the end of the injection

Ex. 1004 (Wirbeleit) at 3:1-7;
see also IPR2023-00292, Paper 1 (Petition) at 19, 41-42;
Paper 23 (Reply) at 19

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

times for the nozzle needle. The actuation times are in the range of milliseconds, preferably between 0 ms and 10 ms. Fast actuation times are around 0.1 to 1 ms.

Ex. 1006 (Klügl) at 4:22-24;
see also IPR2023-00292, Paper 1 (Petition) at 44;
Paper 23 (Reply) at 19-20

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Klügl and Hayes Also Render the Claims Obvious

Newcomb Teaches Injectors Made from Materials With Matching Thermal Expansion Coefficients

The invention relates to a control valve such as a servovalve or fuel injection valve for controlling flow of a medium. The valve comprises a housing which is

example, of the order to 10 or 20 micrometers. It 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. One solution to the problem is to choose a material for the valve housing which material has a similar thermal expansion coefficient to that of the piezoelectric element. An example of such a material is

In this way, the lower surface of the lower end piece 2a where it makes contact with the movable body 6 can be maintained in a substantially fixed position with respect to the seat end of valve housing 21 even though changes in the temperature of the valve may take place.

Ex. 1014 (Newcomb) at 1:5-7; 1:34-42; 3:64-68;
see also IPR2023-00292, Paper 1 (Petition) at 53-55

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E. Ground 3: Claims 1-3, 6, 11-12, 14-15, and 18-19 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, 11-12, 14-15, and 18-19 obvious. (*See* Ex. 1003, ¶¶ 369-370.)

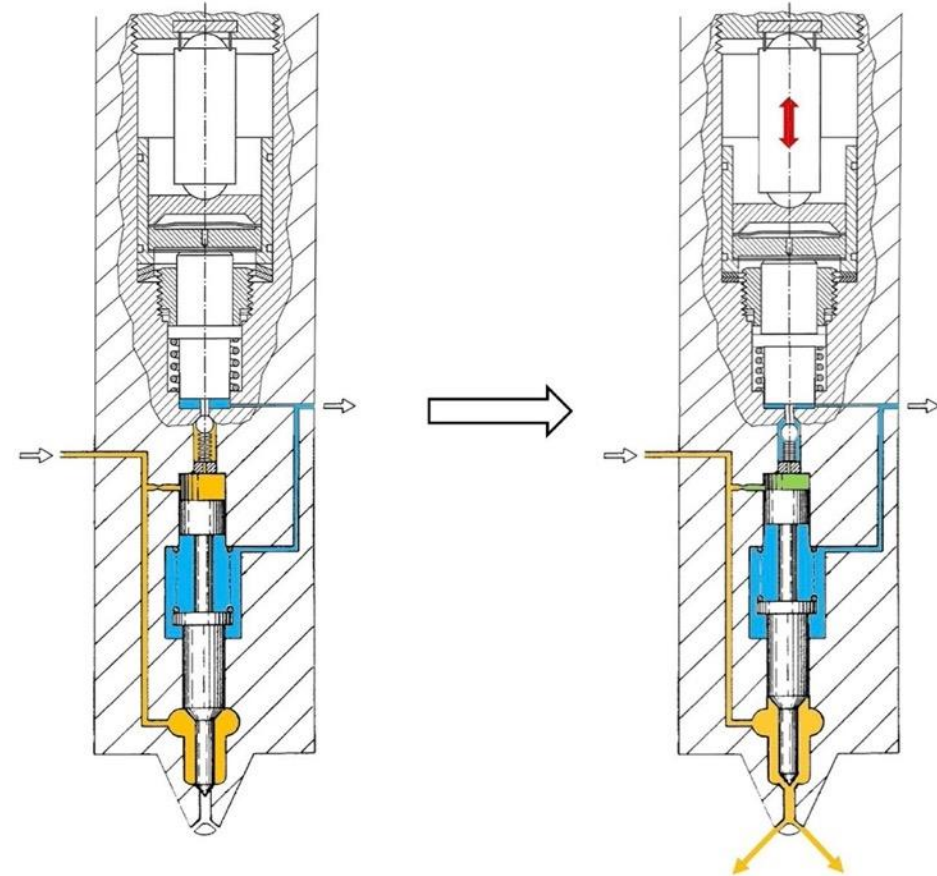
IPR2023-00292, Paper 1 (Petition) at 55-56

The Combination of Klügl and Hayes Is Operable

412. In the combined injector of Hayes and Klügl, the figures below show the impact the opening/closing of Klügl's servo valve has on its injection needle (and how this results in fuel injection). Yellow represents areas of high pressure where high-pressure fuel is present. Blue represents areas of low pressure connected to the relief line. Green represents areas of intermediate pressure:

413. As noted above, movement of Klügl's piston 3, control needle 32, and ball/closing element 4 does not directly open a passage from Klügl's fuel inlet to the combustion chamber—the only Klügl's injection needle does this.

414. Regardless, movement of Klügl's piston 3, control needle 32, and ball/closing element 4 indirectly opens this passage by lowering the pressure in Klügl's pressure chamber causing Klügl's injection needle to unseat so that fuel can be injected into the combustion chamber.



Ex. 1003 (Quinlan Dec.), ¶¶ 412-414
See also IPR2023-00292, Petition (Paper 1) at 64-65