IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of:	Pascal DRILLET et al.	
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Title:	Coated Steel Strips, Coated Stamped Products and Methods	

Declaration of Dr. Michael Miles

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EXHIBITS

EX-1001	U.S. Patent No. 11,326,227 to Drillet ("the '227 Patent")
EX-1002	Excerpts from the Prosecution History of the '227 Patent ("the Prosecution History")
EX-1003	Declaration of Dr. Michael Miles
EX-1004	Curriculum Vitae of Dr. Michael Miles
EX-1005	Engels et al., "Controlling and Monitoring of the Hot-Stamping Process of Boron-Alloyed Heat-Treated Steels" (2006) ("Engels")
EX-1006	Translation Certificate of Michael L. Magee
EX-1007	Excerpt from "New Developments in Sheet Metal Forming" (2006)
EX-1008	Declaration of Prof. Mathias Liewald
EX-1009	Declaration of Christoph Wohlstein
EX-1010	"Engels" and "Hein," in English and German, provided by the German National Library
EX-1011	[Reserved]
EX-1012	[Reserved]
EX-1013	[Reserved]
EX-1014	Cornette et al., "High Strength Steels for Automotive Safety Parts," SAE Technical Paper Series 2001-01-0078 (2001) ("Cornette")
EX-1015	Declaration of Mel DeSart

EX-1016	U.S. Patent Application Publication No. 2004/0009366 ("Takagi")
EX-1017	Japanese Patent No. JP3738754
EX-1018	Translation and Certificate of Translation for portions of EX-1017
EX-1019	Hein et al., "Hot Stamping of USIBOR 1500 P: Part and Process Analysis Based on Numerical Simulation" (2006) ("Hein")
EX-1020	Hein et al., "Pressharten von USIBOR 1500 P: Simulationsbasierte Bauteil- und Prozessanalyse" (2006)
EX-1021	Vaissiere et al., "Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White," SAE Technical Paper Series 2002-01-2048, reprinted from the Proceedings of the 2002 SAE International Body Engineering Conference and Automotive & Transportation Technology Conference (2002) ("Vaissiere")
EX-1022	Declaration of June Ann Munford - #1
EX-1023	U.S. Patent No. 6,296,805 ("Laurent")
EX-1024	French Patent Publication No. FR2833504
EX-1025	Translation of EX-1024 and Certificate of Accuracy
EX-1026	GMW14400 material specification ("GMW14400")
EX-1027	Declaration of June Ann Munford - #2
EX-1028	U.S. Patent No. 9,708,683 ("the '683 Patent")
EX-1029	Final Written Decision for IPR2019-01275, corresponding to EX-1028

EX-1030	Record of Oral Hearing for IPR2019-01275
EX-1031	Petition for IPR2019-01275
EX-1032	Somani et al., "Dimensional Changes and Microstructural Evolution in a B-bearing Steel in the Simulated Forming and Quenching Process," ISIJ International, Vol. 41 (2001) ("Somani")
EX-1033	Japanese Patent Publication JP2004244704
EX-1034	Translation of EX-1033 and Certification of Accuracy
EX-1035	WO Patent Application Publication No. WO02/103073
EX-1036	European Publication No. EP1865086
EX-1037	Translation of EX-1036 and Certification of Accuracy
EX-1038	Winkel, "Quenches for press hardening steel plate in the car industry" (2004)
EX-1039	Translation of EX-1038 and Certification of Accuracy
EX-1040	Excerpts from Vander Voort, "Microindentation Hardness Testing," ASM Handbook, Vol. 8 (2000)
EX-1041	Manual for Buehler IndentaMet 1100 Series Indentation Hardness Tester (2005)
EX-1042	Vander Voort and Lucas, "Microindentation Hardness Testing," Advanced Materials and Processes (Sept. 1998)
EX-1043	Qian et al., "Comparison of nano-indentation hardness to microhardness," Surface & Coatings Technology 195 (2005)
EX-1044	E 384-05 Standard Test Method for Microindentation Hardness of Materials (2005)

EX-1045	Excerpts from Garcia-Aranda, "Étude thermomécanique et modélisation numérique de l'emboutissage à chaud de l'Usibor 1500," École Nationale Supérieure des Mines de Paris (2004)
EX-1046	Translation of EX-145 and Certification of Accuracy
EX-1047	Eriksson et al., "Testing and evaluation of material data for analysis of forming and hardening of boron steel components," Modelling Simul. Mater. Sci. Eng. 10 277 (2002)
EX-1048	[Reserved]
EX-1049	WO Patent Application Publication No. 2004/106573
EX-1050	Translation of EX-1049 and Declaration of Accuracy

I, Dr. Michael Miles, of Springville, UT, declare that:

I. ASSIGNMENT

1. I have been retained by POSCO ("Petitioner") in connection with the above-captioned petition for Inter Partes Review ("IPR") of U.S. Patent No. 11,326,227 to Pascal Drillet et al. ("the '227 patent"). I understand the '227 Patent is currently assigned to ArcelorMittal ("Patent Owner"). I have been asked to provide my independent analysis of the '227 Patent based on the prior art publications cited in this declaration. I was previously engaged by Petitioner as an expert in IPR2019-01275, relating to U.S. Patent No. 9,708,683 (EX-1028), which is a parent patent to the '227 Patent.

2. I have been asked by Petitioner to offer opinions regarding the '227 Patent, including the unpatentability of claims 1-25 (which I may refer to subsequently as the "Challenged Claims") in view of certain prior art. This declaration sets forth the opinions I have reached to date regarding these matters.

3. I am being compensated by Petitioner at my standard hourly consulting rate for my time spent on this matter. My compensation is not contingent on the outcome of the IPR or on the substance of my opinions.

4. I have no financial interest in Petitioner or Patent Owner.

II. BACKGROUND

A. Educational Background

5. I earned a B.S. degree in Metallurgical Engineering in 1989 from the University of Idaho. I then earned my M.S. degree in Metallurgical Engineering in 1991 from the Ohio State University. I earned my Ph.D. degree in Materials Science and Engineering from Ecole des Mines de Paris in 1995. My M.S. research was focused on the formability of sheet metal alloys, including several steel alloys, an aluminum alloy, and a brass alloy. My Ph.D. work involved the modeling of hot forming processes, especially forging, where the heat transfer between the tools and the workpiece were taken into account.

B. Career History & Relevant Industry Participation

6. I joined Brigham Young University (BYU), in Provo, UT, in 2001 as an assistant professor in the manufacturing engineering technology program. At BYU, I became an associate professor in 2007 and a full professor in 2013. I served as program chair of the manufacturing engineering technology program from 2009 – 2016. I am currently a professor in the manufacturing engineering department (there was a program change in 2019) at BYU. My research focus is on the forming and fabrication of metal alloys, with emphasis on microstructure/formability relationships and the welding/joining of dissimilar alloys.

7. I have been funded by the National Science Foundation nine times on various research topics related to forming and joining of sheet metal alloys,

including microstructure/formability relationships in steels containing retained austenite. I have also received funding from the Department of Energy (dissimilar metals joining) and NASA (friction stir welding of aluminum alloys). In all of these projects, I have mentored students in carrying out the research, collaborated with companies and National Labs (General Motors, Honda, Megastir Technologies, Oak Ridge National Lab), and worked with these teams to publish our results in archival journals.

8. Prior to joining BYU, I worked as a project engineer from 1995 to 1996 at Pechiney Research Center in Voreppe, France. From 1996 to 1998, I was a tooling engineer and a project engineer for American National Can (a subsidiary of Pechiney) in Elk Grove Village, Illinois. From 1998 to 1999, I was an engineering manager for American National Can in Whitehouse, Ohio, then assumed the role of assistant plant manager from 2000 to 2001 at the same facility for Rexam PLC (American National Can was purchased by Rexam).

9. I am an inventor listed in the following United States Patents: End Closure with Improved Openability (US 6,024,239), Three-body joining using friction stir processing techniques (US 8,157,154), Friction bit joining using a friction rivet (US 9,764,375), and Systems and methods for friction bit joining (US 11,697,173). A listing of the year, patent number, and patent title is found in my Curriculum Vitae included in Appendix A. I am also a listed inventor on several

international patents.

10. Additional information regarding my background, qualifications, and presentations is included as part of my curriculum vitae.

11. It is for at least these reasons that I am an expert in sheet metal forming and the microstructure/property relationships that influence formability, including phase transformations that occur during the forming of advanced high strength sheet steels for automotive manufacturing.

III. MATERIALS REVIEWED

12. In forming my opinions, I have reviewed the ’227 Patent and considered relevant portions of each of the documents listed in the Exhibit List above and the other references cited in my declaration. In reaching my opinions, I have relied upon my experience in the field and also considered the viewpoint of a person of ordinary skill in the art at the time of the earliest claimed priority date of the ’227 patent, i.e., late 2006. As explained below, I am familiar with the level of skill of a person of ordinary skill in the art regarding the relevant technology at issue as of that time

IV. DESCRIPTION OF THE RELEVANT TIMEFRAME, THE RELEVANT FIELD, AND A PERSON OF ORDINARY SKILL IN THE ART

13. I understand that the ’227 Patent claims a priority date of October 30, 2006. (which I will also refer to as the “Priority Date”). For the purposes of my

analysis, and in the absence of any information to the contrary, I have used the October 30, 2006 date as the relevant date for my analysis of the prior art.

14. I considered several factors to determine the skill level of a person of ordinary skill in the art of the ’227 patent in October 2006, including the types of problems encountered in the art, the solutions to those problems, the pace of innovation in the field, the sophistication of the technology, and the education level of active workers in the field.

15. Based on my knowledge, expertise, and the prior art cited in the ’227 Patent, it is my opinion that a person of ordinary skill in the field of the ’227 Patent would have had at least an undergraduate degree in materials science, manufacturing engineering, mechanical engineering, or equivalent knowledge, training, or experience, with at least two years of experience working in metallurgy.

16. Unless noted otherwise, when I state that something would be known or understood by one skilled in the art, or a skilled artisan, or a person having ordinary skill in the art (“POSITA”), I am referring to a person with this level of education and experience at the time of the alleged invention, which I am assuming to be in or around October 2006.

V. SUMMARY OF THE ’227 PATENT

17. I have reviewed and will now summarize the ’227 Patent. The ’227

Patent purports to provide novel manufacturing methods and structures associated with a "coating" formed by hot-stamping pre-coated steel blanks. The '227 Patent acknowledges that these coatings and their manufacture were already "important, especially in the automotive industry." EX-1001, 1:41-43. As the Background describes, processing to obtain a coating typically included "[p]re-coating of a steel sheet[], by hot dipping; [t]rimming or cutting for obtaining blanks; [h]eating the blanks in order to obtain alloying of the steel substrate with the pre-coating, as well as the austenitizing of the steel; and [h]ot forming followed by rapid cooling of the part in order to obtain predominantly martensitic structures." EX-1001, 1:45-51.

18. Starting with this well-established process, the '227 Patent alleges several improvements. First, the '227 Patent emphasizes the "importan[ce]" of "control of the homogeneity of the pre-coating thickness over the entire sheet" by "monitor[ing] continuously" the pre-coating thickness. EX-1001, 2:58-60, 5:1. However, the '227 Patent does not claim any pre-coating or homogeneity thereof.

19. The '227 Patent further notes (i) certain process parameters that are linked to the manufacture of "fully homogeneous martensitic structure[s]" and (ii) the advantages of "reduction of sulfur below a critical value." EX-1001, 3:1-8. But, as will be demonstrated below, both the claimed low sulfur amounts and the claimed "fully martensitic" products were recognized in the art. For example, Takagi, Vaissiere, and Somani each provide a detailed discussion of how the hot-

stamping process can be tuned to obtain martensitic structures. EX-1016, [0028]; EX-1021, 3, 6; EX-1032, 8.

20. Finally, the ’227 Patent describes that “particularly good weldability [] is associated with a special succession of coating layers on the parts.” EX-1001, 2:64-66. An example of the claimed coating, which includes four layers, is described with respect to the manufacturing process of “Example 2” and illustrated in FIG. 1 of the ’227 Patent, reproduced below. EX-1001, 12:30-61.

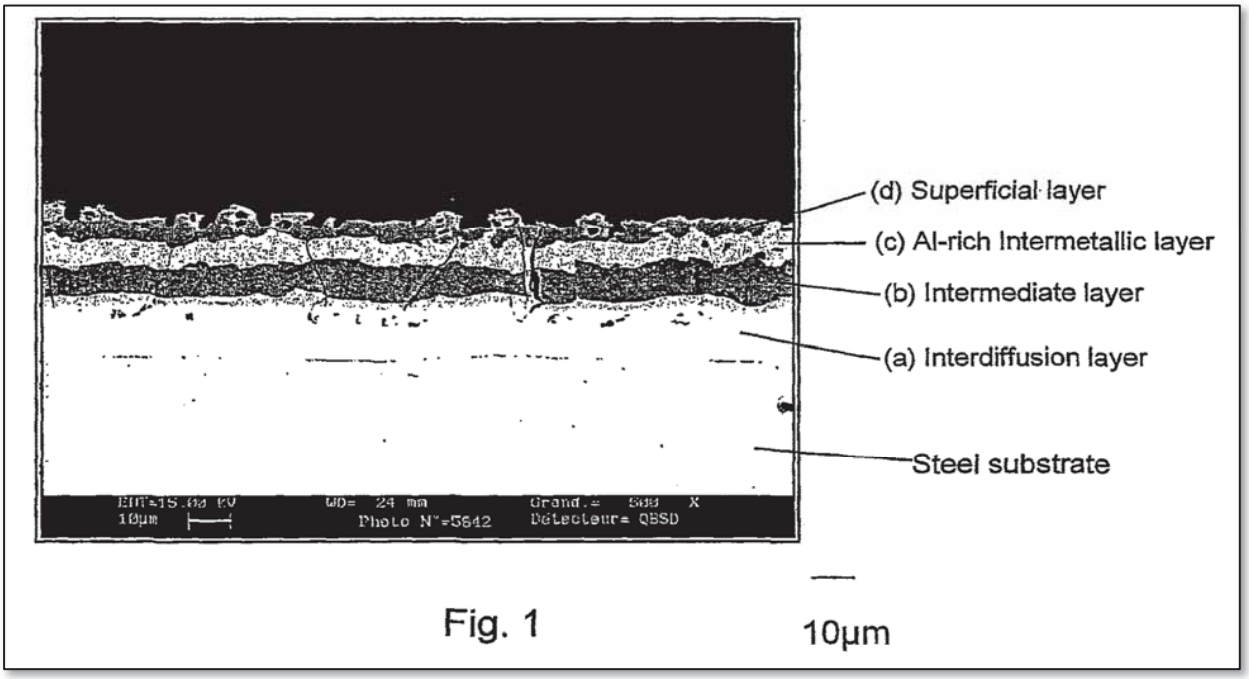


FIG. 1 of the ’227 Patent

21. I have reviewed relevant portions of the file history of the ’227 Patent (EX-1002). Prosecution focused on the compositions of the layers recited in claim 1, and Patent Owner relied heavily on the proceedings of the IPR for the ’683 Patent, with which I am familiar based on my own participation. In that prior IPR,

the claims of the ’683 Patent were found to be invalid, in part because different “layers” were interpreted as not having to be composed of different materials. EX-1029, 20. Here, claim 1 recites that the layers “*each have a different mean composition from one another*.”

22. An initial Office Action, following a Restriction Requirement, rejected the sole independent claim as anticipated by Cornette. The Examiner pointed to Cornette’s FIG. 22 as showing four layers with a total thickness satisfying the claim’s recitation of a “*thickness greater than 30 micrometers*,” an element also found in claim 1 of the ’227 Patent. EX-1002, 200. In reference to the claim’s recitation that “*layers (a), (b), (c), and (d) each have a different mean composition from one another*,” the Examiner further argued that these “different colorations of the respective layers [in Cornette] indicate that the respective layers have different compositions.” *Id*., 201. Several dependent claims were rejected over a combination of Cornette and Laurent. *Id*., 203.

23. In response, the applicant cited the IPR proceedings of U.S. Patent No. 9,708,683 (“the ’683 Patent”), during which Patent Owner’s expert testified that the “shade and tone” of the layers in Cornette’s FIG. 22 were insufficient to demonstrate that the layers had different compositions. EX-1002, 534.

24. The Examiner then issued a Notice of Allowance, stating that “[t]he Office is unable to determine if the materials within the respective layers of the

prior art are different materials through a visual examination of the figures provided in the prior art." EX-1002, 576.

25. To summarize, the only references applied in a rejection during prosecution of the '227 Patent were Cornette and Laurent. The allowance relied on Cornette's lack of disclosure of the compositions of the four layers illustrated in Cornette's FIG. 22 coating. By contrast, the two primary references that I reviewed for this Declaration – Engels and Takagi – provide precise compositions for four and five different layers, respectively, thereby teaching the sole feature that justified allowance.

VI. GROUNDS 1A-102 and 1A-103: Claims 1-2, 4-5, 7, 18, and 24-25 are anticipated by Engels, and claims 1-2, 4-7, 9-10, 13-15, and 18-25 are obvious over Engels

A. Engels

26. Engels is a conference paper submitted as part of the "New Developments in Sheet Metal Forming Technology" conference held in May 2006. Entitled "*Controlling and Monitoring of the Hot-Stamping Process of Boron-Alloyed Heat-Treated Steels*," Engels provides an overview of hot-stamping as applied to "boron-alloyed steels." EX-1005, 136. For example, Engels notes that "blanks" having an "Al-Si-coating" are "austenitized at temperatures between 900 ˚C and 950 ˚C," "stamped," and "systematically cooled down under pressure." EX-1005, 137. A POSITA would have understood that the "Al-Si-coating" is a "pre-

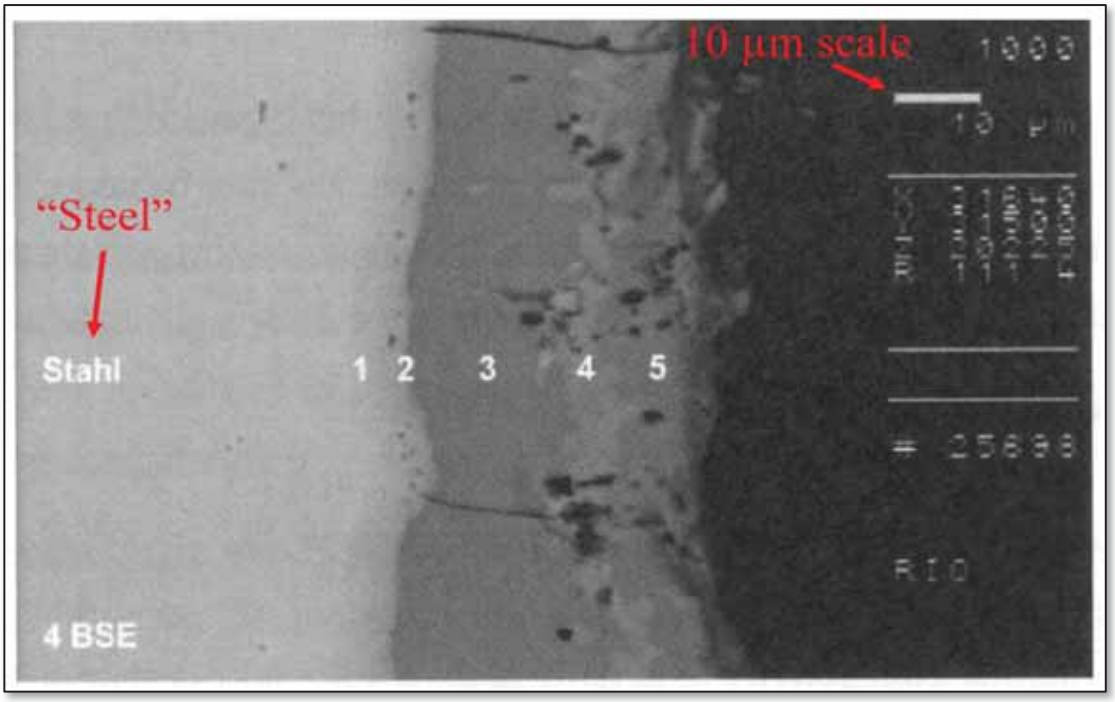
coating" that is transformed, via the hot-stamping process, into a coating found in a final hot-stamped part. "Systematically cooled down under pressure" in this context refers to "quenching," which in a hot-stamping process is performed directly in the stamping die.

27. As a result, a "diffusion layer" (coating) forms, and Engels recognizes that "it is crucial to look for a correctly shaped diffusion layer with regard to layer thickness, porosity and roughness, as this layer will decisively impact the corrosion and welding properties of the hot stamped parts." EX-1005, 142. Among the "parameters which have to be taken into account when setting the temperature profile" are "heating rate," "total processing time," "maximum austenitizing temperature," and "material thickness." *Id*.

28. Engels FIG. 5, an image captured using electron microscopy, shows a "cross-section polish of the diffusion layer of a hot-dip aluminum coated boron steel." EX-1005, 142. "Five phases which differ in their layer thickness and chemical composition can easily be distinguished." *Id*. These phases and their compositions and thicknesses are shown in Engels FIG. 5 and a corresponding table (reproduced below).

phase number	layer thickness, µm	Al	Fe	Si	Cr	Mn
		Volume-%				
1	5 – 9	7,2	89,2	1,9	0,3	1,4
2	< 1µm	unmeasurable				
3	11 – 18	51,4	45,9	1,9	0,1	0,7
4	3 – 8	33,9	54,3	10,6	0,3	0,9
5	5 - 11	53,2	44,1	1,9	0,2	0,6

Engels Table



Engels FIG. 5

29. Several aspects of Engels FIG. 5 and Table bear special comment. First, a scale at the top-right shows a length of 10 µm, permitting the calculation of exact thicknesses from the image itself. As I know from personal experience, these scale bars are common in electron microscopy output and can be relied upon for precise measurements of in-focus materials such as the imaged coating. Second, the included annotation "Stahl" is German for "steel;" this portion of the image

depicts the base steel underlying the coating. EX-1006.

30. Third, although Engels' Table lists compositions with "Volume-%," this is a translation error and would have been recognized as such by a POSITA. The German version of this article describes the compositions as "Masse-%," which, as described in further detail in EX-1006, is correctly and unambiguously translated as "Mass-%," not "Volume-%." EX-1006; EX-1010, 22. Further, the concept of a "Volume-%" for distinct elements in a homogenous compound of those elements is not well-defined. In a crystal structure formed by, for example, iron atoms, silicon atoms, and aluminum atoms intermixed and bonded to one another, it makes little sense to try to quantify how much of the total volume is assigned to each atom. "Mass-%" (or, equivalently, weight-%), by contrast, was and remains by far the most common composition metric among steel researchers. "Volume-%," meanwhile, is an essentially unknown and unused metric in steel research or, for that matter, in any materials science research with which I am familiar. Accordingly, in this Declaration, and consistent with how a POSITA would have understood Engels, I treat the compositions described in Engels' Table as percentages by mass or, equivalently, weight. Mass-% and weight-% are equivalent metrics because weight and mass are related by a constant factor that cancels out when calculating mass/weight proportions.

B. Analysis of Claims

[1pre]: A hot stamped coated steel product, which comprises:

31. Engels FIG. 5 depicts a hot stamped coated steel product. For example, Engels FIG. 5 shows a "diffusion layer" (coating) on underlying "boron steel" ("Stahl") that has undergone hot-stamping. EX-1005, 142-143.

32. With respect specifically to whether the part of Engels FIG. 5 is "hot stamped," Engels (entitled "Controlling and Monitoring of the **Hot-Stamping** Process of Boron-Alloyed Heat-Treated Steels"[1]) describes essentially continuous processes in which parts are transferred directly from a furnace (in which austenitization and coating formation occur) into a die to be stamped (or "formed") and quenched. EX-1005, 137-138. In the field of steel metallurgy, all of these steps were and are understood as portions of a single, unified process referred to, as a whole, as "hot stamping." The heating and the forming (stamping) are two parts of the same process, as the heating step is critical and necessary to the forming step, and in this context make little sense when viewed independently. For example, heating alone does not provide desired steel mechanical properties absent quenching, and stamping (and corresponding quenching in the die) cannot be performed without the heating step.

33. Indeed, as described by Engels, the "[t]ransfer time t_T between furnace

[1] All emphasis is added except where indicated otherwise.

and die" is a factor in determining the mechanical and surface properties of the resulting part, and other art notes that "[t]he transfer time between the furnace and the die has to be reduced as much as possible." e.g., to "less than ten seconds." EX-1005, 141; EX-1019, 167. In view of this continuous, unified process that includes immediate transfer to a die for stamping, a POSITA would have understood Engels FIG. 5 to illustrate a part that has undergone the entirety of that process, including stamping: to depict a part that has undergone only a portion of the process (e.g., furnace treatment without forming in a die) would have been viewed as much less illustrative and relevant. This is particularly true in view of the immediate context of Engels FIG. 5, which includes a discussion of how the forming and quenching process causes "structural change" in the part. EX-1005, 143. A POSITA would have naturally understood Engels FIG. 5 to depict a hot stamped part that has undergone those structural changes as part of the unified hot-stamping process, not a part whose processing has been arbitrarily arrested mid-way through. Accordingly, a POSITA would have understood that Engels discloses or renders obvious a *hot stamped coated steel product*.

34. I further note Engels' disclosure that the "heat treatment," not "stamping and tempering," determine the properties of the "diffusion layer." EX-1005, Table 1. Based on this disclosure, even if the Engels FIG. 5 diffusion layer (coating) had undergone heat treatment without being formed in a die, the coating

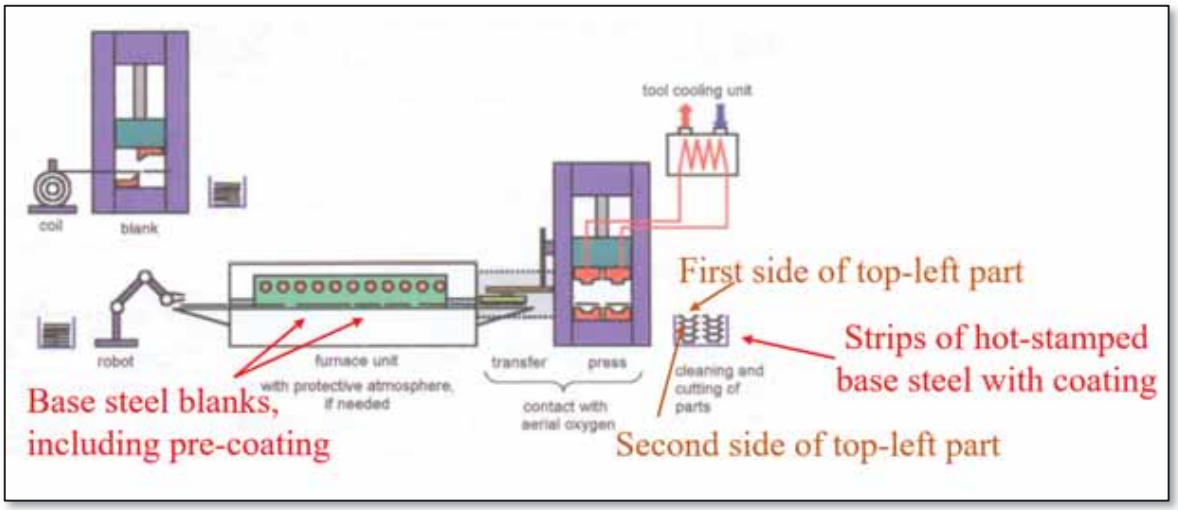
would nevertheless teach characteristics of a formed coating, because the coating would remain substantially the same through the forming and tempering process. This description is consistent with that of the ’227 Patent itself, which describes that an “alliation” “reaction between the pre-coating and base steel” occurs “during the heat treatment **immediately preceding hot stamping**,” and that the “coating” is “the pre-coating after having been subjected to an alliation reaction between the pre-coating and base steel. EX-1001, 14:31-42. That is, based on the ’227 Patent’s own description, a teaching of a coating formed by heat treatment renders obvious a teaching of a coating that has been heat-treated and also formed in a die, because the coating would be the same in either case.

35. The addition of “stamping” would then be an obvious additional process to apply to the heat-treated part, in order to create a formed part having a shape and mechanical properties suitable for use, for example, in a vehicle.

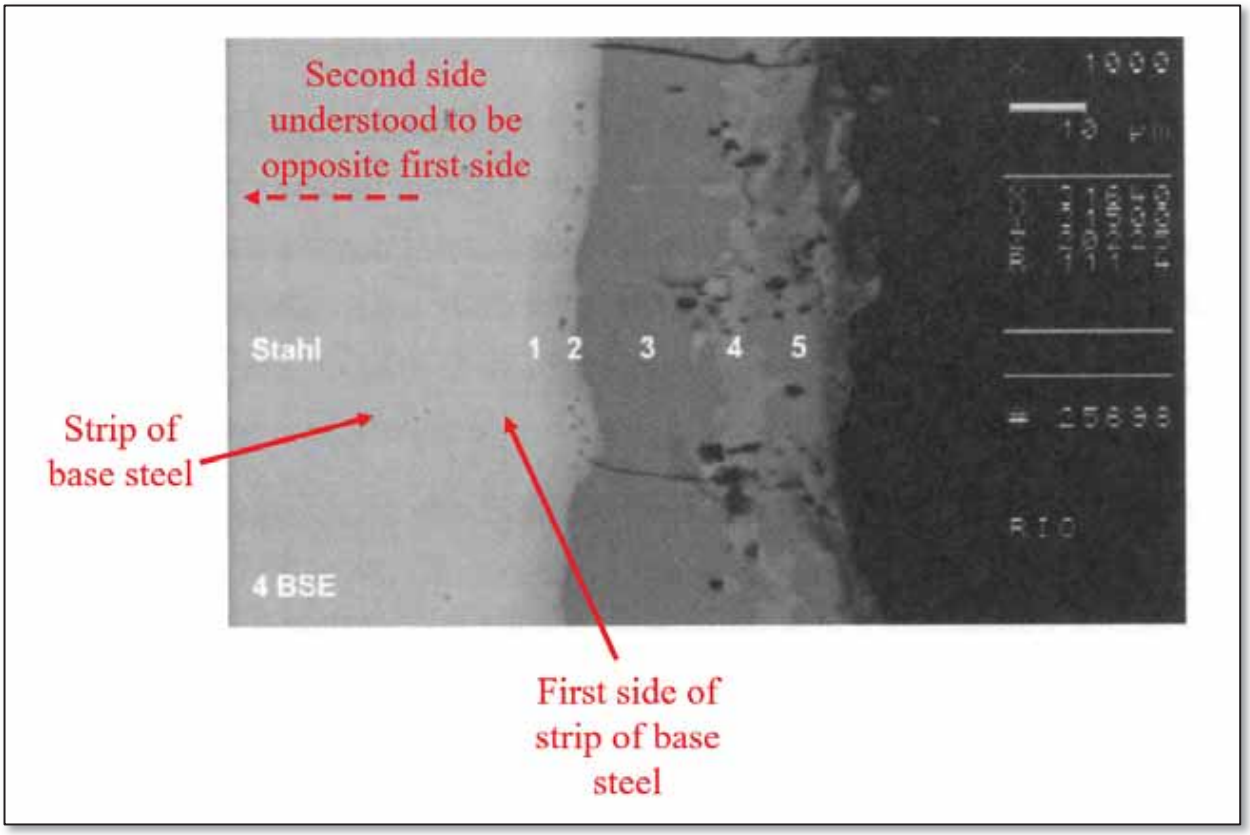
[1a]: a strip of base steel having a first side and a second side; and

36. Engels discloses or renders obvious a strip of base steel having a first side and a second side. For example, in its description of the hot stamping process, Engels illustrates blanks having first sides and second sides, as shown in annotated Engels FIG. 1 below. EX-1005, 137. A POSITA would have understood these blanks as being strips (as, indeed, they are illustrated in FIG. 1) composed of base steel with a pre-coating, which Engels refers to as an “Al-Si-coating.” EX-1005,

137. The strips of base steel are austenitized and formed to produce hot-stamped parts having the same base steel with the first and second sides, and an overlying coating. A strip of base steel and one of its sides (immediately underlying indicated phase 1) are shown in Engels FIG. 5; a POSITA would have understood that there would be a second side opposite the labeled first side.



Annotated Engels FIG. 1



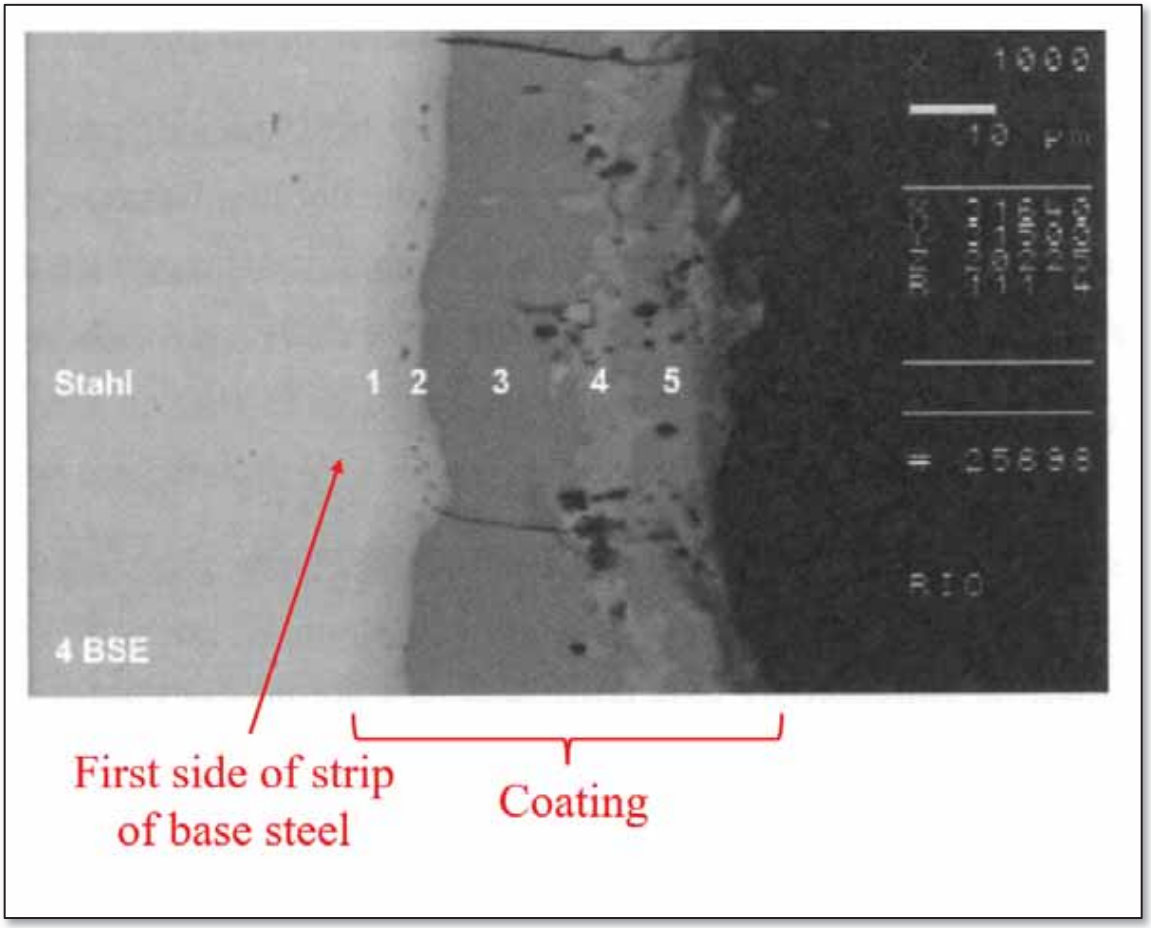
Annotated Engels FIG. 5

[1b]: a coating on at least one of said first side of said strip of base steel and said second side of said strip of base steel, wherein:

37. Engels discloses or renders obvious a coating on at least one of the first side of the strip of base steel. The coating is a "diffusion layer" having five phases, as shown in annotated Engels FIG. 5 below. EX-1005, 142-143.

38. Examining FIG. 5, I note that phases 3, 4, and 5 are highly distinguishable based on their different shadings. In backscattered scanning electron microscopy (SEM) images such as Engels FIG. 5 (as indicated by "BSE" at the bottom left), shading (light/dark) is reflective of the composition of the

imaged material. The boundary of phase 1 appears to be visible as a vertical strip of lighter shade. The researchers who authored Engels would have had access to precise composition data (for example, using energy dispersive X-ray spectroscopy (EDS)) that would have allowed them to accurately identify the different phases and determine thicknesses of each layer, for example, as reflected in Engels' table.



Annotated Engels FIG. 5

39. Phase 2 of Engels is a less cohesive layer, as reflected in Engels' disclosure that this layer is very thin and has an "unmeasurable" composition. EX-1005, 143. Based on my review of the literature, this is not a fluke of Engels

process but, rather, a common characteristic of the coatings of hot-stamped steels: a less distinct layer may or may not be found adjacent to the innermost layer of the coating, depend on the exact thermal process to which the coating was subjected.

40. For example, of Takagi's five samples, Nos. 1 and 4 include five layers, whereas Nos. 2 and 5 include four layers. EX-1016, FIG. 4. A comparison of the compositions of the layers of these coatings strongly suggests that the "missing" layer of Nos. 2 and 5 would be the equivalent of the Inter 1 layers of Nos. 1 and 4, such that the Inter 1 layers of Nos. 2 and 5 corresponds to the Inter 2 layers of Nos. 1 and 4 based on their composition and location within the coating. A POSITA would have understood that this Inter 1 layer corresponds to phase 2 of the Engels coating. Continuing the comparison and analogy, a POSITA would have understood that the Inter 2, Inter 3, and Outer layers correspond to phases 3, 4, and 5, respectively.

Similar compositions between
Inter 2 of Nos. 1, 4 and Inter 1 of Nos. 2,5

TABLE 1

No.	PRODUCTION		COATING LAYER STRUCTURE & COMPOSITION (%)						STEEL BASE HARDNESS (Hv)	COATING LAYER HARDNESS (Hv)			OXIDE WEIGHT (mg/dm²)	FORMABILITY	CORROSION RESISTANCE	WELDABILITY
	RAISED TEMPERATURE (°C)	HOLD TIME (min.)	COMPONENT & HARDNESS	INNER	INTER 1	INTER 2	INTER 3	OUTER		SOFTEST	AVERAGE	SOFTER RANGE (%)				
1	920	3	Al	7.7	31.0	48.4	31.6	54.8	450	310	415	51	300	○	○	○
			Si	2.0	3.9	1.2	5.7	0.8								
			Fe	89.6	65.9	50.1	62.0	44.5								
			Hv	310	360	750	700	800								
2	900	2	Al	27.2	48.4	31.6	—	54.9	415	380	455	22	275	×	○	○
			Si	4.1	1.2	5.7		0.8								
			Fe	67.2	50.1	61.9		44.1								
			Hv	380	760	720	—	810								
3	930	10	Al	9.4	—	—	—	11.6	400	305	385	78	550	○	×	×
			Si	1.3				1.8								
			Fe	88.4				85.7								
			Hv	305	—	—	—	410								
4	950	5	Al	6.0	27.8	51.9	30.4	47.4	440	280	400	59	385	○	○	○
			Si	1.5	4.3	0.6	5.3	2.2								
			Fe	90.7	66.7	46.8	63.1	49.8								
			Hv	280	340	720	690	800								
5	900	4	Al	3.2	54.5	33.4	—	54.5	440	300	410	56	335	○	○	○
			Si	0.4	2.5	15.3		6.8								
			Fe	94.3	42.7	51.4		38.4								
			Hv	300	740	700	—	810								

Annotated Takagi Table 1

41. This physical phenomenon is also indicated by the ’227 Patent’s disclosure that the Interdiffusion layer “is itself composed of two sub-layers.” EX-1001, 12:46.

42. As a result, and consistent with an example in the ’227 Patent, Engels’ phase 2 would be understood as forming a sub-layer of an overall layer composed of both phases 1 and 2, the overall/composite layer having an overall composition similar to that provided for phase 1 and a thickness the same as or similar to the disclosed thickness of phase 1 (e.g., within 1 μm of the phase 1 thickness, a thickness difference that would not change the below discussion). I say that the composition would be similar to that of phase 1 because, as a POSITA would have understood, phase 2 would form only a very small part of the overall layer, such

that the overall layer's overall composition would be almost entirely determined by that of phase 1.

43. The foregoing interpretation is consistent with the '227 Patent's description that, in one example, layer (a) "is itself composed of two sub-layers." EX-1001, 12:46. However, I note that the claims of the '227 Patent lack any requirement that layer (a) be composed of two sub-layers.

44. All arguments provided herein that rely on associating Engels' phase 1 with layer (a) apply equally to this composite layer of phases 1 and 2.

[1c]: (i) said coating results from interdiffusion between said base steel and an aluminum or aluminum alloy pre-coating

45. Engels discloses or renders obvious that the coating results from interdiffusion between the base steel and an aluminum or aluminum alloy pre-coating. Engels describes that the "diffusion layer" (coating) is formed by heat treatment of "hot-dip aluminum coated boron steels." EX-1005, 141-142. "Hot-dip" refers to a process in which a base steel is dipped in a bath of aluminum or aluminum-silicon to form an aluminum or aluminum-silicon pre-coating. A POSITA would have understood Engels to describe specifically an aluminum-silicon pre-coating, based on the descriptions of "an Al-Si-coating" and an "22MnB5+AS diffusion layer," where "AS" would have been understood by a POSITA as referring to "aluminum-silicon." EX-1005, 138, 141.

46. The thermal treatment described by Engels (e.g., "heating rate," "total processing time," and "austenitizing temperature," such as "temperatures between 900 °C and 950 °C") then causes "diffusion" between the material(s) of the pre-coating and the base steel. EX-1005, 136, 142. As a result, Engels' coating includes various phases composed of varying degrees of iron, aluminum, and silicon. EX-1005, 143. Based on these compositions and Engels' use of the term "diffusion," a POSITA would have understood that the "diffusion layer" (coating) was formed by interdiffusion between the iron of the base steel and the aluminum and silicon of the "AS" or "Al-Si" pre-coating.

[1d]: (ii) wherein said coating comprises, proceeding from the base steel outwards:

[1e]: (a) an Interdiffusion layer,

[1f]: (b) an Intermediate layer,

[1g]: (c) an Intermetallic layer, and

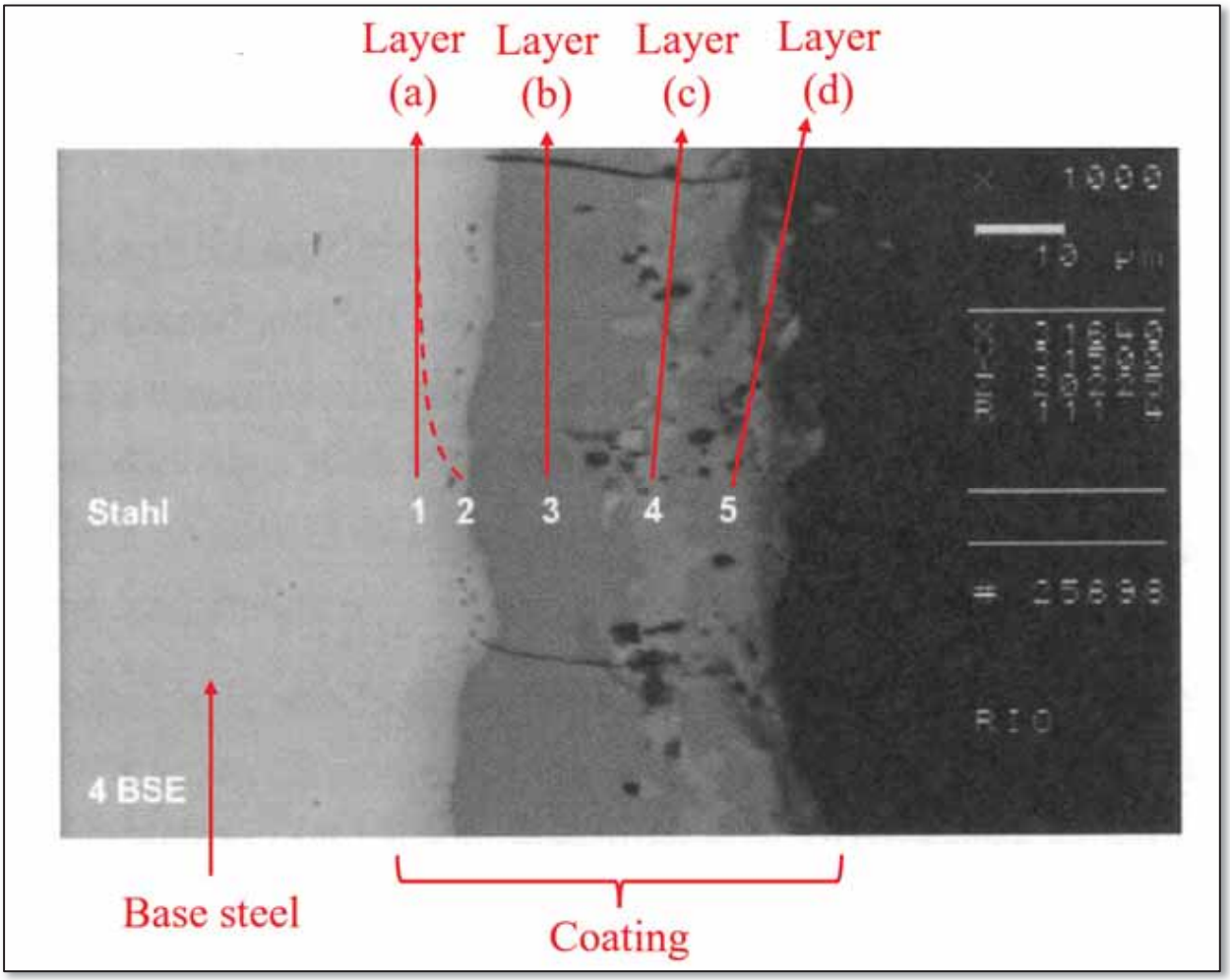
[1h]: (d) a Superficial layer,

47. Engels discloses or renders obvious that the coating comprises, proceeding from the base steel outwards, (a) an Interdiffusion layer, (b) an Intermediate layer, (c) an Intermetallic layer, and (d) a Superficial layer. Engels describes that the "diffusion layer" (coating) includes "five phases which differ in their layer thickness and chemical composition." EX-1005, 142. As shown in

Engels FIG. 5, each of at least phases 1 and 3-5 constitutes a layer and satisfies the foregoing limitation of claim 1 according to the following mappings:

- **Phase 1 or phases 1+2** teaches **layer (a) (the "Interdiffusion layer")**. As shown in FIG. 5, phase 1 is arranged directly on the underlying steel.
- **Phase 3** teaches **layer (b) (the "Intermediate layer")**.
- **Phase 4** teaches **layer (c) (the "Intermetallic layer")**.
- **Phase 5** teaches **layer (d) (the "Superficial layer").**

48. These phases are included in the coating ("diffusion layer") and "proceed[] from the base steel outwards."



Annotated Engels FIG. 5

49. The ’227 Patent does not describe that the names for each of the layers (that is, “Interdiffusion,” “Intermediate,” “Intermetallic,” and “Superficial”) denote any particular characteristics of the layers. However, phases 1 or 1+2, 3, 4, and 5 satisfy the meanings of each of those terms as proposed by Petitioner during IPR proceedings for the ’683 Patent. EX-1031, 22-24. Phase 1 (or phases 1 and 2 together) is formed by diffusion. EX-1005, 141. Phase 3 is intermediate between other phases, e.g., between phases 1/2 and 4. Phase 4 is intermetallic in that it is

composed of two or more metals or a metal and a nonmetal in an alloy. Engels Table. Phase 5 is superficial in that it is arranged at the surface of the coating. Engels FIG. 5.

50. Further, claim 1 does not recite that the layers must be adjacent to one another, such that, for example, the arrangement of phase 2 at least partially between phase 1 and phase 3 is no impediment to the mapping of phase 1 to layer (a) and phase 3 to layer (b). To the extent Patent Owner disputes this mapping, I discussed above that layer (a) can equally be mapped to a composite layer formed by phases 1 and 2. My comments herein with respect to layer (a) or phase 1 apply equally to this composite layer of phases 1 and 2.

[1i]: wherein layers (a), (b), (c), and (d) each have a different mean composition from one another,

51. Engels discloses or renders obvious that layers (a), (b), (c), and (d) each have a different mean composition from one another. This disclosure is provided in Engels' Table, which provides elemental compositions for each of phases 1 and 3-5, which correspond to layers (a)-(d), respectively. For example, each of these layers has a different Al composition and a different Fe composition from one another:

Differing Al and Fe compositions

	phase number	layer thickness, µm	Al	Fe	Si	Cr	Mn
			~~Volume-%~~ Mass-%				
Layer (a)	1	5 – 9	7,2	89,2	1,9	0,3	1,4
[Layer (a)]	2	< 1µm	unmeasurable				
Layer (b)	3	11 – 18	51,4	45,9	1,9	0,1	0,7
Layer (c)	4	3 – 8	33,9	54,3	10,6	0,3	0,9
Layer (d)	5	5 - 11	53,2	44,1	1,9	0,2	0,6

Annotated Engels Table

52. Engels discloses the "chemical composition" of each phase, not explicitly a "mean" composition. However, a POSITA would have understood that, in the field of steel metallurgy, a disclosure of a composition for a material, phase, or layer implicitly is, and would have been understood as, a disclosure of a **mean** composition of the material, phase, or layer. For example, a researcher might sample several representative portions of a material and average the corresponding compositions to obtain values representative of a mean composition of the material. In the case of the hot-stamped coatings discussed herein, the POSITA would have likely selected at least several points in the coating's cross-section to analyze using EDS. Any other type of disclosed composition would be much less useful and less well-defined.

53. Absent a statement or suggestion otherwise – which Engels does not include – a POSITA would have understood Engels' disclosures of compositions to be disclosures of **mean** compositions, thereby satisfying this claim element.

54. Alternatively, to the extent Engels' compositions may not be "mean" compositions, it would have been obvious to treat these compositions as mean compositions when interpreting Engels and, for example, use these compositions as mean compositions when applying Engels' teachings. "Mean" composition is by far the most common way to report a composition and would have been the most accessible measure of a layer's composition for a POSITA seeking to apply Engels' teachings to hot-stamped steel. In order to obtain Engels' coating, a POSITA would have sought to form a coating in which Engels' compositions are mean compositions.

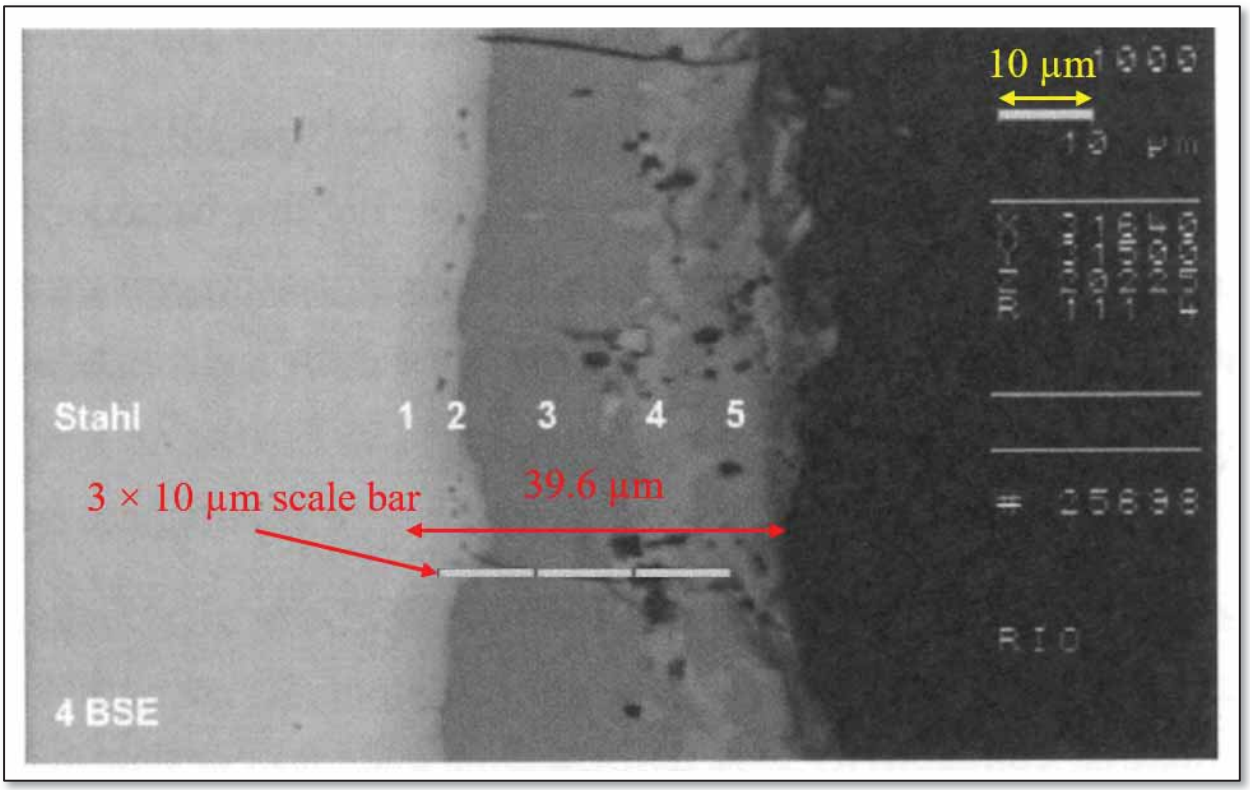
55. Accordingly, Engels' disclosure that each of phases 1 and 3-5 has a different composition from one another discloses or renders obvious that layers (a), (b), (c), and (d) each have a different mean composition from one another.

[1j]: wherein said coating of the hot stamped coated steel product has a thickness greater than 30 micrometers.

56. Engels discloses that the coating of the hot stamped steel product has a thickness greater than 30 micrometers. For example, I have performed a direct measurement in Engels FIG. 5 (shown below) based on the included 10 μm scale. This and other measurements herein (for example, measurements of layers in Hein and Cornette) were conducted by using an on-screen pixel ruler and the included scale to determine a conversion between pixels and μm, and then applying the

conversion to pixel measurements of the layers/coatings. In all cases, the images used do not appear distorted, such that the dimensions can be measured with a high degree of accuracy.

57. In the case of FIG. 5, I measured the coating thickness based on the phase shadings, which, as I discussed above, are representative of different compositions. This measurement shows a thickness of **39.6 µm**, well beyond the recited 30 µm threshold value. This disclosure, in combination with the other teachings of Engels discussed above, directly teaches claim 1.



Annotated Engels FIG. 5

58. Alternatively, Engels renders obvious that the coating has a thickness

greater than 30 µm based on the disclosed thickness ranges in Engels' Table. Many combinations of the disclosed ranges result in a total coating thickness greater than 30 µm. For example, assuming that each phase has a value in the middle of the disclosed range (7 µm for phase 1, 14.5 µm for phase 3, 5.5 µm for phase 4, and 8 µm for phase 5), and neglecting any thickness of phase 2, results in a coating thickness of **35 µm**. Even assuming that each phase has a value one-third of the way through its disclosed range (toward the lower end) results in a coating thickness of **31.3 µm**, again satisfying this claim element. Any marginal thickness contributed by phase 2 would not substantively alter this reasoning in the case where layer (a) is mapped to phases 1+2.

59. Generally, the Engels Chart discloses ranges of total coating thickness from 24 µm (assuming each phase has its lowest-disclosed thickness) to 46 µm (assuming each phase has its highest-disclosed thickness). This range overlaps the claimed range of "greater than 30 micrometers," which, according to my understanding, renders the claimed range obvious. I am informed that a presumption of obviousness applies where a claimed range overlaps with a range disclosed in the prior art, but that this presumption can be overcome if the prior art teaches away from the claimed range, or the claimed range produces new and unexpected results. Here, Engels does not teach away from the claimed range, and, indeed, discloses a specific value within the claimed range. In addition, the '227

Patent does not assert that the claimed range of "greater than 30 micrometers" is associated with any unexpected results relative to the range disclosed by Engels. Although the range is described as "a preferred embodiment," the '227 Patent fails to discuss any particular effects, results, or criticality associated with the range, and certainly does not describe that these results would be unexpected relative to the ranges disclosed by Engels. EX-1001, 6:46-47.

60. And, according to my understanding of materials science, such criticality or unexpected results would be very unlikely. For example, a POSITA would expect a 31 μm coating to exhibit essentially the same properties as a 29 μm coating.

61. Moreover, it would have been obvious to try varying and experimenting with the coating thickness based on Engels' disclosure that "it is crucial to look for a correctly shaped diffusion layer with regard to **layer thickness** [] as this layer will decisively impact the corrosion and welding properties of the hot stamped parts." EX-1005, 142. Coating thickness was generally recognized as an important parameter both for physical layer properties and for industrial application. For example, as discussed in more detail below in Section XII.C, suppliers of hot-stamped steel parts for General Motors were required to provide coatings with a thickness greater than 35 μm. EX-1026, 7. And JP2004244704 describes that "[a] thickness of 20 μm or more is preferred because a thicker layer

responsible for corrosion resistance results in greater overall corrosion resistance and a longer material life." EX-1034, [0013].

62. In addition, the prior art recognized that coating thickness could be tuned at least by adjustment of the pre-coating thickness. For example, FR2833504 describes that alloying of a pre-coating "generally corresponds to a 50% increase" in thickness for the resulting coating. EX-1025, 5:17-20. And GMW14400 provides guidelines for pre-coating thickness in order to achieve the required coating thickness. EX-1026, 7.

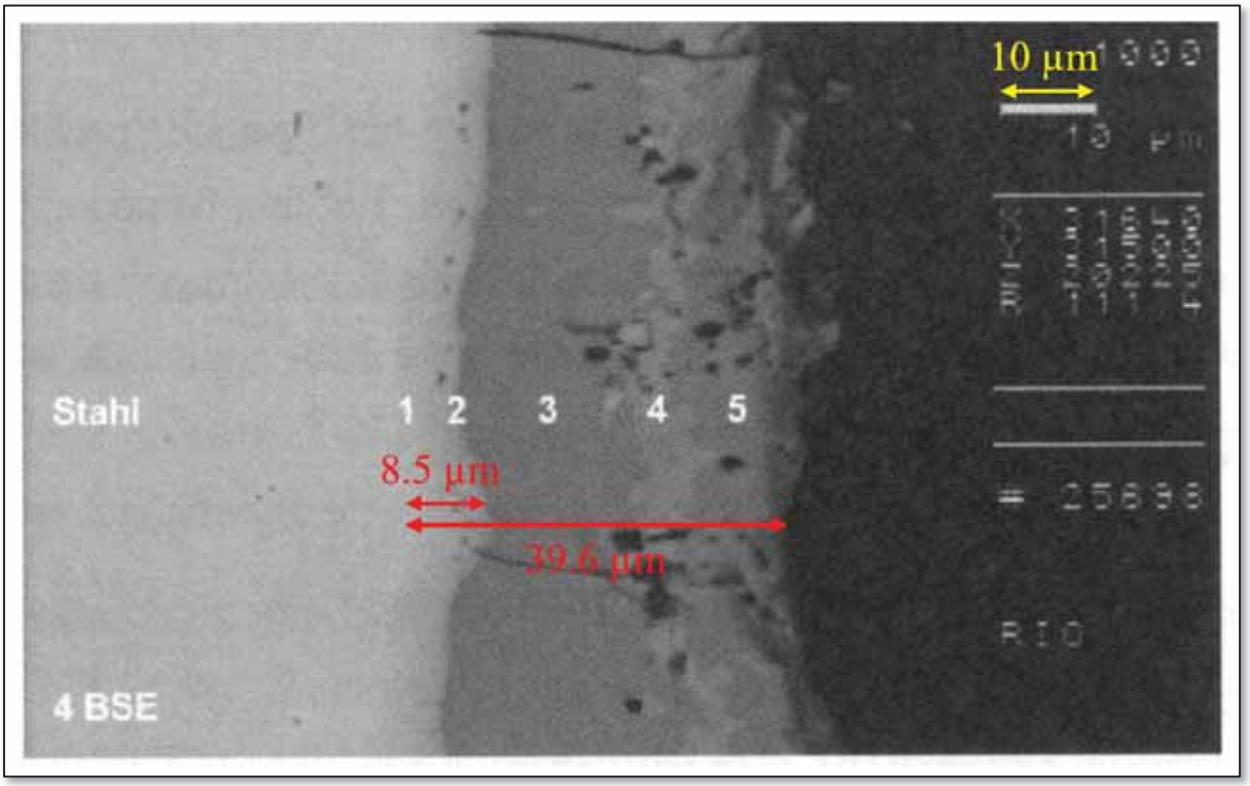
63. Accordingly, Engels directly discloses (Ground 1A-102) or renders obvious (Ground 1A-103) claim 1.

[2]: The hot stamped coated steel product according to claim 1, wherein said layer (a) has a thickness that is less than half of said thickness of the coating.

64. Engels discloses or renders obvious that layer (a) has a thickness that is less than half of the thickness of the coating. As disclosed in Engels' Table, phase 1 (corresponding to layer a) has a thickness in a range from **5-9 µm**. The minimum thickness of the remaining phases 2-5 (neglecting any thickness of phase 2) is 19 µm, corresponding to a 28 µm-thick coating in the case where phase 1 has its thickest value of 9 µm. Half of 28 µm is **14 µm**, which is larger than **9 µm**. Accordingly, even assuming the thickest-disclosed phase 1 and the thinnest-disclosed other phases, phase 1 satisfies this claim element. Further, such a

configuration is shown in Engels FIG. 5, in which the thickness of phase 1 is clearly less than half a total thickness of the coating, where phase 1 is delineated by the pale stripe of material extending vertically down to the left of the "1" label. Any marginal thickness contributed by phase 2 would not substantively alter this reasoning in the case where layer (a) is mapped to phases 1+2.

65. For example, as shown below, I measured a thickness for phase 1 or phase 1+2 of **8.5 µm**, much less than the measured 39.6 µm coating thickness.



Annotated Engels FIG. 5

[4]: The hot stamped coated steel product according to claim 1, wherein said layer (a) has a thickness of 17 micrometers or less.

[5]: The hot stamped coated steel product according to claim 1, wherein said layer (a) has a thickness of 15 micrometers or less.

66. Engels discloses or renders obvious that layer (a) has a thickness of 17 micrometers or less and 15 micrometers or less. As disclosed in Engels' Table, phase 1 (corresponding to layer a) has a thickness in a range from **5-9 µm**, such that the entire range of thicknesses satisfies both of the claimed ranges of "**17 micrometers** or less" and "**15 micrometers** or less." Any marginal thickness contributed by phase 2 would not substantively alter this reasoning in the case where layer (a) is mapped to phases 1+2. Further, the measured thickness of **8.5 µm** for phase 1 or phase 1+2 presented above satisfies these claims.

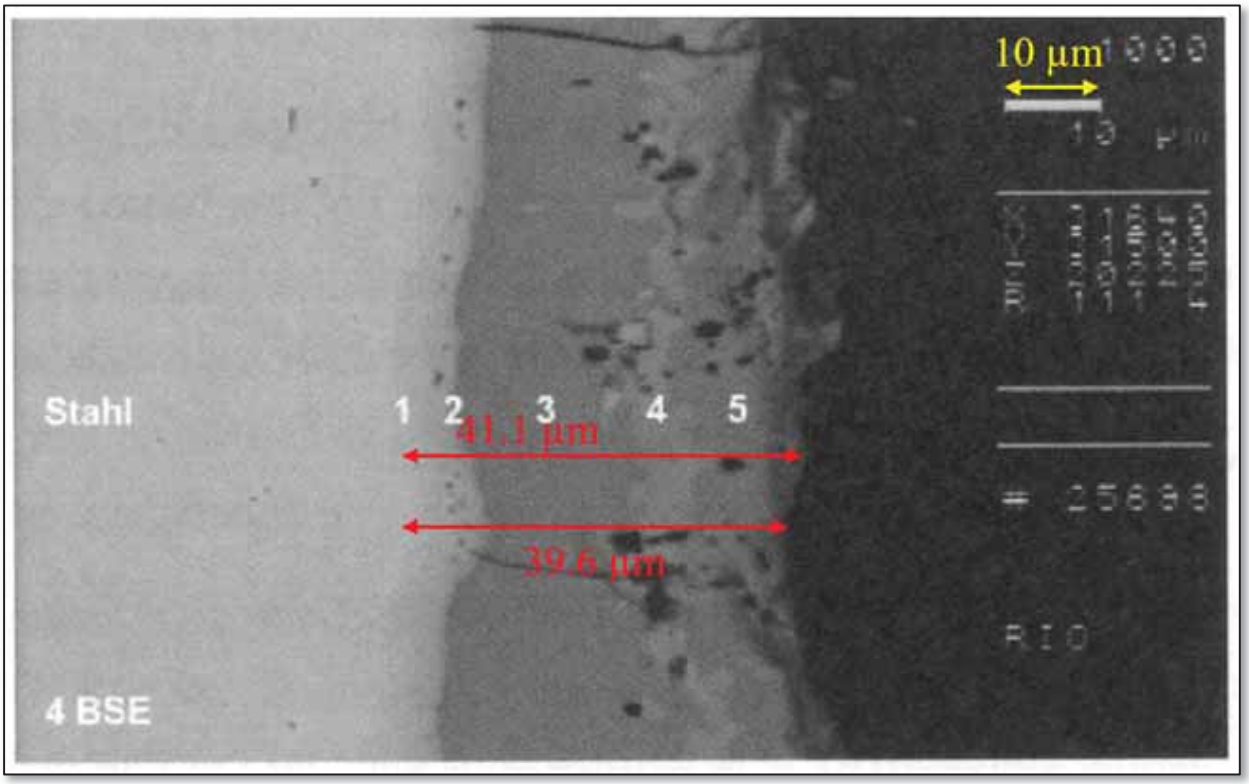
[6]: The hot stamped coated steel product according to claim 4, wherein the coating is 40 micrometers thick.

67. Engels renders obvious that the coating is 40 µm thick. First, as discussed above in reference to element [1j], the Engels Chart discloses ranges of total coating thickness from **24 µm to 46 µm**, which includes the claimed value of **40 µm**.

68. In addition, the measured thickness of the coating of Engels FIG. 5 is **39.6 µm**, very close to the claimed value and certainly close enough to render it obvious. A 0.4 µm difference in coating thickness would have been within manufacturing tolerances, such that a coating described as "40 micrometers thick"

would be expected to include at least some portions with a thickness of 39.6 μm. Thickness variations on that scale would be an expected part of the hot-stamping process. For example, GMW14400 describes that thickness measurements of the pre-coating should be conducted with instruments that "have a capability of ± 1.0 μm," indicating a tolerance for and expectation of thickness variations on that scale. EX-1026, 3.

69. An additional measurement I performed on Engels FIG. 5, as shown below, indicates that, at another portion of Engels' coating, the coating thickness is 41.1 μm. Because the coating thickness is a physical, continuous quantity, it follows that the thickness must be exactly 40 μm at at least one position.



Annotated Engels FIG. 5

70. Based on those above disclosures, it would have been obvious to a POSITA to experiment with the coating thickness to arrive at the claimed value of 40 µm, or to try a thickness of 40 µm. I am advised that, 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. Here, the general conditions of the claim are disclosed, in that Engels' thickness exactly matches or is very close to the recited thickness. And Engels recognizes coating thickness as result-effective by noting that "it is crucial to look for a correctly shaped diffusion

layer with regard to **layer thickness** [] as this layer will decisively impact the corrosion and welding properties of the hot stamped parts." EX-1005, 142.

71. Further, in this case, a POSITA would have had a reasonable expectation of success in trying various coating thicknesses. Engels teaches four distinct variables ("heating rate," "total processing time," "maximum austenitizing temperature," and "material thickness") that can be adjusted to tune the coating thickness. EX-1005, 142. All of these parameters would have been easily adjustable by a researcher, for example, by modifying the dip-coating process that provides the pre-coating and/or by modifying the programming of the furnace in which heating is performed. Armed with Engels' guidance and the ability to adjust each of these parameters, it would have been well within the skill of a POSITA to experiment based on Engels' hot-stamping process to obtain a coating with a thickness of 40 μm (and/or certain relative layer thicknesses, as discussed below).

72. Finally, although I am advised that discovery of an optimum value may be non-obvious where the results of optimizing a variable were unexpectedly good, this exception does not apply to claim 6. The '227 Patent does not describe any unexpected results or criticality associated with the 40 μm thickness. Nor does the '227 Patent even describe that the 40 μm thickness is itself an optimum or preferred value: 40 μm simply happens to be the thickness obtained for the '227 Patent's "Example 2," whereas the "preferred" range is "greater than 30

micrometers." EX-1001, 6:46-47, 12:41-42.

73. For these reasons, and for the reasons discussed with respect to claim 4, Engels renders obvious claim 6.

[7]: The hot stamped coated steel product according to claim 1, wherein the interdiffusion layer has a first mean iron composition, the intermediate layer has a second mean iron composition less than the first mean iron composition; wherein the intermetallic layer has a third mean iron composition, the third mean iron composition less than the first mean iron composition and greater than the second mean iron composition, and the superficial layer has a fourth mean iron composition, the fourth mean iron composition begin [sic] less than the third mean iron composition.

74. Engels discloses or renders obvious the foregoing relative mean iron compositions. Represented in more compact form, claim 7 recites that Fe%(layer (a)) > Fe%(layer (c)) > [Fe%(layer (b)) and Fe%(layer (d))]. As discussed with respect to claim 1 above, layers (a), (b), (c), and (d) correspond to Engels' phases 1 or 1+2, 3, 4, and 5, respectively. As further discussed with respect to claim 1, a POSITA would have understood Engels' disclosures of "composition[s]" as referring to or rendering obvious mean compositions. Accordingly, Engels' Table directly teaches the claimed relative compositions, as shown below:

Fe%(phase 1) > Fe%(phase 4) > Fe%(phase 3) > Fe% (phase 5)
(Layer (a)) (Layer (c)) (Layer (b)) (Layer (d))

	phase number	layer thickness, µm	Al	Fe	Si	Cr	Mn
				~~Volume-%~~ Mass-%			
Layer (a)	1	5 – 9	7,2	89,2	1,9	0,3	1,4
[Layer (a)]	2	< 1µm	unmeasurable				
Layer (b)	3	11 – 18	51,4	45,9	1,9	0,1	0,7
Layer (c)	4	3 – 8	33,9	54,3	10,6	0,3	0,9
Layer (d)	5	5 - 11	53,2	44,1	1,9	0,2	0,6

Annotated Engels Table

[9]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness that is greater than a thickness of layer (c).

75. Engels renders obvious that layer (a) has a thickness that is greater than a thickness of layer (c). As shown in Engels' Table, phases 1 and 4 (corresponding to layers (a) and (c), respectively) have thickness ranges of **5-9 µm** and **3-8 µm**. A large proportion of pairs of values from these ranges satisfy the relationship of this claim. For example, the midpoints of the ranges (7 µm and 5.5 µm) satisfy this relationship. For reasons similar to those discussed with respect to claim 6, it would have been obvious to a POSITA to experiment with and try various relative thickness values based on Engels' teachings of the importance of layer characteristics, with a reasonable expectation of success based on the adjustment of the tunable parameters described by Engels. EX-1005, 142. For example, a POSITA would have been motivated by Engels' disclosure that "it is

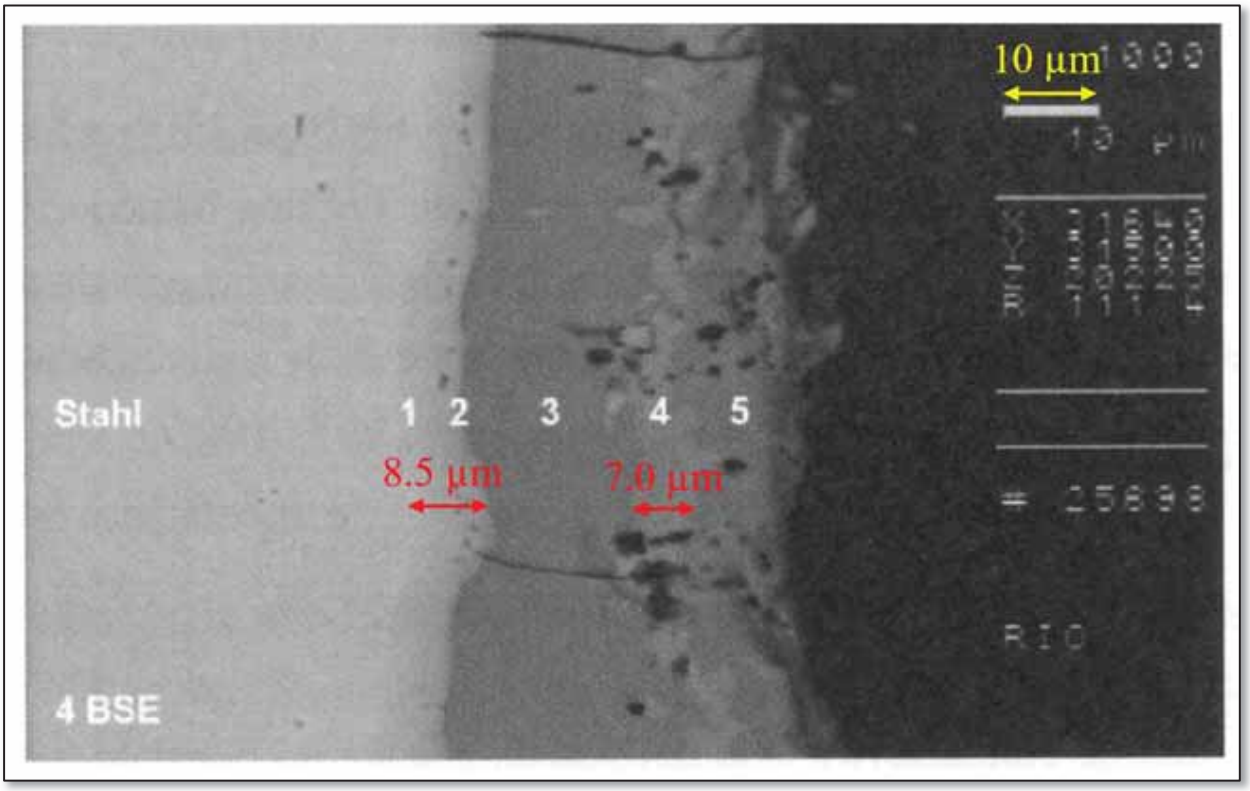
crucial to look for a correctly shaped diffusion layer with regard to layer thickness, porosity and roughness, as this layer will decisively impact the corrosion and welding properties of the hot stamped parts." EX-1005, 142. The '227 Patent does not describe any benefit to the claimed thickness relationship, and a POSITA would have arrived at it based on values in Engels' Table. Any marginal thickness contributed by phase 2 would not substantively alter this reasoning in the case where layer (a) is mapped to phases 1+2.

Thicknesses in ranges satisfy thickness(phase 1 – layer (a)) > thickness (phase 4 – (layer (c))

	phase number	layer thickness, µm	Al	Fe	Si	Cr	Mn
			~~Volume-%~~ Mass-%				
Layer (a)	1	5 – 9	7,2	89,2	1,9	0,3	1,4
[Layer (a)]	2	< 1µm	unmeasurable				
Layer (b)	3	11 – 18	51,4	45,9	1,9	0,1	0,7
Layer (c)	4	3 – 8	33,9	54,3	10,6	0,3	0,9
Layer (d)	5	5 - 11	53,2	44,1	1,9	0,2	0,6

Annotated Engels Table

76. As confirmation, I measured, at one position in the coating, respective thicknesses of **8.5 µm** and **7.0 µm** for phases 1 or 1+2 and phase 4, as shown below.



Annotated Engels FIG. 5

[10]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness that is greater than a thickness of layer (d).

77. Engels renders obvious that layer (a) has a thickness greater than thickness of layer (d). As shown in Engels' Table, phases 1 and 5 (corresponding to layers (a) and (d), respectively) have thickness ranges of **5-9 µm** and **5-11 µm**, respectively. A large proportion of pairs of values from these ranges satisfy the relationship of this claim (for example, thicknesses of 7 µm and 6 µm, respectively), and, as discussed for claim 9, achieving these relative thicknesses would have involved no more than routine experimentation, guided by Engels'

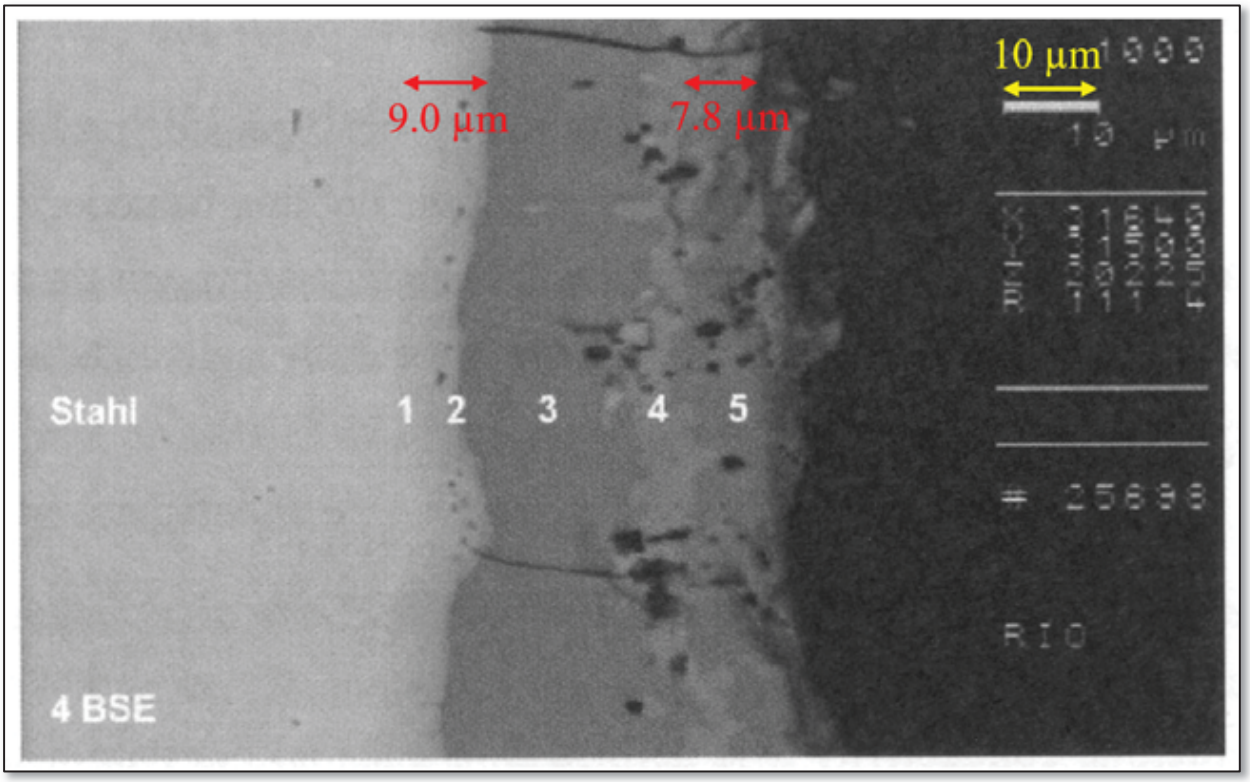
teaching of relevant tunable parameters for modifying the coating. EX-1005, 142. The '227 Patent does not describe any benefit to the claimed thickness relationship, and a POSITA would have arrived at it based on values in Engels' Table Any marginal thickness contributed by phase 2 would not substantively alter this reasoning in the case where layer (a) is mapped to phases 1+2.

Thicknesses in ranges satisfy thickness(phase 1 – layer (a)) > thickness (phase 5 – layer (d))

	phase number	layer thickness, µm	Al	Fe	Si	Cr	Mn
			~~Volume-%~~ Mass-%				
Layer (a)	1	5 – 9	7,2	89,2	1,9	0,3	1,4
[Layer (a)]	2	< 1µm	unmeasurable				
Layer (b)	3	11 – 18	51,4	45,9	1,9	0,1	0,7
Layer (c)	4	3 – 8	33,9	54,3	10,6	0,3	0,9
Layer (d)	5	5 - 11	53,2	44,1	1,9	0,2	0,6

Annotated Engels Table

78. Indeed, this relationship is directly shown in Engels FIG. 5, in which I measured, at one position in the coating, respective thicknesses of about 9.0 µm for phase 1 or 1+2, and about 7.8 µm for phase 5, as shown below.



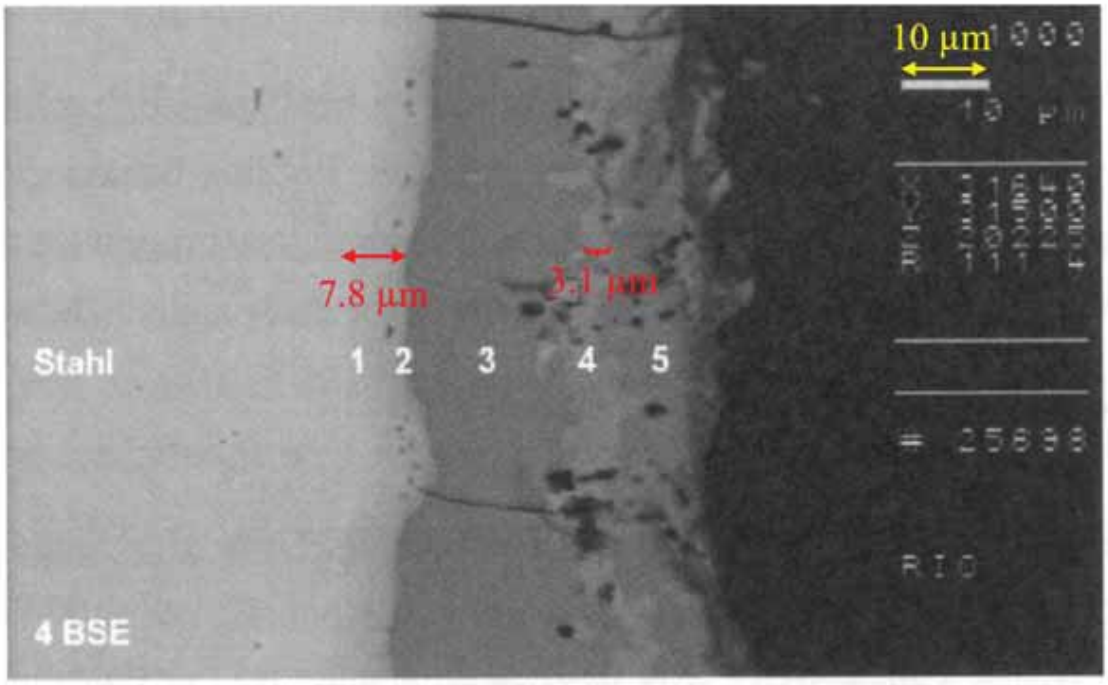
Annotated Engels FIG. 5

[13]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness that is more than twice a thickness of layer (c).

79. For reasons similar to those discussed above with respect to claim 9, Engels renders obvious that layer (a) has a thickness that is more than twice a thickness of layer (c). Based on the mapping of Engels phases 1 and 4 to layers (a) and (c), respectively, Engels' table discloses thickness ranges of **5-9 µm** and **3-8 µm**, respectively. A large proportion of pairs of values from these ranges satisfy the relationship of this claim. For example, a 7 µm phase 1 is more than twice as thick as a 3 µm phase 4. Moreover, as discussed with respect to claim 9, achieving

these relative thicknesses would have involved no more than routine experimentation, guided by Engels' teaching of relevant tunable parameters for modifying the coating. EX-1005, 142. The '227 Patent does not describe any benefit to the claimed thickness relationship, and a POSITA would have arrived at it based on values in Engels' Table Any marginal thickness contributed by phase 2 would not substantively alter this reasoning in the case where layer (a) is mapped to phases 1+2.

80. For example, at one position in the coating of Engels FIG. 5, I measured respective thicknesses of **7.8 µm** and **3.1 µm** for phases 1 or 1+2 and 4.



Annotated Engels FIG. 5

[14]: See Section VII.C.

[15]: The hot stamped coated steel product according to claim 1, wherein the hot stamped coated steel product is fully martensitic.

81. Engels renders obvious that the hot stamped coated steel product is fully martensitic. Engels describes that "[hot-stamped] boron steels belong to the group of **martensitic** steels which stand out for their good hardenability at low cooling rates." EX-1005, 135. Engels further discloses that a "**martensitic** transformation" is achieved, "resulting in [an] increase in strength," when "blanks or parts are [] stamped at high strain rates and kept under pressure inside the die [such that] controlled cooling and tempering [] of the material takes place." *Id.*, 136.

82. Engels does not disclose that the resulting product is **fully** martensitic. However, the difference between "martensitic" and "fully martensitic" is at most a change in degree, which I am advised is obvious absent compelling reasoning otherwise.

83. Further, Engels counsels that "[c]ooling realized according to TTT diagram" is a relevant factor for determining a stamped component's "[m]echanical properties." EX-1005, 141. A TTT ("time-temperature-transformation") diagram is a plot of temperature vs. time to illustrate how steel forms various phases when heated/cooled to various temperatures and at various rates. Therefore, in identifying "[c]ooling realized according to TTT diagram" in

particular as relevant, Engels is pointing to the cooling rate that the art identifies as the most important parameters for achieving martensitic transformations. *See, e.g.*, EX-1021, 6; EX-1016, [0028]; EX-1005, 135-136, 143-146. As such, a POSITA would have had a reasonable expectation of success in achieving a "fully martensitic" product based on Engels' "martensitic" product by performing cooling according to the TTT diagram.

[18]: The hot stamped coated steel product according to claim 1, wherein the Interdiffusion layer comprises the following components by weight based on total weight: 86 to 95% Fe, 4 to 10% Al, and 0 to 5% Si.

84. Engels discloses or renders obvious the foregoing composition. As discussed at [1e], the Interdiffusion layer is mapped to Engels phase 1. Further, Engels' Table discloses that phase 1 has weight composition of **89.2% Fe, 7.2% Al**, and **1.9% Si**. EX-1005, 143. *See* above at Section VI.A for discussion of the interpretation of the composition values in Engels' Table as weight percentages.

85. Moreover, a POSITA would have understood the percentages disclosed by Engels to be percentages "based on **total** weight." This is implied by Engels' additional disclosure of Cr and Mn content, which suggest that Engels is considering all non-negligible components, not just Fe, Al, and Si, in providing elemental concentrations. Absent disclosure otherwise, a POSITA would have understood that the disclosed compositions reflect percentages based on total

weight, given that a POSITA would have expected the percentages to reflect the general overall composition with a possible small percentage of impurities.

[19]: The hot stamped coated steel product according to claim 18, wherein the Intermediate layer comprises the following components by weight based on total weight: 39 to 47% Fe, 53 to 61% Al, and 0 to 2% Si.

86. Engels renders obvious the foregoing composition. As discussed at [1f], the Intermediate layer is mapped to Engels phase 3. Further, Engels' Table discloses that phase 3 has weight composition, by total weight, of **45.9% Fe, 51.4% Al**, and **1.9% Si**. EX-1005, 143. See above at [18] for citations relevant to this interpretation of Engels' Table.

87. The disclosed Fe% and Si% of Engels phase 3 satisfy the ranges of claim 19, while the Al% is slightly outside of the claimed range (**51.4%** compared to **53-61%**). However, I am informed that a claimed amount that does not overlap with, but is close to, a prior art amount, is obvious absent evidence of unexpected results or teaching-away. Here, the '227 Patent describes no criticality or unexpected results for a range of 53-61% Al compared to the very similar art value of 51.4% Al. Based on my metallurgical experience, I would not expect there to be any qualitative difference in layer properties between a 51.4% Al layer and a 53% Al layer.

88. A POSITA would have been motivated to experiment with various

Al% so as to arrive at the claimed Al% range. First, a POSITA would have naturally understood that the concentration of a primary component in a layer would have been relevant for determining properties of that layer, e.g., determining "layer thickness, porosity, and[/or] roughness" as described by Engels. EX-1005, 142. Engels' disclosure of the Al composition of each phase would have reinforced this understanding. A POSITA would have also been aware of other art teaching Al% as a result-effective variable, e.g., Takagi's and JP2004244704's disclosures that Al% at least partially determines corrosion resistance. EX-1016, [0021]; EX-1033, [0012]. And a POSITA would have had a reasonable expectation of success in arriving at the claimed Al% based on Engels' disclosure of the various process parameters that determine characteristics of the coating ("heating rate," "total processing time," "maximum austenitizing temperature," and "material thickness"). EX-1005, 142.

89. I further note that a difference of 1.6% in Al concentration (the difference between 51.4% and 53%) would have been well within manufacturing tolerances for a micron-scale layer in a thin, multi-layer coating. Layers would never be perfectly uniform, and the composition of the layer would be expected to vary from part-to-part and within a given part, e.g., because the composition of an area of measurement can be affected by adjacent areas of different compositions.

90. It follows that the disclosed composition of Engels' phase 3 renders

obvious the claimed composition of the Intermediate layer.

[20]: The hot stamped coated steel product according to claim 19, wherein the Intermetallic layer comprises the following components by weight based on total weight: 62 to 67% Fe, 30 to 34% Al, and 2 to 6% Si.

91. Engels renders obvious the foregoing composition based on its teaching that phase 4 (mapped to the Intermetallic layer; *see* [1g] above) has weight %, by total weight, of 54.3% Fe, 33.9% Al, and 10.6% Si. EX-1005, 143. See above at [18] for citations relevant to this interpretation of Engels' Table.

92. Of these values, the Al% is within the claimed range, while the Fe% and the Si% are outside, but close to, their claimed ranges. For the reasons discussed with respect to [19] above, absent a showing of criticality or unexpected results, the values taught by Engels are sufficient to render obvious the claimed ranges. For example, the '227 Patent fails to describe a "difference in kind and not of degree" resulting from an Fe% of 62% compared to 54.3%, or from a Si% of 6% compared to 10.6%, for a single layer in a four-layer coating. Indeed, based on my professional and academic experience, a POSITA would not have expected there to be any such qualitative difference in properties, as the differences in composition are not greater than many ranges given for nominal steel compositions, which can routinely span 20% or more. *See*, e.g., EX-1047, Table 1.

93. A POSITA would have recognized each of Fe%, Si%, and Al% as

result-effective, for example, based on Engels and common knowledge in the art as set forth for claim 19 above. In addition, a POSITA would have been aware of Takagi's teaching that Fe% is important for determining layer hardness, JP2004244704's disclosure that the Si% is associated with/an indicator of the Al%, and WO02/103073's disclosure that Si% and Al% modulate layer hardness, workability, weldability, and/or corrosion resistance. EX-1016, [0020]; EX-1033, [0012]; EX-1035, 25:21-28, 29:3-7, 31:6-12. These disclosures would have motivated a POSITA to perform routine experimentation in modifying these concentrations.

94. Further, as discussed for [19], Engels discloses various process parameters that determine characteristics of the coating ("heating rate," "total processing time," "maximum austenitizing temperature," and "material thickness"), providing a POSITA a reasonable expectation of success in arriving at the claimed values. EX-1005, 142.

95. Accordingly, Engels renders obvious the claimed composition.

[21]: The hot stamped coated steel product according to claim 20, wherein the Superficial layer comprises the following components by weight based on total weight: 39 to 47% Fe, 53 to 61% Al, and 0 to 2% Si, and wherein said layer (a) has a thickness that is less than half of said thickness of the coating.

96. Engels renders obvious the foregoing composition and thickness. For

a discussion of the thickness element of this claim, *see* [2] above. With respect to the claimed composition, as discussed at [1h], the Superficial layer is mapped to Engels phase 5. Engels' Table discloses that phase 5 has weight composition, by total weight, of **44.1% Fe, 53.2% Al**, and **1.9% Si**. See above at [18] for citations relevant to this interpretation of Engels' Table. Each of these described composition values satisfies the recited range. As such, Engels renders obvious this claim.

[22]: See [19] above.

[23]: See [20] above.

[24]: The hot stamped coated steel product according to claim 1, wherein the hot stamped coated steel product has a mechanical strength in excess of 1000 MPa.

[25]: The hot stamped coated steel product according to claim 1, wherein the hot stamped coated steel product has a mechanical strength in excess of 1500 MPa.

97. Engels discloses or renders obvious the mechanical strengths recited in claims 24 and 25. Engels describes that "hot-stamping of boron-alloyed steels (22MnB5) is used to produce the components mentioned above. These boron steels belong to the group of martensitic steels which stand out for their good hardenability at low cooling rates. They allow **tensile strengths R_m of up to 1600**

MPa." EX-1005, 135.

98. A POSITA would have understood that "tensile strengths Rm of up to 1600 MPa" applies to the part shown in FIG. 5, which features the cited coating. The coating is "of a hot-dip aluminum coated boron steel," a description matching that provided for the "boron steels" such as "22MnB5" with an "Al-Si-coating," which have the described strengths of "up to 1600 MPa." EX-1005, 135-137, 141-142. Moreover, the FIG. 5 coating is not discussed in isolation but, rather, as part of an overall description of the hot-stamping of the same boron-alloyed steels that can have the strengths "up to 1600 MPa."

99. A POSITA would have also understood "tensile strength" to be a type of "mechanical strength." Typically, when referring to the "strength" of a steel, a POSITA would be referring specifically to the tensile strength. I note the '227 Patent's disclosure that "[t]he welding operation should also be performed in such a way that high mechanical resistance is obtained on the weld. This mechanical resistance may be evaluated by tests such as by shear-tensile tests or cross-tensile tests." EX-1001, 2:24-27. This association between "mechanical resistance" and "tensile tests" would have further suggested that a "tensile strength" is an example of a "mechanical strength."

100. Accordingly, although Engels lacks explicit disclosure that FIG. 5 shows a product having strength "up to 1600 MPa," a POSITA would have at one

envisaged that the coating would be found on such a product. Alternatively, a POSITA would have found it obvious to apply the disclosed strengths to the part having the FIG. 5 coating, which is formed on the same steel and processed in the same way as the parts having those strengths.

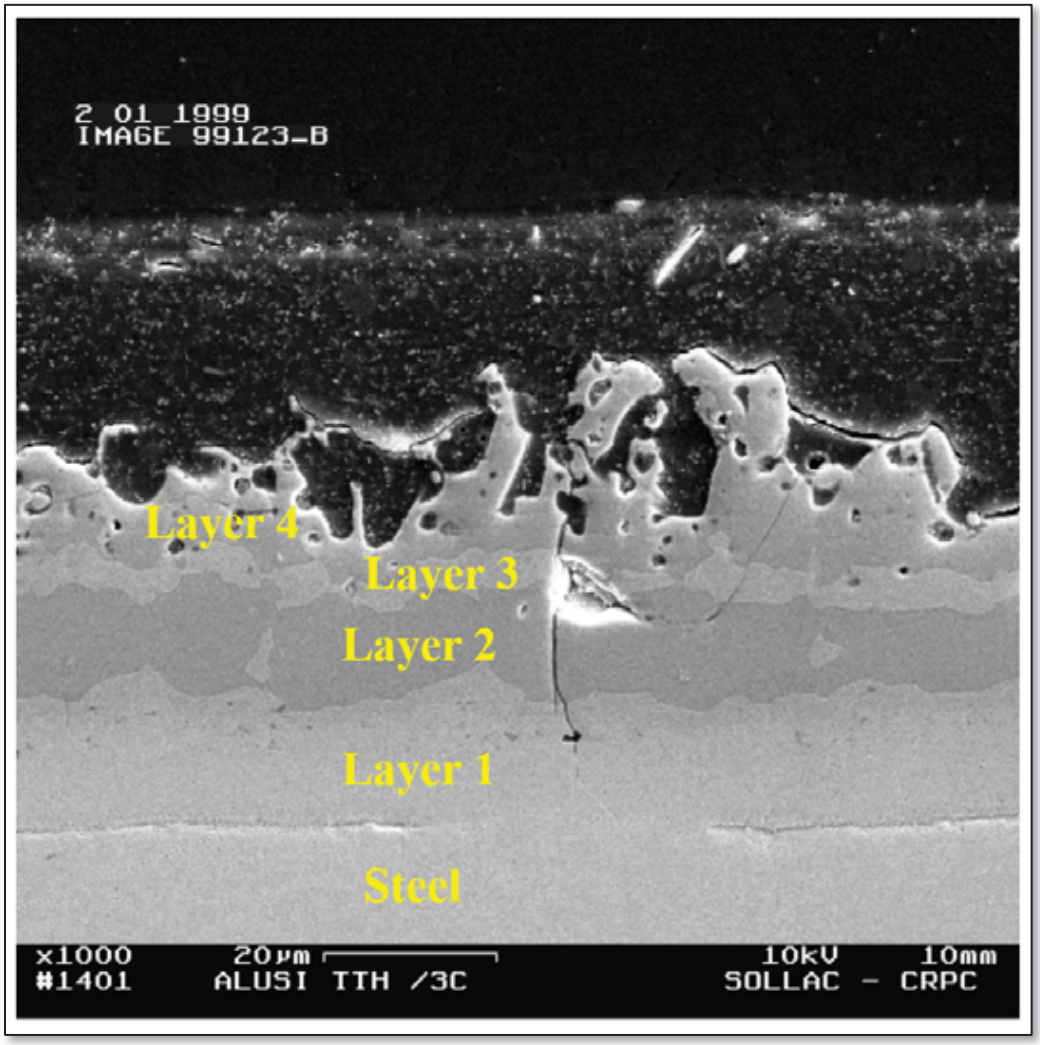
VII. GROUND 1B: Claims 8, 11-14, and 24-25 are obvious over Engels in view of Cornette

A. Cornette

101. Cornette describes "mechanical testing and different design solutions associated with" certain steel grades. EX-1014, 3. "A specific part of [Cornette] deals with a ultra high tensile strength pre-coated boron steel for hot forming." *Id*. Specifically, Cornette describes the use of "USIBOR 1500" steel in a hot-stamping (or "hot forming") process. *Id*., 9. A "hot dipped" aluminum-silicon pre-coating with average thickness 25 µm is applied to the steel, and the pre-coated steel is heated at "generally 900˚C [for] 5 minutes" and hot-stamped to obtain, as a result of an "alloying reaction between substrate [] and the coating," an "Fe-Al-Si layer [] at the steel surface" that is "typically about 40 µm." *Id*., 9.

102. FIG. 22 of Cornette, reproduced below, shows the coating (a "multiphase alloy layer"), in which four distinct layers are visible. *Id*. It would have been clear to a POSITA that these four layers constitute the Fe-Al-Si coating, with an indicated base steel region underneath. The morphology at the top of the

coating (top of indicated layer 4) is representative of a top layer, not of a layer adjacent to base steel. And the coating forms part of a hot-stamped product, for example, for the reasons discussed in the ’683 Patent’s IPR, in which it was found that these layers and the underlying steel form a “stamped product.” EX-1029, 32-35.



Annotated Cornette FIG. 22

B. Combination of Engels and Cornette

103. It would have been obvious to apply Cornette's process-related disclosure to Engels to obtain a coating having layer compositions at least similar to those described by Engels, with the layer thicknesses described by Cornette. Engels describes hot-stamping with heat treatment generally at "temperatures between 900 ˚C and 950 ˚C," and a POSITA would have understood general ranges of other process parameters (e.g., austenitization time, a specific austenitization temperature, and pre-coating thickness) based on general knowledge in the art.

104. To identify specific numerical values of process parameters, a POSITA would have been motivated to consider values used in similar prior art processes such as that of Cornette. It would have been obvious to a POSITA to follow or be generally guided by Cornette's teachings when experimenting with hot-stamping processes, e.g., by using the disclosed "USIBOR 1500" steel and/or by performing a 900˚C austenitization for five minutes using a 25 μm pre-coating. EX-1014, 9-10. As I noted above in Section VI.B, these parameters would have been easily configurable by a POSITA, and a POSITA would have also had access to the disclosed USIBOR 1500, which was commercially available at the time.

105. Moreover, 22MnB5 and USIBOR 1500 have similar compositions, such that the substitution of one for the other would have constituted a minor modification within the general conditions of what was already in use. These

compositions are shown in the table below. EX-1037, Table 1; EX-1014, 9. Indeed, Engels references USIBOR 1500 steel, such that a POSITA would have known that the use of USIBOR 1500 would not represent a notable departure from Engels' teachings. EX-1005, 139.

Element	**22MnB5 Composition (%)**	**USIBOR 1500 Composition (%)**
C	0.233	$0.2 \leq C\% \leq 0.25$
Mn	1.23	$1.1 \leq Mn\% \leq 1.35$
Si	0.24	$0.15 \leq Si\% \leq 0.35$
Cr	0.14	$0.15 \leq Cr\% \leq 0.3$
Ti	0.033	$0.02 \leq Ti\% \leq 0.05$
Al	0.035	$0.02 \leq Al\% \leq 0.06$
P	0.018	--
S	0.001	≤ 0.008
B	0.0022	$0.002 \leq B\% \leq 0.004$
Ni	0.023	--

106. The POSITA would have been further motivated by Cornette's reporting that these parameters provide good results in terms of weldability, corrosion resistance, and mechanical strength. EX-1014, 10.

107. A POSITA would have had a reasonable expectation of success in making the combination. The process parameters noted by Cornette would all have been readily available to a steel metallurgist working on hot-stamping. And the coatings disclosed by Engels and Cornette are quite similar: each includes four primary layers identifiable using electron microscopy (in the case of Engels, five total phases, where the second phase is negligible and/or where the first and second

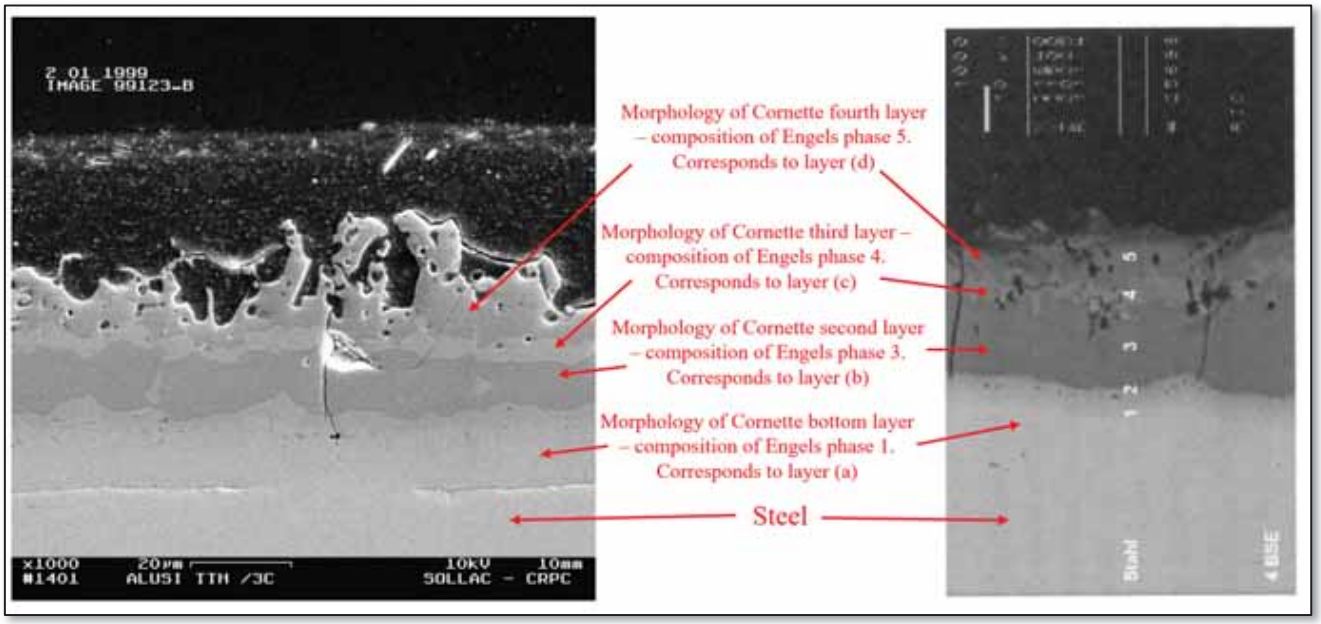
phases together are interpreted as one layer), and each is approximately 40 µm thick (*see* [1j] above). Moreover, Engels' disclosure of using temperatures "between 900 ˚C and 950 ˚C" suggests that Engels' FIG. 5 coating was processed under conditions generally similar to those of Cornette, which discloses thermal treatment at 900 ˚C. EX-1014, 3.

108. And Engels itself provides detailed guidance that "heating rate," "total processing time," "maximum austenitizing temperature," and "material thickness" are all process parameters that can be tuned to achieve a "correctly shaped diffusion layer." EX-1005, 142.

109. Accordingly, it would have been obvious to a POSITA to apply Cornette's teachings to obtain a "**modified Engels coating**" in which the four layers have the thicknesses and morphologies described by Cornette, and compositions like those described by Engels, as shown below. By adjustment of the parameters identified by Engels and guided by Cornette's teachings, a POSITA would have been able to adjust the hot-stamping process to arrive at such a layer as a matter of design choice and routine experimentation, and as an example of a layer that it would have been obvious to try manufacturing and testing, given that there are only a finite number of options for the thicknesses of four layers in the four-primary-layer, approximately 40 µm coating disclosed by both Engels and Cornette.

110. Certainly, layer thickness/morphology and composition may be associated with one another. For example, based on my experience, a POSITA would expect that a given change to austenitization temperature might affect both coating and/or layer thickness **and** the composition of one or more layers, such that a POSITA would have had to exercise care when performing experimentation, e.g., to generally retain a multi-layer structure with target hardness and corrosion resistance. However, this type of optimization was well-established and would have constituted merely routine optimization in the field. I note, for example, Takagi's clear description of how the high-temperature diffusion process proceeds to form a multi-layer coating. EX-1016, [0019].

111. I also note that, in order to satisfy claim 1, the layers of the modified coating need not have **exactly** the same compositions as those disclosed by Engels but, rather, merely "have a different mean composition from one another," as recited in claim 1.



Modified Engels coating

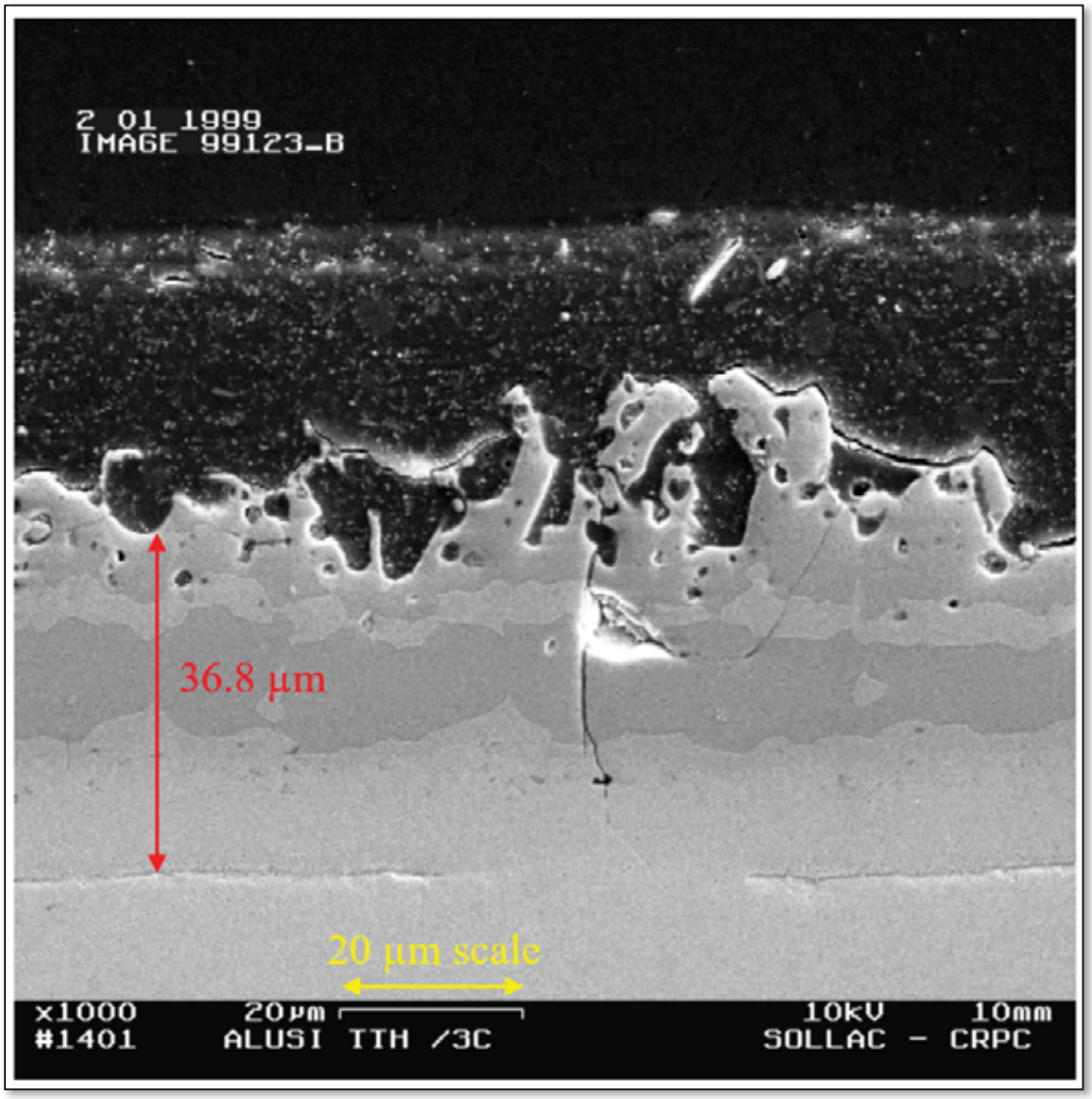
C. Analysis of Claims

[8]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness that is greater than a thickness of layer (b).

112. The Engels-Cornette combination renders obvious that layer (a) has a thickness that is greater than a thickness of layer (b). In the modified Engels coating (discussed in Section VII.B), the four coating layers of FIG. 22, proceeding from the steel outward, correspond to layers (a), (b), (c), and (d), respectively, and have compositions at least similar to phases 1, 3, 4, and 5 of Engels, respectively. A POSITA would expect that the use of USIBOR 1500 steel and/or the use of Cornette's process parameters (or variations thereof based on routine experimentation) to produce the modified Engels coating might result in layer

compositions that differ from those of Engels. For example, higher temperatures and/or longer high-temperature processing might result in increased levels of iron diffusion into the coating. However, in view of the similarities between Engels' and Cornette's coatings, and in view of the at least five different elements forming each of the layers, a POSITA would expect that the layers of the modified Engels coating would differ at least slightly in their compositions in a similar manner to Engels' layers, satisfying claim 1's requirement that "layers (a), (b), (c), and (d) each have a different mean composition from one another."

113. Further, the modified Engels coating has a thickness of "about 40 µm," as confirmed by my below-illustrated measurement of Cornette FIG. 22 (at the measured position, 36.8 µm), thereby satisfying claim 1's requirement that the "coating of the hot stamped coated steel product has a thickness greater than 30 micrometers." EX-1014, 9. A POSITA would have understood that measurements at other positions would result in different measured thicknesses, which would be more or less than 36.8 µm and would be equally valid as the 36.8 µm measurement. This statement also applies to other measured thicknesses of coatings and layers herein.

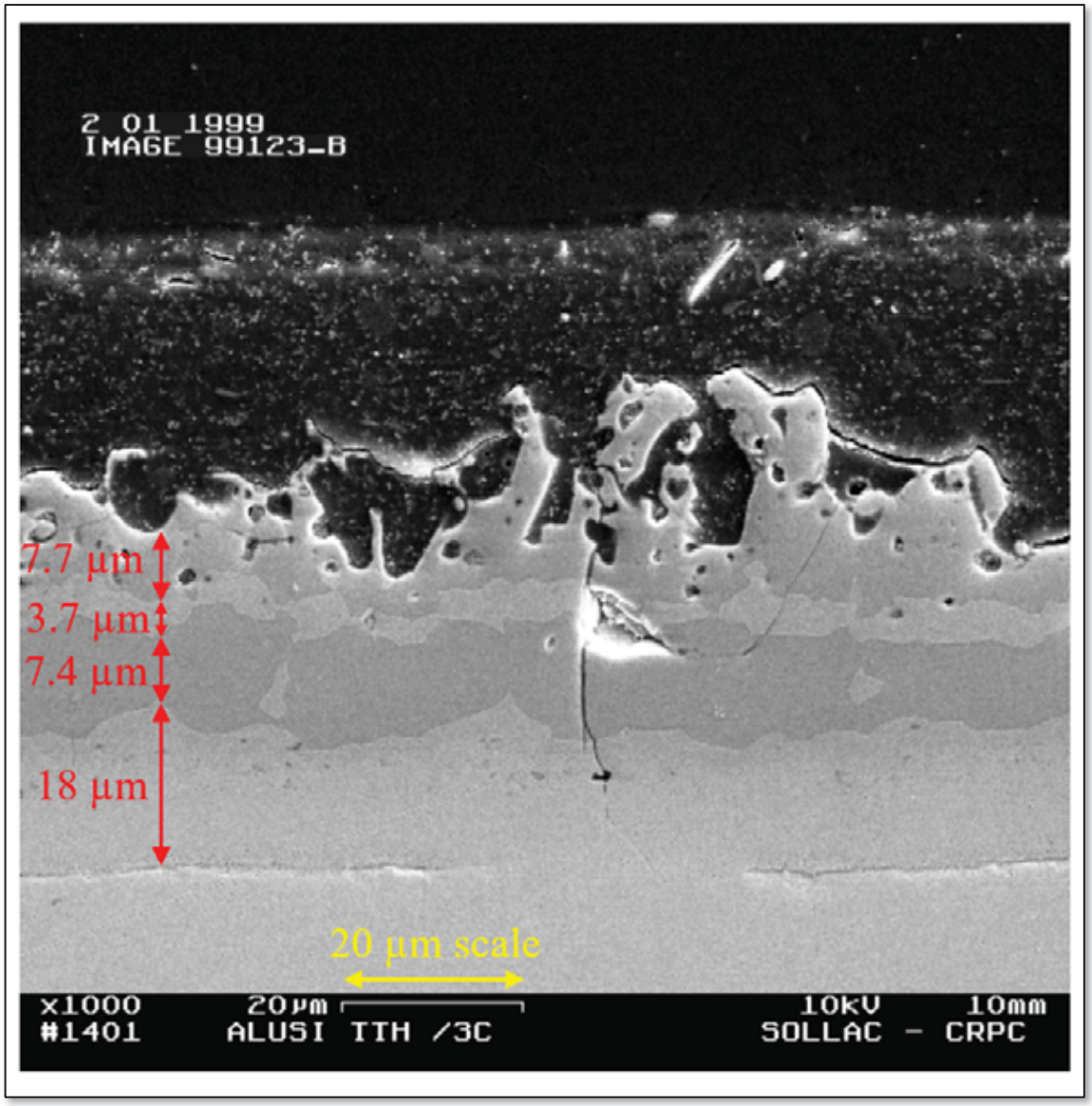


Annotated Cornette FIG. 22

114. The other elements of claim 1 are satisfied as described with respect to claim 1 in Section VI.B.

115. In addition, in the modified Engels coating, the deepest layer (corresponding to layer (a)) has a thickness that is greater than a thickness of the third-deepest layer (corresponding to layer (b)). As shown in annotated Cornette

FIG. 22 below, I performed a measurement based on the included scale and found thicknesses of **18 µm** and **7.4 µm, respectively**, for the layers corresponding to layers (a) and layer (b). Accordingly, the modified Engels coating has a layer (a) thickness that is greater than its layer (b) thickness.



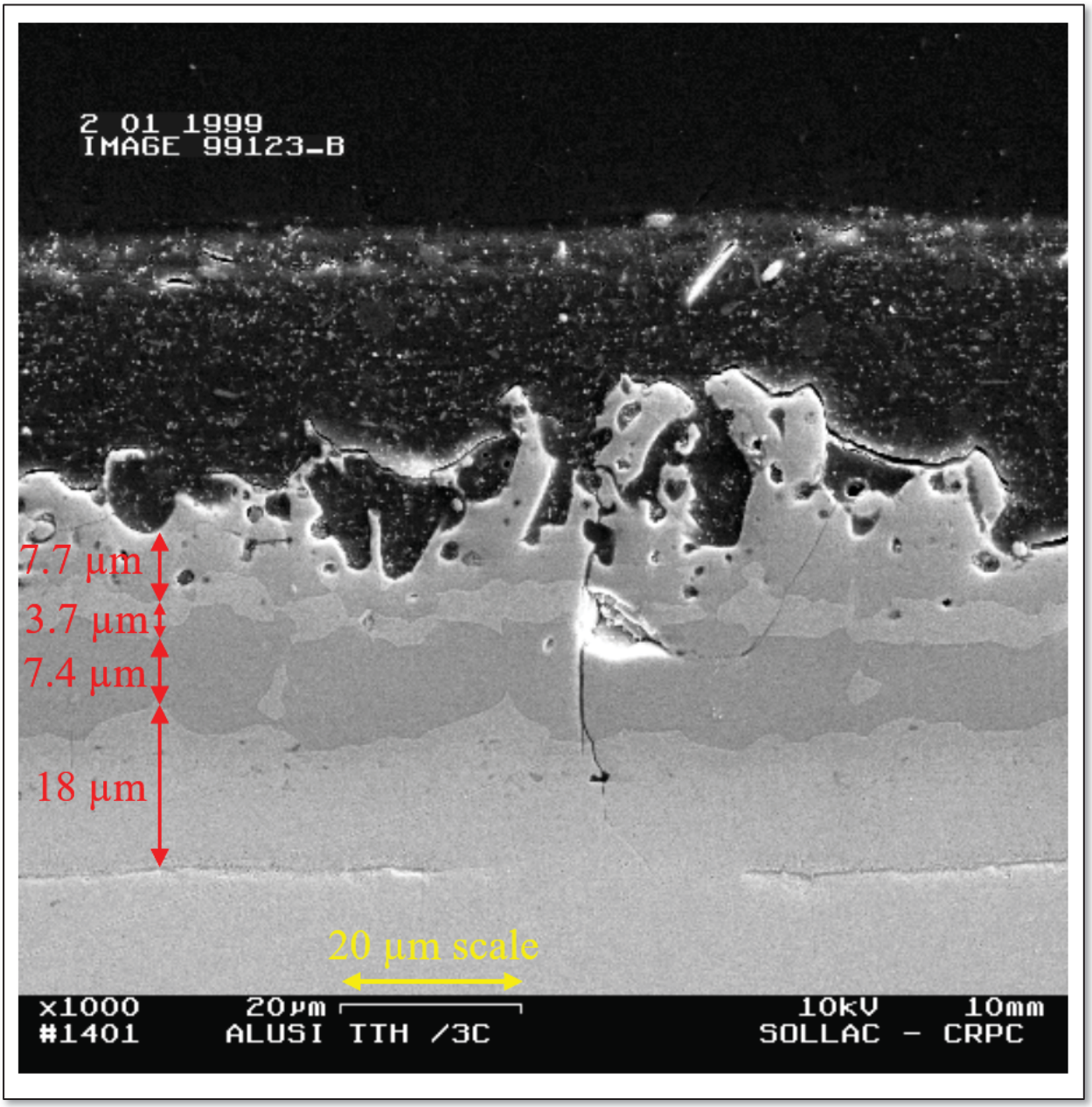
Annotated Cornette FIG. 22

[11]: The hot stamped coated steel product according to claim 1, wherein

layer (a) has a thickness: that is greater than a thickness of layer (b); that is greater than a thickness of layer (c); and that is greater than a thickness of layer (d).

116. The Engels-Cornette combination renders obvious these relative thicknesses. Discussion of how the Engels-Cornette combination satisfies claim 1 is found above with respect to [8].

117. In addition, my below-illustrated measurements in Cornette FIG. 22 indicate that the modified Engels coating has layer thicknesses of **18 µm, 7.4 µm, 3.7 µm, and 7.7 µm, respectively,** proceeding from the base steel outwards. Accordingly, the modified coating has the relative thicknesses recited in this claim.



Annotated Cornette FIG. 22

[12]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness that is more than twice a thickness of layer (b).

118. As discussed with respect to [8] and [11] above, the modified Engels-

Cornette coating has measured thicknesses of **18 µm** and **7.4 µm** for the two layers corresponding to layers (a) and (b), respectively. 18 µm is more than twice 7.4 µm. Accordingly, the Engels-Cornette combination renders obvious this claim.

[13]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness that is more than twice a thickness of layer (c).

119. As discussed with respect to [8] and [11] above, the modified Engels coating has measured thicknesses of **18 µm** and **3.7 µm** for the two layers corresponding to layers (a) and (c), respectively. 18 µm is more than twice 3.7 µm. Accordingly, the Engels-Cornette combination renders obvious this claim.

[14]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness that is more than twice a thickness of layer (d).

120. As part of the obviousness analysis in Section VI.B (Ground 1A-103), Engels renders obvious this claim. Engels' Table teaches that phase 1 (corresponding to layer (a)) has a thickness of 5-9 µm and that phase 5 (corresponding to layer (d)) has a thickness of 5-11 µm. EX-1005, 143. A slight increase in the thickness of phase 1 and/or a slight decrease in the thickness of phase 5 (for example, from 9 µm to 9.5 µm and from 5 µm to 4.5 µm) would result in relative thicknesses satisfying claim 14, achieved as a result of routine experimentation. A POSITA would have been motivated to vary the thicknesses and would have had a reasonable expectation of success in varying the thicknesses

for the reasons discussed in Section VI.B with respect to [6]. Any marginal thickness contributed by phase 2 would not substantively alter this reasoning in the case where layer (a) is mapped to phases 1+2.

121. Alternatively, as discussed with respect to [8] and [11] above, the modified Engels-Cornette coating has measured thicknesses of **18 µm** and **7.7 µm** for the two layers corresponding to layers (a) and (d), respectively. 18 µm is more than twice 7.7 µm. Accordingly, the Engels-Cornette combination renders obvious this claim.

[24]: The hot stamped coated steel product according to claim 1, wherein the hot stamped coated steel product has a mechanical strength in excess of 1000 MPa.

[25]: The hot stamped coated steel product according to claim 1, wherein the hot stamped coated steel product has a mechanical strength in excess of 1500 MPa.

122. The Engels-Cornette combination renders obvious that the hot stamped coated steel product has a mechanical strength in excess of 1000 MPa and 1500 MPa. First, it would have been obvious to use the well-known USIBOR 1500 steel taught by Cornette and referenced in Engels, which, based on my experience, a POSITA would have believed would result in a mechanical strength in excess of 1500 MPa when processed according to the process parameters described by

Engels. EX-1005, 139; EX-1014, 9. I base this opinion on Engel's disclosure of tensile strengths up to 1600 MPa and the knowledge in the art that USIBOR 1500 is called "USIBOR 1500" specifically because the steel can achieve mechanical strength at or in excess of 1500 MPa. EX-1005, 135. The convention for all alloys in the advanced high strength steel (AHSS) category is to use UTS as part of the name. For example, a dual phase steel with nominal UTS of 980 is referred to in the industry as DP 980. A transformation-induced plasticity steel (TRIP) with UTS of 1180 is referred to in the industry as TRIP 1180. Hot stamped boron steels are in the upper range of AHSS alloys, and use the same convention, where the mechanical strength of the material is provided as UTS (e.g., USIBOR 1500).

123. In addition, as discussed in Section VII.B above, it would have been obvious to a POSITA to use the hot-stamping process parameters described by Cornette, including the use of USIBOR 1500 steel. EX-1014, 9. As a result, a POSITA would have arrived at Cornette's "typical values [] obtained after austenitization at 900˚C during 5 minutes and cooling in the die" for "pre-coated boron steel," including an ultimate tensile strength ("UTS") of **1510 MPa**, satisfying the elements of claims 24 and 25. EX-1014, 10. A POSITA would have understood the claims' reference to "mechanical strength" to refer to UTS, or a POSITA would have understood UTS to be an example of a "mechanical strength."

124. Alternatively, a POSITA would have arrived at the mechanical strength in excess of 1500 MPa by using USIBOR 1500 steel and by routine optimization of the austenitization process using the result-effective process parameters identified by Engels and Cornette, including "temperature profile," "[t]ransfer time t_T between furnace and die," "[c]ooling realized according to TTT diagram," and Cornette's disclosed process parameters which "typically" provide a UTS of **1510 MPa**. EX-1005, 141; EX-1014, 10. Indeed, a POSITA would have had a high expectation of success in obtaining the high UTS, in view of the fact that, as noted above, a POSITA would have understood that the name "USIBOR 1500" derives from the tensile strengths of 1500 MPa or higher achievable using the steel.

VIII. GROUND 1C: Claims 3, 8-11, and 18-23 are obvious over Engels in view of Takagi

An overview of Takagi is provided below in Section XII.A.

A. Analysis of claims

[3]: *The hot stamped coated steel product according to claim 1, wherein layer (a) has an HV50g hardness between 290 and 410; layer (b) has an HV50g hardness between 900 and 1000, +/−10%; layer (c) has an HV50g hardness between 580 and 650, +/−10%; and layer (d) has an HV50g harness between 900 and 1000, +/−10%.*

125. Engels in view of Takagi renders obvious the hardness ranges recited in claim 3. Although Engels provides compositions for each of cited phases 1, 3, 4, and 5, as shown below, Engels does not provide hardness values for the corresponding layers.

Phase	Engels Composition	Takagi No. 1 Composition	Takagi No. 4 Composition	Takagi No. 1, 4 Hardness (Hv)	Claimed Hardness (HV50g)
1	7.2 Al% 1.9 Si% 89.2 Fe %	7.7 Al% 2.0 Si% 89.6 Fe%	6.0 Al% 1.5 Si% 90.7 Fe%	310, 280	290 - 410
3	51.4 Al% 1.9 Si% 45.9 Fe%	48.4 Al% 1.2 Si% 50.1 Fe%	51.9 Al% 0.6 Si% 46.8 Fe%	750, 720	810 - 1100
4	33.9 Al% 10.6 Si% 54.3 Fe%	31.6 Al% 5.7 Si% 62.0 Fe%	30.4 Al% 5.3 Si% 63.1 Fe%	700, 690	522 - 715
5	53.2 Al% 1.9 Si% 44.1 Fe%	54.8 Al% 0.8 Si% 44.5 Fe%	47.4 Al% 2.2 Si% 49.8 Fe%	800	810 - 1100

126. However, I am informed that a POSITA generally is understood to have an expectation that compounds similar in structure will have similar properties. In the case of alloyed steels, it is not only the composition but also the thermal history that matters. For example, two materials with the same element composition may exhibit quite different physical properties, e.g., based on different phases formed based on the heating and/or cooling which the materials have undergone. This is why the cooling rate discussed in Section VI.B is important for

establishing a martensitic structure and obtaining desired mechanical strength.

127. In the case of the Engels-Takagi combination, the compositions of Engels' phases and the corresponding layers of Takagi are very similar, as shown in the table above. In addition, the thermal histories of the layers, too, would be similar. Engels describes austenitization at temperatures between 900˚C and 950˚C, followed by "controlled cooling and tempering (martensitic transformation)" according to a "TTT diagram" that a POSITA would understand to dictate the appropriate cooling rate. EX-1005, 136. Takagi's No. 1 and No. 4 samples, meanwhile are austenitized at 920˚C and 950˚C, respectively, and then quenched with a cooling rate in a particular range in order to "promot[e] martensitic transformation sufficiently." EX-1016, [0026], [0028], FIG. 4.

128. Because both the elemental compositions and the thermal histories of the layers of Engels and Takagi are very similar, a POSITA would have expected Engels' phases to have hardnesses similar to those of the corresponding Takagi layers, which themselves are within or similar to the recited hardness ranges of claim 3.

129. Starting with those hardnesses, it would have been obvious to a POSITA to experiment with process parameters of the Engels coating to achieve hardness values in the recited ranges. Engels and Takagi provide a clear roadmap for doing so: Engels describes that properties of the "diffusion layer" (coating)

depend on the "[t]emperature profile" (e.g., "heating rate," "total processing time," "maximum austenitizing temperature," and "material thickness), and Takagi describes (i) how layer hardness depends on Fe composition and (ii) how Fe composition can be controlled "by controlling the raised temperature of the heating and the holding time at the raised temperature." EX-1005, 141-142; EX-1016, [0019]-[0021]. Given this extensive guidance and the close similarities between the layer compositions of Engels and Takagi, it would have been obvious and well within the skill of a POSITA to obtain the recited hardness values by routine experimentation, for example, by experimenting with the thermal parameters identified by Engels guided by Takagi's more-specific temperature disclosures.

130. Further, the art recognizes layer hardness as an important parameter to be optimized. For example, Takagi describes the importance of having a "thick soft layer" near the base steel to "prevent[] cracks" , and also the importance of having a "hard outermost layer [] for maintaining good contact with a welding gun in spot welding." EX-1016, [0017], [0024]. Other art, too, recognizes the importance of hardness values of specific layers within a coating: FR2833504 describes the benefit of a "hardness gradient" in the "alloy layer" for "giv[ing] the part increased fatigue resistance," and WO02/103073 describes the benefit of including a "soft ferrite layer" in the alloy coating at the interface between the coating and the base steel. EX-1025, 6:11-15; EX-1035, 24:25-35:20. And, indeed, the understanding

that hardness in a surface coating would be an important characteristic to be optimized would have been generally understood by steel researchers.

131. Accordingly, a POSITA would have been motivated to experiment with the layer hardnesses as discussed above, for example, by trying Takagi's hardness values and values similar to Takagi's hardness values, to arrive at hardness values in the recited ranges.

132. As discussed below in Section XII.E, this reasoning holds despite Takagi's lack of disclosure of the load used for measuring hardness.

[8], *[9]*, *[10]*, *[11]*:

133. Although Takagi generally does not disclose thicknesses for the individual layers of Takagi's coating, Takagi describes that it is advantageous for the coating to include an inner "soft layer" having a "thickness [] equal to or greater than 50% of the total thickness of the alloy coating layer," this "thick soft layer extending from a level at or near the boundary with the steel substrate, to or beyond the middle in the depth of the coating layer is effective for preventing progress of crack and securing sufficient corrosion resistance." EX-1016, [0017].

134. It would have been obvious for a POSITA to apply Takagi's teachings to Engels to cause Engels' corresponding innermost layer – phase 1 – to have a thickness at least 50% of the thickness of the entirety of Engels' coating. For example, according to Takagi Table 1, each of Takagi's Nos. 1, 4 and 5 have an

innermost layer satisfying this condition (as indicated by the "SOFTER RANGE" column), and a POSITA would have been motivated to try applying Takagi's corresponding temperatures and hold times to obtain a similarly-proportioned inner layer in Engels' coating. EX-1016, Table 1. Elsewhere, Takagi discloses other detailed process parameters, including heating rate, forming temperature, and cooling rate. EX-1016, [0026]-[0027], [0037]. Further, Takagi includes extensive discussion of the physical mechanisms underlying the formation of the thick, soft innermost layer, which, together with the specific disclosed process parameters, would have provided a POSITA with a reasonable expectation of success in making the modification.

135. Engels' coating, modified such that phase 1 or 1+2 has a thickness at least 50% of the thickness of the coating, satisfies each of claims 8 through 11, such that these claims are obvious.

[18]: The hot stamped coated steel product according to claim 1, wherein the Interdiffusion layer comprises the following components by weight based on total weight: 86 to 95% Fe, 4 to 10% Al, and 0 to 5% Si.

[19]: The hot stamped coated steel product according to claim 18, wherein the Intermediate layer comprises the following components by weight based on total weight: 39 to 47% Fe, 53 to 61% Al, and 0 to 2% Si.

[20]: The hot stamped coated steel product according to claim 19, wherein

the Intermetallic layer comprises the following components by weight based on total weight: 62 to 67% Fe, 30 to 34% Al, and 2 to 6% Si.

[21]: The hot stamped coated steel product according to claim 20, wherein the Superficial layer comprises the following components by weight based on total weight: 39 to 47% Fe, 53 to 61% Al, and 0 to 2% Si, and wherein said layer (a) has a thickness that is less than half of said thickness of the coating.

[22]: The hot stamped coated steel product according to claim 1, wherein the Intermediate layer comprises the following components by weight based on total weight: 39 to 47% Fe, 53 to 61% Al, and 0 to 2% Si.

[23]: The hot stamped coated steel product according to claim 22, wherein the Intermetallic layer comprises the following components by weight based on total weight: 62 to 67% Fe, 30 to 34% Al, and 2 to 6% Si.

136. Engels in view of Takagi renders obvious the layer compositions recited in claims 18-23. As discussed in Section VI.B, Engels' phase 1 and 5 compositions directly teach the recited compositions of the Interdiffusion and Superficial layers, while Engels' phases 3 and 4 render obvious the recited compositions of the Intermediate and Superficial layers.

137. For example, Engels' phase 4, which corresponds to the recited "Intermetallic layer," has weight %, by total weight, of 54.3% Fe, 33.9% Al, and 10.6% Si. EX-1005, 143. Of these, the Al% satisfies claim 20, while the Fe% and

Si% are close to, but outside, the recited ranges.

138. Takagi describes that several hot-stamped coatings, including No. 1 and 4, provide desirable formability, corrosion resistance, and weldability. EX-1016, Table 1. Takagi associates these advantages with certain layer characteristics, including innermost layer hardness and thickness, intermediate layer Al%, and outermost layer Fe%. EX-1016, [0017]-[0025].

139. Takagi's Inner, Inter 2, Inter 3, and Outer layers are similar to Engels' phases 1, 3, 4, and 5, respectively, based on layer-by-layer comparisons of Takagi's and Engels' layers, as discussed above in Section VI.B. Each also have the same positioning in a five-layer coating. For example, Engels' phase 4 and Takagi's Inter 3 are each the second-shallowest layer in a five-layer coating. Thus, a POSITA would have applied Takagi's teachings for the Inner, Inter 2, Inter 3, and Outer layers to Engels' phases 1, 3, 4, and 5.

140. For at least these reasons, it would have been obvious to optimize the composition of Engels' phases 1, 3, 4, and/or 5 (that is, to modify one, multiple, or all of those compositions) to that of the corresponding layers of Takagi's Nos. 1 and 4 coatings, to achieve the formability, corrosion resistance, and weldability benefits associated with the No. 1 and 4 coatings. As Takagi notes, these benefits are directly associated with the compositions of the layers of the coatings, such that a POSITA would have been motivated to obtain the same or similar compositions.

EX-1016, [0020]-[0025]. Further, as discussed in this section with respect to claims 3 and 8-11, this modification would have constituted merely discovery of the optimum composition by routine experimentation, with a reasonable expectation of success based on Takagi's extensive teachings of the relevant parameters to adjust (e.g., "the raised temperature of the heating and the holding time at the raised temperature" and "heating rate") and the close similarities between Takagi's and Engels' processes and coatings. EX-1016, [0019], [0026]. This optimization would have constituted no more than experimentation within the general conditions already disclosed by Engels. For example, as shown in the table below, the layer compositions are similar to one another.

Phase/ Layer	Engels Composition	Takagi No. 1 Composition	Takagi No. 4 Composition
1 / Inner	7.2 Al% 1.9 Si% 89.2 Fe%	7.7 Al% 2.0 Si% 89.6 Fe%	6.0 Al% 1.5 Si% 90.7 Fe%
3 / Inter 2	51.4 Al% 1.9 Si% 45.9 Fe%	48.4 Al% 1.2 Si% 50.1 Fe%	51.9 Al% 0.6 Si% 46.8 Fe%
4 / Inter 3	33.9 Al% 10.6 Si% 54.3 Fe%	31.6 Al% 5.7 Si% 62.0 Fe%	30.4 Al% 5.3 Si% 63.1 Fe%
5 / Outer	53.2 Al% 1.9 Si% 44.1 Fe%	54.8 Al% 0.8 Si% 44.5 Fe%	47.4 Al% 2.2 Si% 49.8 Fe%

141. The resulting modified phases 1, 3, 4, and/or 5 would satisfy or render obvious claims 18-23, as discussed in Section XII.E. For the thickness element of

[21], *see* [2] and [21] in Sections VI.B and XII.E.

IX. GROUND 1D: Claims 15-17 are obvious over Engels in view of Hein

An overview of Hein is provided below in Section XII.B.

A. Analysis of claims

[15]: The hot stamped coated steel product according to claim 1, wherein the hot stamped coated steel product is fully martensitic.

142. The combination of Engels and Hein renders obvious that the hot stamped coated steel product is fully martensitic. As discussed above in Section VI.B, Engels discloses the benefits of a "martensitic transformation" and alone renders obvious claim 15. EX-1005, 136. Hein provides additional teachings relevant to claim 15, disclosing that the "martensitic transformation" is obtained with a "cooling speed between 50˚C/s and 100˚C/s." EX-1019, 164. This disclosure would have reinforced the reasonable expectation of success of a POSITA in achieving a "fully martensitic" structure from Engels' "martensitic" structure, thereby further rendering obvious claim 15.

[16]: The hot stamped coated steel product according to claim 1, wherein the base steel consists of the following components by weight based on total weight: 0.15%<carbon<0.5%; 0.5%<manganese<3%; 0.1%<silicon<0.5%; 0.01%<chromium<1%; titanium<0.2%; aluminum<0.1%; phosphorus<0.1%; sulfur<0.05%; 0.0005%<boron<0.08%; a remainder being iron and impurities

inherent in processing.

[17]: The hot stamped coated steel product according to claim 1, wherein the base steel consists of the following components by weight based on total weight: 0.15%<carbon<0.25%, 0.8%<manganese<1.8%, 0.10%<silicon<0.35%, 0.01%<chromium<0.5%, titanium<0.1% aluminum<0.1% phosphorus<0.1% 0.002%<boron<0.005%, a remainder being iron and impurities inherent in processing.

143. Hein discloses the use of a specific steel ("Usibor 1500 P") that provides "numerous" "technical and economic advantages," including "an ultimate tensile strength of 1400 MPa to 1600 MPa." EX-1019, 164-165. A POSITA would have found it obvious to use this steel as the steel of Engels' hot-stamped product in order to achieve these advantages and for reasons discussed in Section VII.B.

144. As shown in the table below, Hein's proportions entirely satisfy or overlap with the ranges recited in claims 16-17, rendering those ranges obvious. I am advised that, absent criticality (which has not been alleged or demonstrated here), ranges which overlap or lie within ranges disclosed by the prior art are obvious. That condition certainly applies here. I note that Hein does not explicitly disclose Al%, P%, and S%; a POSITA would have interpreted this as a disclosure of a small amount or none of Al, P, and S, i.e., a range encompassing 0% for each, within the claimed ranges. Further, Hein's disclosure of using "coated boron **steel**"

would have been understood by a POSITA as disclosing that the remainder of the material would be composed of iron and any trace impurities, iron being the primary component of steel. EX-1019, 164. The obviousness of these compositions is further corroborated, e.g., by EX-1050, Table 1.

Element	[16] composition	[17] composition	Hein composition
C	0.15% < C < 0.5%	0.15% < C < 0.25%	C ≤ 0.25%
Mn	0.5% < Mn < 3%	0.8% < Mn < 1.8%	Mn ≤ 1.4%
Si	0.1% < Si < 0.5%	0.10% < Si < 0.35%	Si ≤ 0.35%
Cr	0.01% < Cr < 1%	0.01% < Cr < 0.5%	Cr ≤ 0.3%
Ti	Ti < 0.2%	Ti < 0.1%	Ti ≤ 0.05%
Al	Al < 0.1%	Al < 0.1%	[none (satisfied)]
P	P < 0.1%	P < 0.1%	[none (satisfied)]
S	S < 0.05%	S < 0.05%	[none (satisfied)]
B	0.0005% < B < 0.08%	0.002% < B < 0.005%	B ≤ 0.005%
Remainder	"iron and impurities inherent in processing"	"iron and impurities inherent in processing"	iron (implicit)

X. GROUND 1E: Claim 15 is obvious over Engels in view of Vaissiere

A. Vaissiere

145. Vaissiere is a technical paper describing "[t]he development of the pre-coated boron steel associated with the hot stamping." EX-1021, 3. Among other guidance for obtaining an "increase of the mechanical properties," Vaissiere describes that "[t]he critical [minimum] quenching speed enabling a **completely martensitic structure** [] is 27˚C/s." *Id.*, 3, 6.

B. Combination of Engels and Vaissiere and Analysis of *[15]:*

[15]: The hot stamped coated steel product according to claim 1, wherein the hot stamped coated steel product is fully martensitic.

146. It would have been obvious to a POSITA to apply Vaissiere's teachings to the steel part of Engels to obtain a "*fully martensitic*" structure. Engels itself motivates such a structure, describing that "martensitic steels [] stand out for their good hardenability" and that "controlled cooling and tempering (martensitic transformation) of the material takes place, resulting in a respective increase in strength." EX-1005, 135, 136. As such, given that Vaissiere discloses the condition for obtaining such a structure (a "critical quenching speed [of] 27˚C/s" and the use of "pre-coated USIBOR 1500" steel which is "optimized for the stability of its quenchability"), and given that this accords with Engels' disclosure that "cooling" influences the "[m]echanical properties" of a hot-stamped part, it would have been obvious for a POSITA to optimize the cooling speed (e.g., trying a cooling speed of at least 27˚C/s) to obtain the "**completely martensitic structure**," "**pure martensite**," and "**totally martensitic structure**" described by Vaissiere. EX-1021, 5-6, 9. This optimization and combination would have entailed no more than application of Vaissiere's known technique to Engels.

147. Further, a POSITA would have understood the desirability of obtaining a fully martensitic structure. *See*, e.g., EX-1023, 3:60-4:17; EX-1014, 5;

EX-1021, 9.

XI. GROUND 1F: Claims 16-17 are obvious over Engels in view of Laurent

A. Laurent

148. Laurent describes "steel sheet[s]" having compositions that "ensur[e] a very high mechanical resistance after thermal treatment." EX-1023, 1:47-62. In more detail, Laurent discusses various elemental components of the steel and how those components improve performance of the steel. *Id*., 4:18-33. Laurent further notes that components of the steel "allow hardening in the stampers" and that the "mechanical characteristics [] of the sheet [] allow [] a deep stamping." *Id*., 2:50, 4:30. Laurent's references to "stamping," "hardening in the stampers," "hot-shaping," and description of controlled heating and cooling would have suggested to a POSITA that the disclosed steel is well-suited for hot-stamping processes. EX-1023, 1:45, 3:60-4:9, 4:29, 4:49.

B. Combination of Engels and Laurent and Analysis of [16] and [17]

[16]: The hot stamped coated steel product according to claim 1, wherein the base steel consists of the following components by weight based on total weight: 0.15%<carbon<0.5%; 0.5%<manganese<3%; 0.1%<silicon<0.5%; 0.01%<chromium<1%; titanium<0.2%; aluminum<0.1%; phosphorus<0.1%; sulfur<0.05%; 0.0005%<boron<0.08%; a remainder being iron and impurities inherent in processing.

[17]: The hot stamped coated steel product according to claim 1, wherein the base steel consists of the following components by weight based on total weight: 0.15%<carbon<0.25%, 0.8%<manganese<1.8%, 0.10%<silicon<0.35%, 0.01%<chromium<0.5%, titanium<0.1% aluminum<0.1% phosphorus<0.1% 0.002%<boron<0.005%, a remainder being iron and impurities inherent in processing.

149. It would have been obvious to a POSITA to use the steel compositions of Laurent in the hot-stamping process described by Engels. This would have constituted no more than substitution of one element (the Laurent steel) for another (the "22MnB5" steel of Engels) known in the field. EX-1005, 135, 141, 149. A POSITA would have been motivated at least by Laurent's discussion of the advantages of such a steel and the specific advantages of the particular elements and concentrations of the elements of the steel, as noted in Section XI.A.

150. As shown in the table below, 22MnB5 and Laurent's steel have generally similar compositions, such that the substitution of one for the other would have constituted a minor modification within the general conditions of what was already in use. EX-1037, Table 1; EX-1023, 1:66-2:10.

Element	22MnB5 Composition (%)	Laurent Composition (%)
C	0.233	0.20% < C < 0.5%
Mn	1.23	0.8% < Mn < 1.5%
Si	0.24	0.1% < Si < 0.35%
Cr	0.14	0.01% < Cr < 1%
Ti	0.033	Ti < 0.1%
Al	0.035	Al < 0.1%
P	0.018	P < 0.05%
S	0.001	S < 0.03%
B	0.0022	0.0005% < B < 0.01%
Ni	0.023	--

151. The "preferabl[e]" "steel composition by weight" of Laurent satisfies or renders obvious each of the recited compositions of claims 16 and 17, as shown in the below chart, illustrating that there was nothing new about the compositions recited in claims 16 and 17. EX-1001, 1:50-53.

Element	**[16] composition**	**[17] composition**	**Laurent composition** (col.2)
C	0.15% < C < 0.5%	0.15% < C < 0.25%	0.20% < C < 0.5%
Mn	0.5% < Mn < 3%	0.8% < Mn < 1.8%	0.8% < Mn < 1.5%
Si	0.1% < Si < 0.5%	0.10% < Si < 0.35%	0.1% < Si < 0.35%
Cr	0.01% < Cr < 1%	0.01% < Cr < 0.5%	0.01% < Cr < 1%
Ti	Ti < 0.2%	Ti < 0.1%	Ti < 0.1%
Al	Al < 0.1%	Al < 0.1%	Al < 0.1%
P	P < 0.1%	P < 0.1%	P < 0.05%
S	S < 0.05%	S < 0.05%	S < 0.03%
B	0.0005% < B < 0.08%	0.002% < B < 0.005%	0.0005% < B < 0.01%
Remainder	"iron and impurities inherent in processing"	"iron and impurities inherent in processing"	"iron and impurities inherent in processing"

152. For each element, the Laurent composition either exactly matches, falls fully within, or overlaps substantially with the compositions of claims 16 and 17, thereby rendering obvious those compositions.

XII. GROUND 2A: Claims 1-25 are obvious over Takagi in view of Hein and GMW14400

A. Takagi

153. Takagi is a patent application publication directed to steel parts with "Al-Si-Fe alloy layer[s]." EX-1016, [0005]. As described by Takagi, "a heat resisting hot-dip aluminum-coated steel sheet containing Si in a coating layer is heated at a rate of 1-10° C./sec to a temperature in the temperature range of 900-950° C., and held at that raised temperature for a holding time (or duration) of 2-8 minutes." *Id*., [0026]. "After the heat treatment for holding in the abovementioned

temperature range, the steel sheet is carried from a heating furnace to a forming press." *Id*., [0027]. "The forming operation into a desired shape is started in the temperature range of 700-800° C. After the forming operation, the shaped sheet is cooled rapidly." *Id*., [0028]. A POSITA would have understood that this process – heating, forming while hot, and rapid cooling – is a hot-stamping process as disclosed in the '227 Patent.

154. Takagi describes that "[d]uring the growth of the Al-Si-Fe alloy layer by the heat treatment, mutual diffusion between Al coating and steel substrate layer produces various Al-Si-Fe ternary intermetallic compounds []. The Al-Si-Fe alloy layer formed by the heat treatment has a layered structure made up of these intermetallic compounds, and offers advantages of formability, corrosion resistance and weldability." EX-1016, [0016]. Table 1 of Takagi provides manufacturing methods, compositions, and hardness values for multiple layers of coatings obtained using five different combinations of temperature and hold time. Nos. 1 and 4 in Table 1 are coatings having five distinct layers.

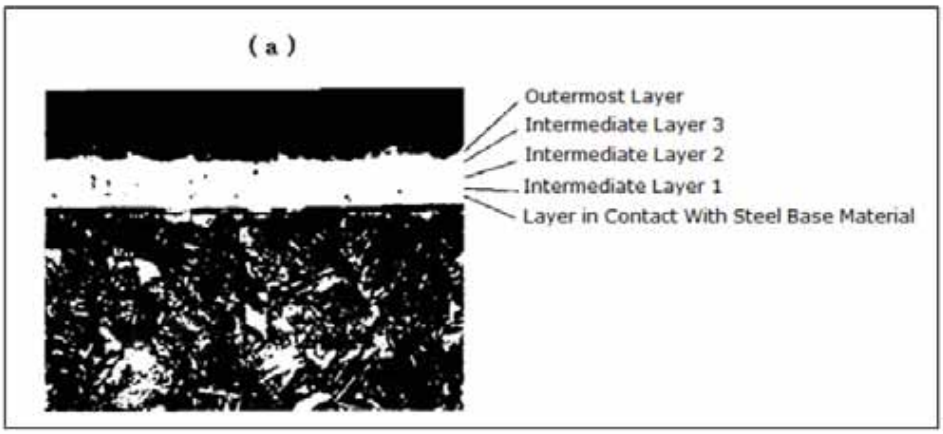
Coatings with five layers

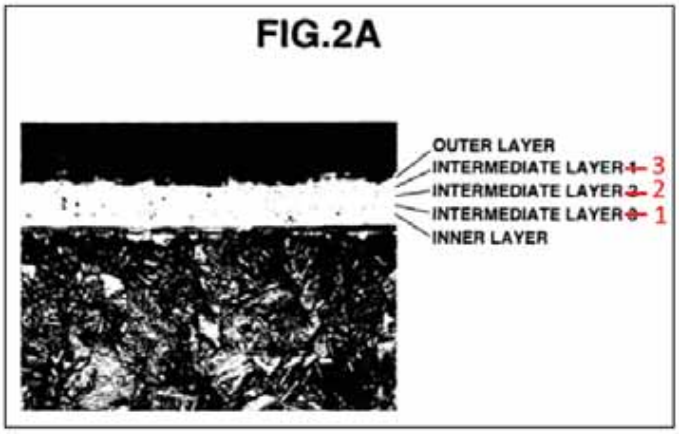
TABLE 1

No.	PRODUCTION		COATING LAYER STRUCTURE & COMPOSITION (%)						STEEL BASE HARDNESS (Hv)	COATING LAYER HARDNESS (Hv)			OXIDE WEIGHT (mg/dm²)	FORMABILITY	CORROSION RESISTANCE	WELDABILITY
	RAISED TEMPERATURE (°C)	HOLD TIME (min.)	COMPONENT & HARDNESS	INNER	INTER 1	INTER 2	INTER 3	OUTER		SOFTEST	AVERAGE	SOFTER RANGE (%)				
1	920	3	Al	7.7	31.0	48.4	31.6	54.8	450	310	415	51	300	○	○	○
			Si	2.0	3.9	1.2	5.7	0.8								
			Fe	89.6	65.9	50.1	62.0	44.5								
			Hv	310	360	750	700	800								
2	900	2	Al	27.2	48.4	31.6	—	54.9	415	380	455	22	275	×	○	○
			Si	4.1	1.2	5.7		0.8								
			Fe	67.2	50.1	61.9		44.1								
			Hv	380	760	720	—	810								
3	930	10	Al	9.4	—	—	—	11.6	400	305	385	78	550	○	×	×
			Si	1.3				1.8								
			Fe	88.4				85.7								
			Hv	305	—	—	—	410								
4	950	5	Al	6.0	27.8	51.9	30.4	47.4	440	280	400	59	385	○	○	○
			Si	1.5	4.3	0.6	5.3	2.2								
			Fe	90.7	66.7	46.8	63.1	49.8								
			Hv	280	340	720	690	800								
5	900	4	Al	3.2	54.5	33.4	—	54.5	440	300	410	56	335	○	○	○
			Si	0.4	2.5	15.3		6.8								
			Fe	94.3	42.7	51.4		38.4								
			Hv	300	740	700	—	810								

Annotated Takagi Table 1

155. In Table 1, layers Inner, Inter 1, Inter 2, Inter 3, and Outer are arranged from the base steel outwards in that order. Takagi FIG. 2A erroneously shows the opposite order for intermediate layers 1, 2, and 3. FIG. 2(a) of the original Japanese patent filing, JP3738754, shows the correct order, which accords with the order in which the layers are presented in Table 1 and with Takagi's discussion of the soft inner layer. EX-1018. Especially in view of the descriptions relating to the soft inner layer, a POSITA would have recognized that Takagi's FIG. 2A represents a clear error. The translated drawing from the JP filing, along with a corrected version of the US publication, are shown below.





Top: translation of FIG. 2(a) of JP3738754
Bottom: corrected FIG. 2A of Takagi

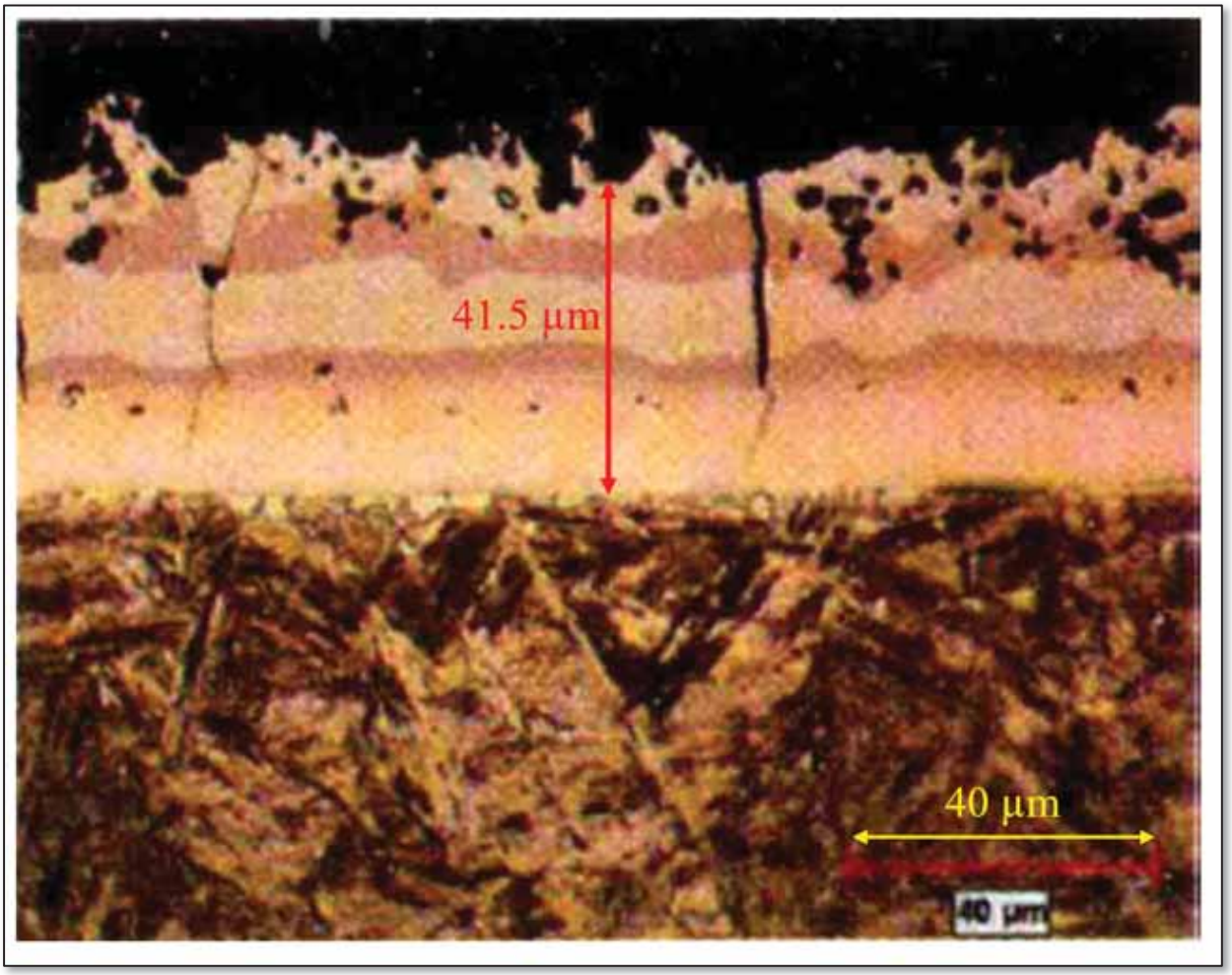
B. Hein

156. Hein is an article titled "Hot Stamping of USIBOR 1500 P: Part and Process Analysis Based on Numerical Simulation." Hein describes the use of "Usibor 1500 P," a "precoated boron steel, with a metallic coating of aluminium-silicon [] of approximately 25 µm/side." EX-1019, 164. The steel is "hot-stamp[ed]" by "heating blanks until complete austenitization (900°C to 950°C, during 4 to 10 minutes)" and "transferr[ing] very quickly on a press for the

stamping." *Id*., 163. "The quenching [] is carried out just after the forming, the heat being absorbed by the closed die (cooling speed between 50°C/s and 100°C/s). The total cycle time (transfer + stamping+ cooling in the die) lies today between 15 s and 25 s." *Id*., 164. "During the heat treatment in the furnaces, this protective coating is transformed into an alloyed layer made of Fe-Al-Si, [] highly adherent on the substrate and with good corrosion properties." *Id*., 165.

157. Hein FIG. 4 shows the "[s]tructure of the alloyed layer Al-Fe-Si after hot-stamping." EX-1019, 165.[2] Five layers can be distinguished based on comparison of shading and tone. The included 40 µm scale in this figure permits the calculation of exact thicknesses for the coating as a whole and for each layer. For example, my measurements indicate, for at least one possible measurement point, a total coating thickness of 41.5 µm.

[2] Measurements and depictions of Hein FIG. 4 in this Declaration are drawn from EX-1020, a higher-resolution color version of EX-1019, in German.



Annotated Hein FIG. 4

C. GMW14400

158. GMW14400 is a material specification published by General Motors and designed to inform steel makers of the requirements of steel to be used in GM vehicles. Steel manufacturers were required to follow this specification to supply vehicle parts to GM. The specification "covers the requirements for low carbon, heat-treatable boron steel used in the manufacture of structural parts requiring heat treatments to achieve high strength." EX-1026, 1. "Part sections [] supplied under

this standard shall be made by austenitizing a pre cut blank, hot stamping the heated blank and rapid cooling (quenching) the stamped part in the die or via water quenching." *Id*.

159. GMW14400 requires that the Al-Si pre-coating "[p]rior to hot-stamping" have a thickness of "20 to 33" µm, and that the coating thickness "[f]ollowing hot-stamping" be ">35" µm. EX-1026, 7. I note that this pre-coating thickness range **exactly matches** the target pre-coating thickness range disclosed by the '227 Patent. EX-1001, 5:12-19. GMW14400 also requires a certain chemical composition of the base steel. *Id*., 2.

D. Combination of Takagi, Hein, and GMW14400

160. Takagi describes a pre-coating thickness of 10-20 µm. EX-1016, [0035]. A POSITA would have expected a thickness increase with heat treatment on the order of about "50%." EX-1025, 5:17-20. This would have agreed with intuitive reasoning for a researcher: as elements diffuse from and/or to the pre-coating, the coating will tend to become thicker. As a result, using a 20 µm pre-coating a POSITA would have expected Takagi to obtain a coating of 30 µm or more. GMW14400 corroborates this analysis, with GMW14400 using a 20-33 µm pre-coating to obtain a coating > 35 µm. EX-1026, 7. Takagi does not disclose a specific numerical value for thickness after heat treatment.

161. Given GMW1400's disclosure, and motivated at least by market

demand, a POSITA would have found it obvious to implement Takagi's coating thickness to meet GMW1400's specification, adjusting parameters (e.g., pre-coating thickness and heat treatment parameters) as needed. Such adjustments would have been well within the skill of POSITA and would have been achievable with a reasonable expectation of success.

162. It would have been quite typical for a researcher in industry or academia to review standards such as GMW14400 to learn about industrial objectives and steel processing, for example, in order to guide internal design and research. Based on GMW14400's requirements, a POSITA would have sought to form a hot-stamped coating with a thickness greater than 35 µm.

163. In pursuit of this goal, the POSITA would have identified Hein as teaching process parameters that, when employed in hot-stamping, produce a coating having a thickness of approximately 40 µm, satisfying the > 35 µm requirement of GMW14400. And, based on this disclosure, the POSITA would have found it obvious to try modifying Takagi's processes based on Hein's and/or GMW1440's process parameters in order to obtain such a coating. In addition, independent of the teachings of GMW14400, a POSITA would have been motivated by Hein's disclosure that Hein's steel and process parameters provide benefits including high tensile strength and yield strength, a lack of springback, and a "highly adherent" coating with "good corrosion properties." EX-1019, 164-

165. Such modifications would have entailed nothing more than applying Hein's and GMW14400's known techniques and parameters to Takagi to obtain a predictable result.

164. For example, while Takagi describes a pre-coating thickness of 10-20 µm, the POSITA would have found it obvious to try a pre-coating thickness of "25 µm/side" as described by Hein, and to try a pre-coating thickness range of "20 to 33" µm as described by GMW14400. EX-1019, 164; EX-1026, 7. The POSITA would have also been aware of a direct correlation between pre-coating thickness and coating thickness, e.g., as indicated by FR2833504's disclosure that alloying of a pre-coating "generally corresponds to a 50% increase" in thickness for the resulting coating. EX-1025, 5:17-20. And the POSITA would have recognized that pre-coating and coating thickness were result-effective variables, e.g., as taught by Engels, by GMW14400, and by JP2004244704's disclosure that "[a] thickness of 20 µm or more [of pre-coating] is preferred because a thicker layer responsible for corrosion resistance results in greater overall corrosion resistance and a longer material life." EX-1005, 142; EX-1034, [0013].

165. The POSITA would also have found it obvious to try varying the pre-coating composition, e.g., by trying the 90 Al% aluminum-silicon pre-coating described by Hein and the 85-95 Al% aluminum-silicon coating bath described by GMW14400. EX-1019, 164; EX-1026, 6. The POSITA would have been

motivated at least by Takagi's disclosure that the silicon proportion in the pre-coating can be varied over a range of 3% to 11% (such that the POSITA would have been motivated to identify the optimum Si% within that range), and Takagi's disclosure that the Al% in the resulting coating is highly determinative of the coating's adhesion and corrosion resistance. EX-1016, [0013], [0021].

166. The POSITA would also have found it obvious to try varying the base steel, e.g., by trying a steel having the compositions disclosed by GMW1440 and by trying the USIBOR 1500 steel disclosed by Hein, which satisfies or approximately satisfies the steel compositions required by GMW14400. EX-1019, 164; EX-1026, 2.

167. In addition, the POSITA would have found it obvious to try varying the various heating parameters described by Takagi, e.g., within the thermal process windows described by Hein. EX-1019, 163-164. All of these parameters – heating rate, heating temperature, rate of primary cooling, forming temperature, and quenching rate – were recognized by Takagi as result-effective. EX-1016, [0019], [0026]-[0037]. Moreover, the corresponding experimentation was well within the reach and skill of a POSITA, e.g., by appropriately configuring the austenitization furnace and quenching die.

168. Moreover, a POSITA would have had high confidence that the modifications would be successful: the heating profiles used for Takagi's parts are

all within or close to the temperature and time ranges disclosed by Hein, and a modified pre-coating thickness of, for example, 25 µm represents a small modification compared to the 10-20 µm range disclosed by Takagi. EX-1016, FIG. 4, [0035]; EX-1019, 163. For example, Hein discloses austenitization at "900°C to 950°C, during 4 to 10 minutes," while Takagi discloses a heating temperature of "900~950° C" with a holding time of "2~10 min." EX-1016; [0047]; EX-1019, 163.

169. As a result, based on the foregoing routine experimentation, a POSITA would have arrived at various coatings with layers having various thicknesses and compositions. For example, a POSITA would have arrived at "**modified Takagi coatings No. 1 and No. 4**" having, for each of their five layers, the layer composition described for Takagi's No. 1 and No. 4 coatings (or similar composition), and having the layer thickness and morphology shown in Hein FIG. 4 (or similar thickness and morphology). It is true that obtaining those compositions and thicknesses would require experimentation and some degree of trial and error, within the finite number of possible experimental values for some or all of the foregoing thermal treatment parameters. However, given (i) the knowledge that both Takagi's and Hein's processes result in the formation of five-layer coatings, (ii) the relatively small increase in pre-coating thickness associated with a modification of Takagi based on Hein's pre-coating thickness (only from 20

μm to 25 μm), (iii) the art's recognition that layer characteristics (e.g., hardness and corrosion resistance) depend directly on layer composition, and (iv) the art's clear recognition of the most relevant process parameters for modifying layer compositions and thicknesses, the manufacture of the modified coatings would have been obvious. EX-1016, [0019]-[0026].

170. As a result, the modified Takagi coatings No. 1 and No. 4 are members of a wide class of coatings that are, in my opinion, rendered obvious by Takagi, Hein, and GMW14400. For example, insofar as any aspects of the coating layers described in the '227 Patent may be the result of specific heating parameters or pre-coating parameters, a POSITA would have arrived at such layers by routine experimentation. I base this opinion at least on a comparison between the values disclosed in the '227 Patent and those in Takagi, Hein, and GMW14400. The values are generally identical or very similar, and the '227 Patent includes no disclosure to suggest an unexpected criticality in any of these parameters that would place any of the claimed layer parameters outside the bounds of routine experimentation. When comparing the '227 Patent to the prior art, a POSITA would have seen very similar processes being applied to very similar steel parts.

Parameter	’227 Patent	’227 Patent Example 2	Takagi	Hein	GMW14400
Pre-coating thickness (μm)	20 – 30	---	10 – 20	25	20 - 33
Heating rate (˚C/s)	4 - 12	10	8; 1-10	---	---
Temperature (˚C)	880 - 940	920	920, 950	900 - 950	---
Hold time (min)	< 3 – 13	< 6	3, 5	<[3] 4 – 10	
Cooling rate (˚C/s)	> 30, or > 50		20 – 100	50 – 100	

171. From my experience during IPR proceedings for the ’683 Patent, I am aware that the heating rates disclosed in the ’227 Patent were a focus of some discussion. With respect to the heating rates, I will briefly note that the disclosed preferential heating rate range of “4 [to] 12°C./s” encompasses Takagi’s disclosed heating rates of 8˚C/s and 1-10˚C/s; encompasses the heating rate range of 5-10˚C/s disclosed by WO02/103073; and encompasses the heating rates from 20˚C to 700˚C disclosed in FIG. 2 of EX-1039, which I measure to be 5.2 °C/s and 8°C/s.[4] EX-1001, 7:13-24; EX-1016, [0026], [0037]; EX-1035, 57:1; EX-1039,

[3] “<” here indicates that the disclosed time includes both the heating ramp-up time and the hold time.

[4] For the EX-1039 value, I measured the average heating rate over the 20˚C to 700˚C range based on the curves in FIG. 2.

FIG. 2. I can find no evidence that any of the foregoing temperature or coating parameters disclosed by the ’227 Patent represented an invention or novel insight. These parameter ranges described by the ’227 Patent were general in view of the prior art, and it would have been well within the skill of a POSITA to arrive at the claimed coatings as a result of routine experimentation within the conditions of the prior art.

E. Analysis of Claims

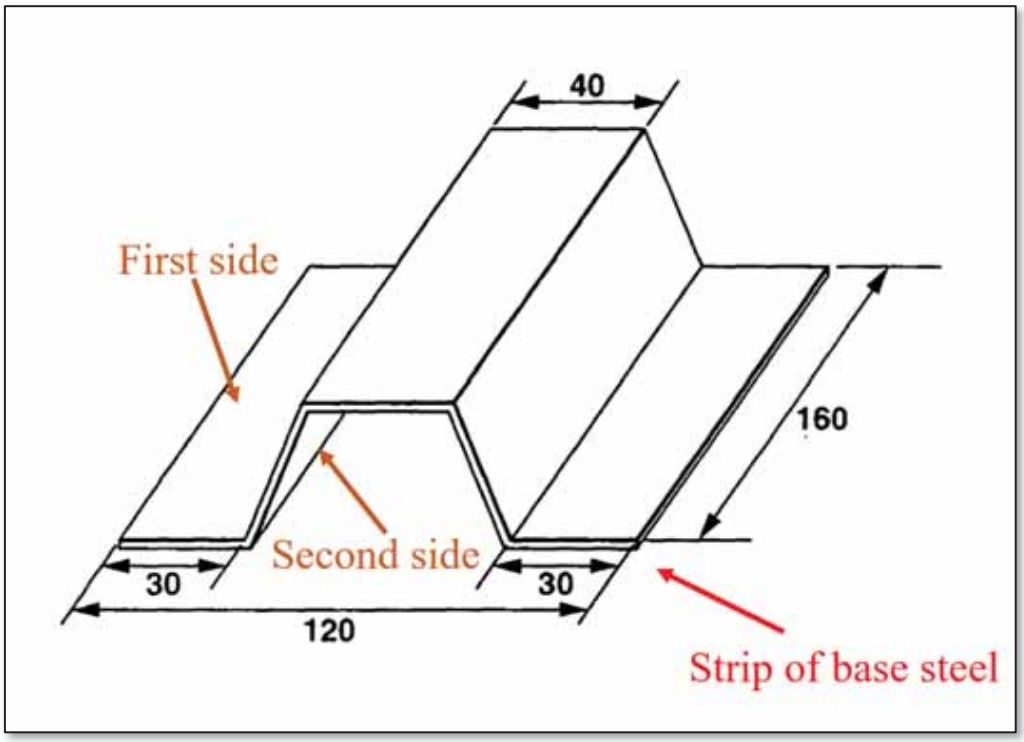
[1pre]: a hot stamped coated steel product, which comprises

172. The modified Takagi parts are hot-stamped coated steel products. Takagi describes that, in the “[t]est [p]rocedure” used for producing the Nos. 1 and 4, “[f]rom the [] hot-dip aluminum-coated steel sheet, a flat plate [] was cut out, heat-treated [] and **formed into a shape** shown in FIG. 1.” EX-1016, [0036]. “Form[ing]” refers to stamping. Further, Hein FIG. 4 shows a “[s]tructure of the alloyed layer Al-Fe-Si **after hot-stamping**.” EX-1019, 165.

[1a]: a strip of base steel having a first side and a second side; and

173. The modified Takagi parts comprise a strip of base steel having a first side and a second side. These sides are shown, for example, in Takagi FIG. 1, which illustrates the “shape” of the hot-stamped parts of Takagi Nos. 1 and 4. This shape is obtained by “form[ing]” a “**flat plate**.” EX-1016, [0036]. The “base steel” of the FIG. 1 part, and its two sides, would be underneath a coating. That is, in

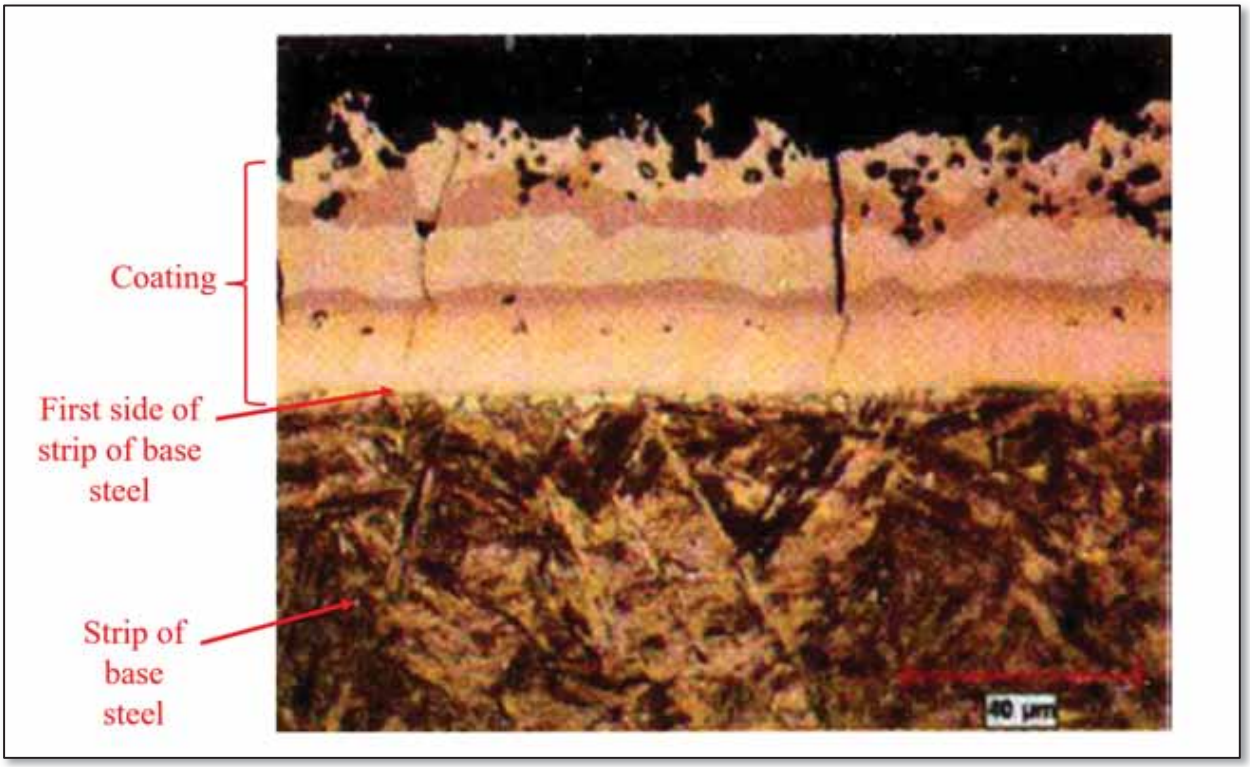
FIG. 1, the visible surfaces are surfaces of the coating, but a POSITA would have understood that a strip of base steel with two sides was under the coating.



Annotated Takagi FIG. 1

[1b]: a coating on at least one of said first side of said strip of base steel and said second side of said strip of base steel, wherein:

174. The modified Takagi parts comprise a coating on at least one of the first side of the strip of base steel and the second side of said strip of base steel. Hein FIG. 4 shows an example of such a coating which, as discussed in Section XII.D, corresponds to the modified Takagi coatings Nos. 1 and 4.



Annotated Hein FIG. 4

[1c]: (i) said coating results from interdiffusion between said base steel and an aluminum or aluminum alloy pre-coating,

175. The modified Takagi coatings result from interdiffusion between the base steel and the aluminum or aluminum alloy pre-coating. Takagi describes that "[d]uring the growth of the Al-Si-Fe alloy layer by the heat treatment, **mutual diffusion between Al coating and steel substrate layer** produces various Al-Si-Fe ternary intermetallic compounds." EX-1016, [0016].

[1d]: (ii) wherein said coating comprises, proceeding from the base steel outwards:

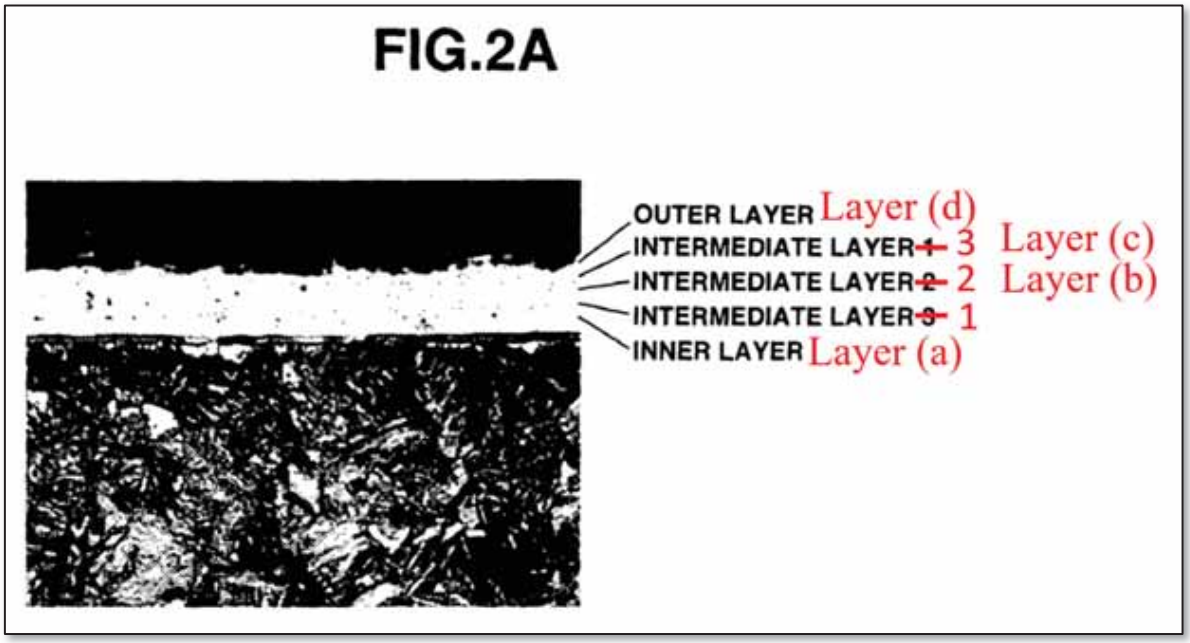
[1e]: (a) an Interdiffusion layer,

[1f]: (b) an Intermediate layer,

[1g]: (c) an Intermetallic layer, and

[1h]: (d) a Superficial layer,

176. The modified Takagi coatings have the foregoing recited layers. For example, the modified Takagi coatings include five layers corresponding to the Inner, Inter 1, Inter 2, Inter 3, and Outer layers of Takagi Table 1. At least the **Inner, Inter 2, Inter 3, and Outer layers** of each of the modified Takagi Nos. 1 and 4 coatings teach the recited layers (a), (b), (c), and (d), respectively. The Inner, Inter 2, Inter 3, and Outer layers proceed "from the base steel outwards," as shown in Takagi FIG. 2A. These layers also satisfy the meanings of "Interdiffusion," "Intermediate," "Intermetallic," and "Superficial" proposed by Petitioner during IPR proceedings for the '683 Patent. EX-1031, 22-24.



Annotated Takagi FIG. 2A

177. The compositions and thickness/morphology of the modified Takagi coatings' layers, in association with the corresponding layers of the '227 Patent, are shown in the annotated Takagi Table 1 and Hein FIG. 4 below.

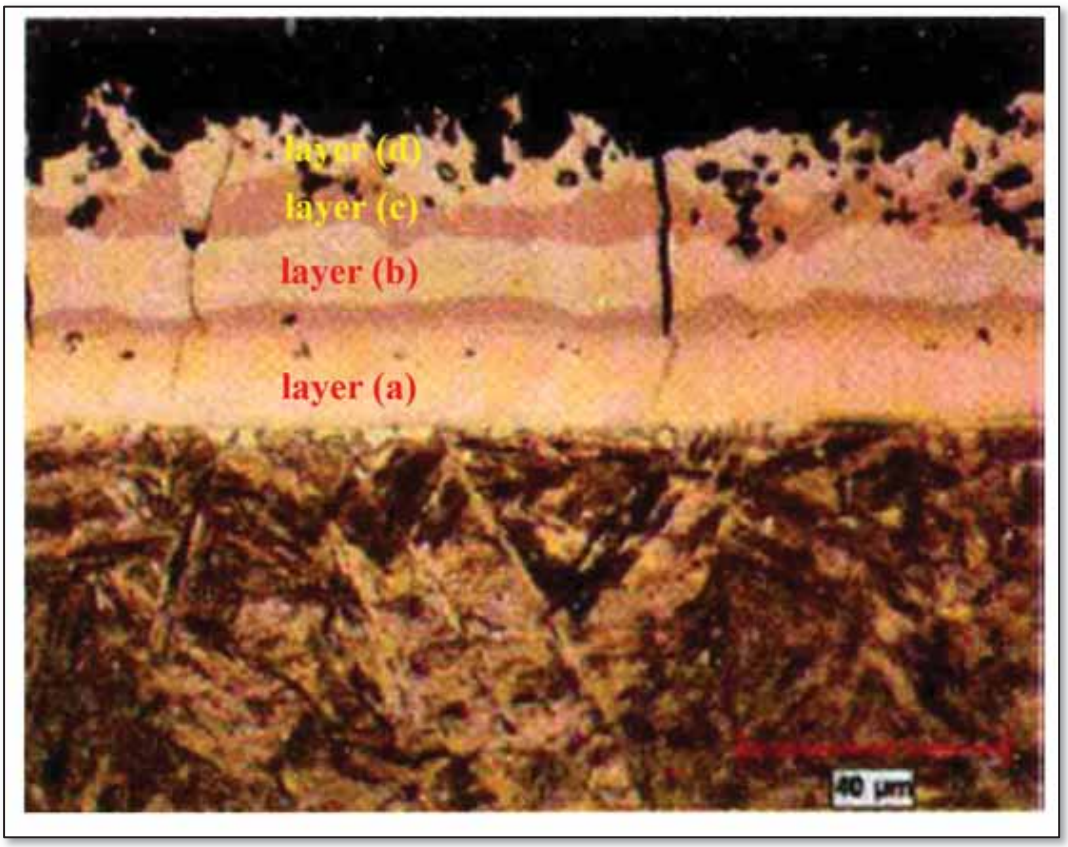
Corresponding layers of '227 Patent

TABLE 1

(a) (b) (c) (d)

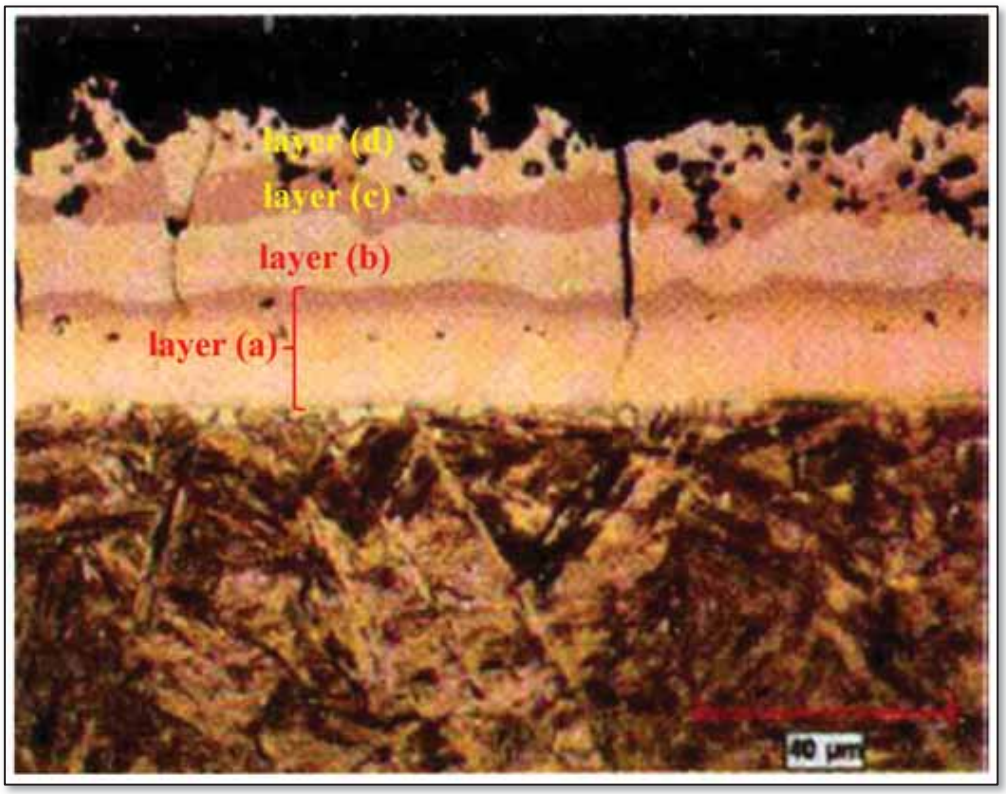
No.	PRODUCTION		COATING LAYER STRUCTURE & COMPOSITION (%)						STEEL BASE HARDNESS (Hv)	COATING LAYER HARDNESS (Hv)			OXIDE WEIGHT (mg/dm²)	FORMABILITY	CORROSION RESISTANCE	WELDABILITY
	RAISED TEMPERATURE (°C)	HOLD TIME (min.)	COMPONENT & HARDNESS	INNER	INTER 1	INTER 2	INTER 3	OUTER		SOFTEST	AVERAGE	SOFTER RANGE (%)				
1	920	3	Al	7.7	31.0	48.4	31.6	54.8	450	310	415	51	300	○	○	○
			Si	2.0	3.9	1.2	5.7	0.8								
			Fe	89.6	65.9	50.1	62.0	44.5								
			Hv	310	360	750	700	800								
2	900	2	Al	27.2	48.4	31.6	—	54.9	415	380	455	22	275	×	○	○
			Si	4.1	1.2	5.7		0.8								
			Fe	67.2	50.1	61.9		44.1								
			Hv	380	760	720	—	810								
3	930	10	Al	9.4	—	—	—	11.6	400	305	385	78	550	○	×	×
			Si	1.3				1.8								
			Fe	88.4				85.7								
			Hv	305	—	—	—	410								
4	950	5	Al	6.0	27.8	51.9	30.4	47.4	440	280	400	59	385	○	○	○
			Si	1.5	4.3	0.6	5.3	2.2								
			Fe	90.7	66.7	46.8	63.1	49.8								
			Hv	280	340	720	690	800								
5	900	4	Al	3.2	54.5	33.4	—	54.5	440	300	410	56	335	○	○	○
			Si	0.4	2.5	15.3		6.8								
			Fe	94.3	42.7	51.4		38.4								
			Hv	300	740	700	—	810								

Annotated Takagi Table 1



Annotated Hein FIG. 4

178. In addition, the **Inner and Inter 1** layers of the modified Takagi Nos. 1 and 4 coatings **together** teach the Interdiffusion layer (layer (a)). This mapping, reflected in the annotated Hein FIG. 4 below, would be consistent with one example of the ’227 Patent’s disclosure for the reasons discussed in Section VI.B. All arguments provided herein that rely on associating the Inner layer with layer (a) apply equally to this composite layer of the Inner and Inter 1 layers, and that alternative mapping should be understood as being included in the discussions below.



Annotated Hein FIG. 4

[1i]: wherein layers (a), (b), (c), and (d) each have a different mean composition from one another,

179. The Inner, Inter 2, Inter 3, and Outer layers of the modified Takagi coatings each have a different mean composition from one another. Takagi Table 1 shows the compositions of each of the layers of Nos. 1 and 4, illustrating that they satisfy the foregoing limitation. As discussed in Section XII.D, the layers of the modified Takagi coatings have compositions the same as or similar to these compositions. *See* Section VI.B for a discussion of why a POSITA would have interpreted Takagi's "percent by mass" to be a "mean" composition. EX-1016, [0020].

Corresponding layers of '227 Patent

TABLE 1

(a) (b) (c) (d)

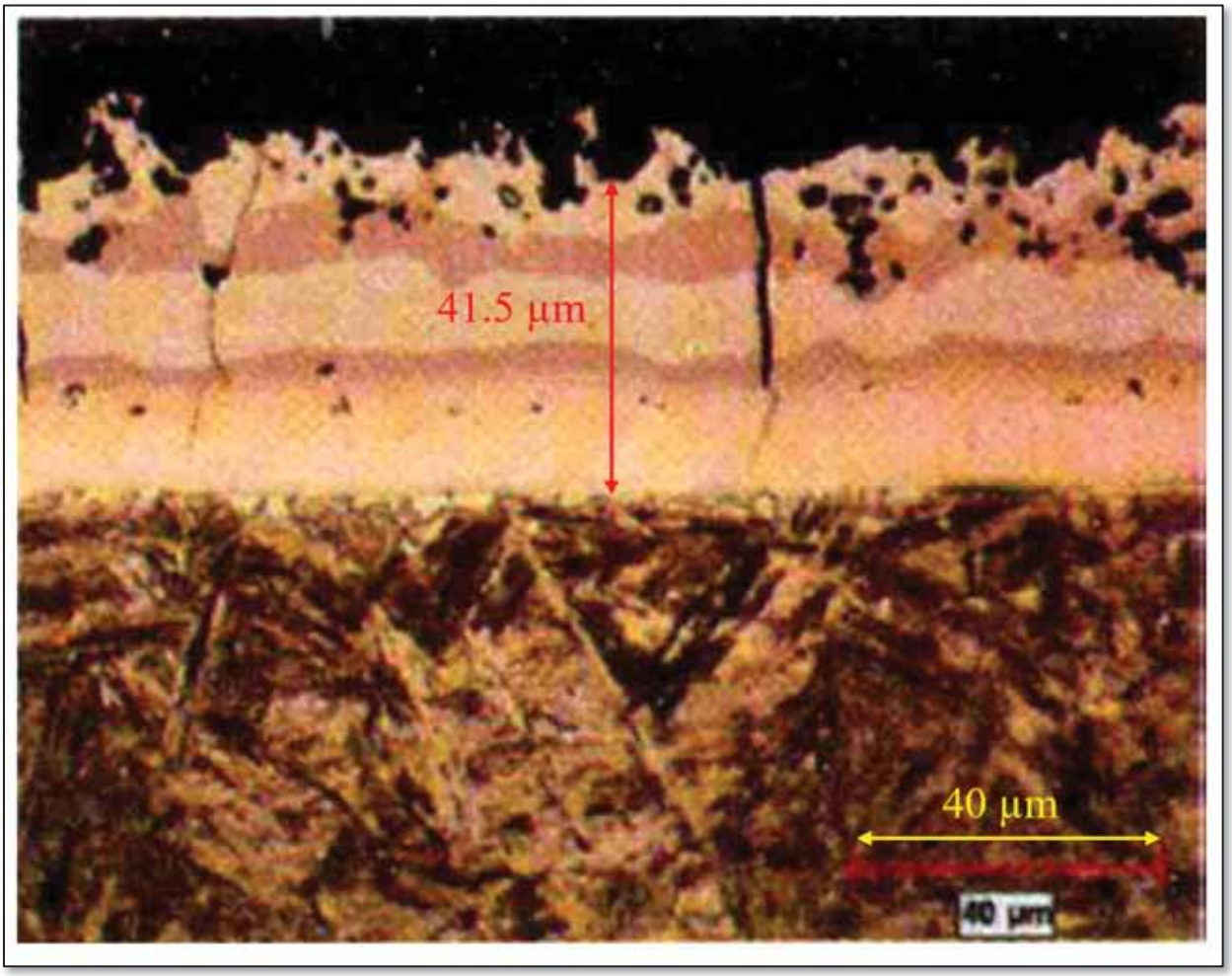
No.	PRODUCTION		COATING LAYER STRUCTURE & COMPOSITION (%)						STEEL BASE HARDNESS (Hv)	COATING LAYER HARDNESS (Hv)			OXIDE WEIGHT (mg/dm²)	FORMABILITY	CORROSION RESISTANCE	WELDABILITY
	RAISED TEMPERATURE (°C)	HOLD TIME (min.)	COMPONENT & HARDNESS	INNER	INTER 1	INTER 2	INTER 3	OUTER		SOFTEST	AVERAGE	SOFTER RANGE (%)				
1	920	3	Al	7.7	31.0	48.4	31.6	54.8	450	310	415	51	300	○	○	○
			Si	2.0	3.9	1.2	5.7	0.8								
			Fe	89.6	65.9	50.1	62.0	44.5								
			Hv	310	360	750	700	800								
2	900	2	Al	27.2	48.4	31.6	—	54.9	415	380	455	22	275	×	○	○
			Si	4.1	1.2	5.7		0.8								
			Fe	67.2	50.1	61.9		44.1								
			Hv	380	760	720	—	810								
3	930	10	Al	9.4	—	—	—	11.6	400	305	385	78	550	○	×	×
			Si	1.3				1.8								
			Fe	88.4				85.7								
			Hv	305	—	—	—	410								
4	950	5	Al	6.0	27.8	51.9	30.4	47.4	440	280	400	59	385	○	○	○
			Si	1.5	4.3	0.6	5.3	2.2								
			Fe	90.7	66.7	46.8	63.1	49.8								
			Hv	280	340	720	690	800								
5	900	4	Al	3.2	54.5	33.4	—	54.5	440	300	410	56	335	○	○	○
			Si	0.4	2.5	15.3		6.8								
			Fe	94.3	42.7	51.4		38.4								
			Hv	300	740	700	—	810								

Inner, Inter 2, Inter 3, and Outer layers have different compositions

Annotated Takagi Table 1

[1j]: wherein said coating of the hot stamped coated steel product has a thickness greater than 30 micrometers.

180. The modified Takagi coatings have thicknesses greater than 30 µm. As discussed in Section XII.D, the modified Takagi coatings have thicknesses the same as or similar to that of Hein FIG. 4. My measurements indicate that the Hein FIG. 4 coating has a thickness of 41.5 µm, satisfying this claim element.

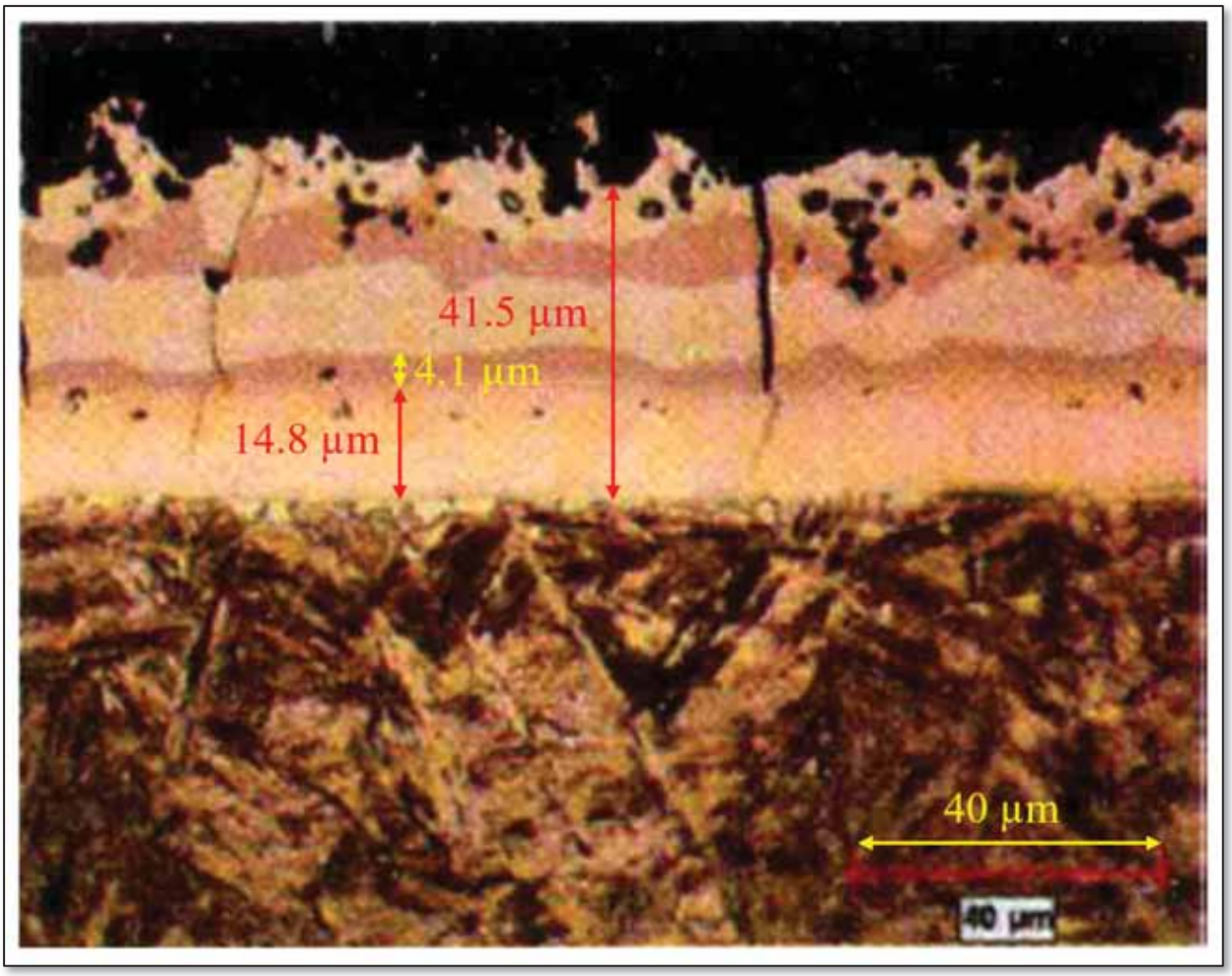


Annotated Hein FIG. 4

[2]: The hot stamped coated steel product according to claim 1, wherein said layer (a) has a thickness that is less than half of said thickness of the coating.

181. The modified Takagi coatings have a layer (a) thickness that is less than half of the thickness of the coating. As discussed in Section XII.D, the layers of the modified Takagi coatings have thicknesses the same as or similar to those of Hein FIG. 4. My measurements indicate that the deepest layer of the Hein FIG. 4

coating has a thickness of **14.8 µm**, which is less than half of the **41.5 µm** thickness of the coating, thereby satisfying this claim element.

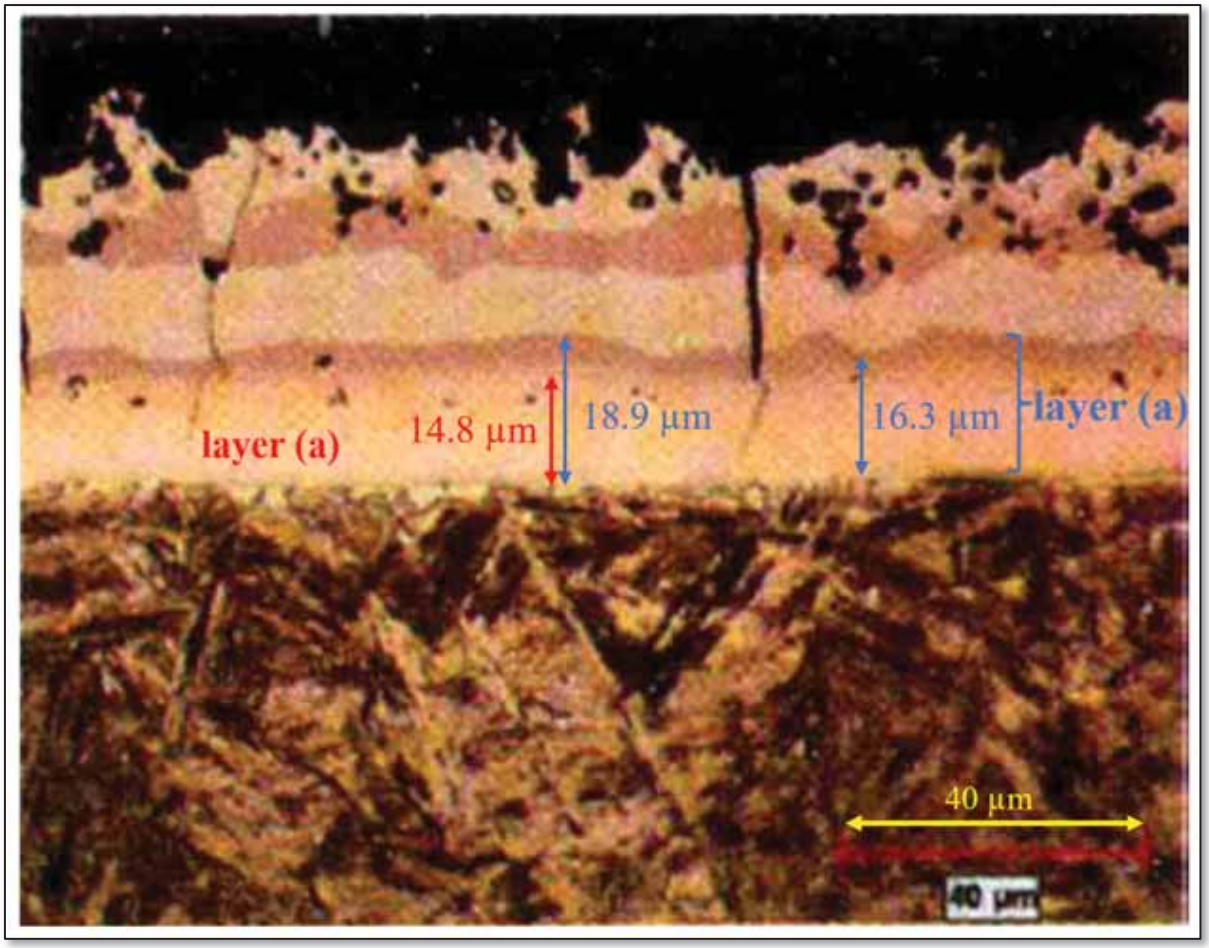


Annotated Hein FIG. 4

182. In addition, Takagi describes that "there is formed a less hard or soft layer [] at or near the boundary between the steel and coating. [T]he thickness of this soft layer is made **equal to or greater than 50% of the total thickness of the alloy coating layer**." EX-1016, [0017]. This range abuts the claimed range, a characteristic which I am advised is sufficient to render the claimed range obvious,

absent a showing of criticality (which is not present in the ’227 Patent).

183. In the case where Inner and Inter 1 are together applied as layer (a), the composite layer has a measured thickness of **18.9 µm** or **16.3 µm**, which satisfies claim 2.



<u>Annotated Hein FIG. 4</u>

[3]: The hot stamped coated steel product according to claim 1, wherein layer (a) has an HV50g hardness between 290 and 410; layer (b) has an HV50g hardness between 900 and 1000, +/−10%; layer (c) has an HV50g hardness between 580 and 650, +/−10%; and layer (d) has an HV50g harness between 900

and 1000, +/−10%.

184. The combination of Takagi, Hein, and GMW14400 renders obvious the recited layer hardnesses. For example, the layers of the modified Takagi coatings have hardnesses the same as or similar to the hardnesses disclosed in Takagi Table 1, and these hardnesses are within or close to the recited hardness ranges, as demonstrated in the chart below:

'227 Patent layer	**Claimed range (HV50g)**	**Takagi No. 1 hardness (Hv)**	**Takagi No. 1 deviation**	**Takagi No. 4 hardness (Hv)**	**Takagi No. 4 deviation**
(a)	290 – 410	310 (Inner)	[in range]	280 (Inner)	3.5%
(b)	810 - 1100	750 (Inter 2)	7.5%	720 (Inter 2)	11%
(c)	522 – 715	700 (Inter 3)	[in range]	690 (Inter 3)	[in range]
(d)	810 - 1100	800 (Outer)	1.3%	800 (Outer)	1.3%

185. A POSITA would expect the layers of the modified Takagi coatings to have hardness values the same as, or similar to, the corresponding layers of the disclosed Takagi coatings. For example, Takagi itself discusses a direct correlation between layer composition and layer hardness, noting a target Fe% range that provides a target layer hardness. EX-1016; [0020]. Because the modified Takagi coating layers have compositions the same as or similar to the disclosed Takagi coating layers, and would have been processed under conditions generally similar to those used by Takagi, it follows that the hardnesses would also be the same or similar, consistent with my knowledge and the general knowledge in the art that

hardness is a function of composition and thermal history.

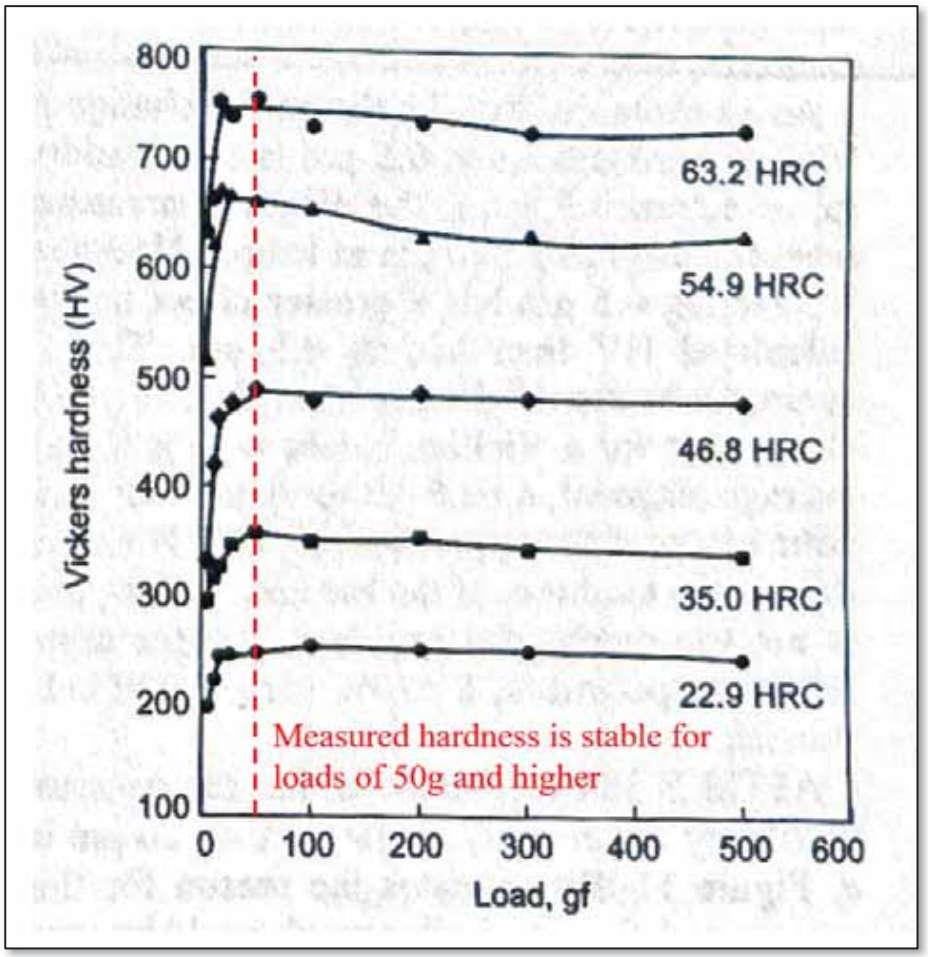
186. Starting from those hardnesses, it would have been obvious to experiment with the hardnesses of the modified Takagi coatings to achieve hardnesses in the claimed ranges. I am advised that, where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation. This rule seems particularly applicable here, in view of the motivation provided by Takagi's detailed discussion of the importance of individual-layer hardness for coating performance, Takagi's discussion of how the layer hardness depends on the layer composition, and Takagi's discussion of how layer hardness and composition can be tuned by adjusting heating rate, heating temperature, and hold time. EX-1016, [0019]-[0026]. *see also* Section XII.A above. And the difference between Takagi's explicitly-disclosed hardnesses and those recited in claim 3 are minor: at most 7.5% for the modified No. 1 coating, and at most 11% for the modified No. 4 coating, differences that would be well within the range of routine experimentation. All of these factors suggest to me that it would have been obvious and well within the skill of a POSITA to obtain the recited hardnesses.

187. There is one more factor to consider when comparing Takagi and the '227 Patent. While claim 3 recites an "HV50g hardness" (that is, a "hardness measured using a 50g load"), Takagi does not disclose the load used to obtain the

values in Table 1. In a Vickers hardness test, the "load" refers to the mass or force used to form an indentation that indicates the hardness. Further, a POSITA would have been aware that, in some cases, the measured hardness may depend on the load, particularly in cases in which the load is less than 100g. This effect is sometimes referred to as the "indentation size effect (ISE)." However, Takagi's ambiguity on this point does not change my assessment that the recited hardnesses are obvious.

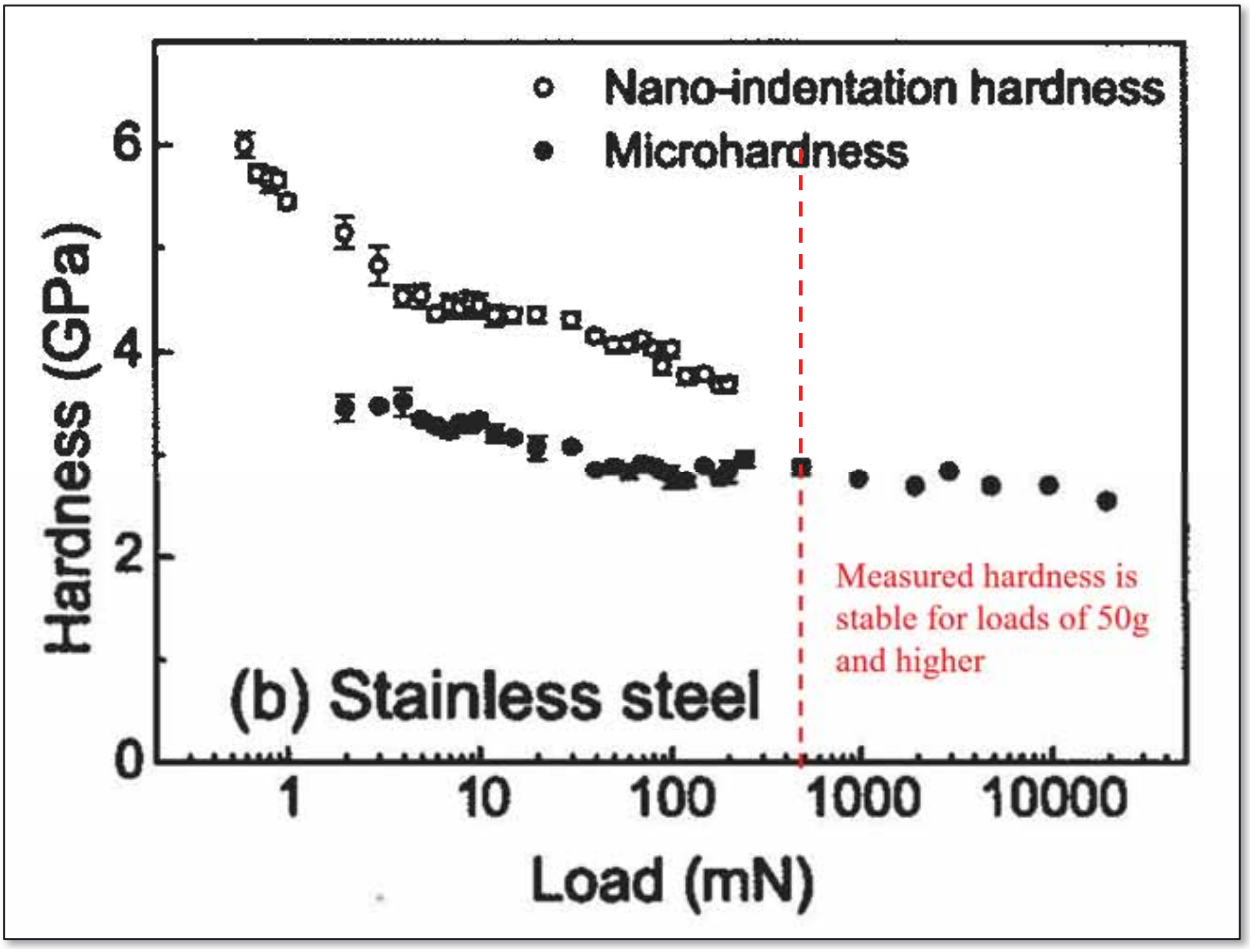
188. First, the most obvious choice of load for a POSITA to use in measuring the hardnesses would have been either 50g, or a load providing a hardness value substantially matching that provided by 50g. Although loads can theoretically be selected arbitrarily, my own experience suggests that, in practice, among loads in the range where hardness might depend on load, a POSITA using standard test equipment would have almost certainly chosen from among a small number of possible loads, those being or primarily being 5g, 10g, 20g, 25g, 50g, and 100g. *See*, e.g., EX-1041, 5; EX-1044, 7; EX-1040, FIG. 13. In addition, given widespread recognition in the art that hardness can depend on load, the POSITA would have consulted existing literature to identify a load providing reliable results. The references with which a POSITA would have been familiar suggest that, for microindentation and nanoindentation measurements on steel, loads of 50g and higher provide relatively similar hardness measurements. For example, EX-

1040 FIG. 13, illustrating measured Vickers hardness for steel test blocks using test forces from 5-500 gf, shows the hardness generally stabilizing for loads of 50 g and higher:



Annotated EX-1040 FIG. 13

189. And EX-1043's plot of microindentation measurements on stainless steel also shows relatively stable results for loads of 50 g and higher (50 gf is about 490 mN):

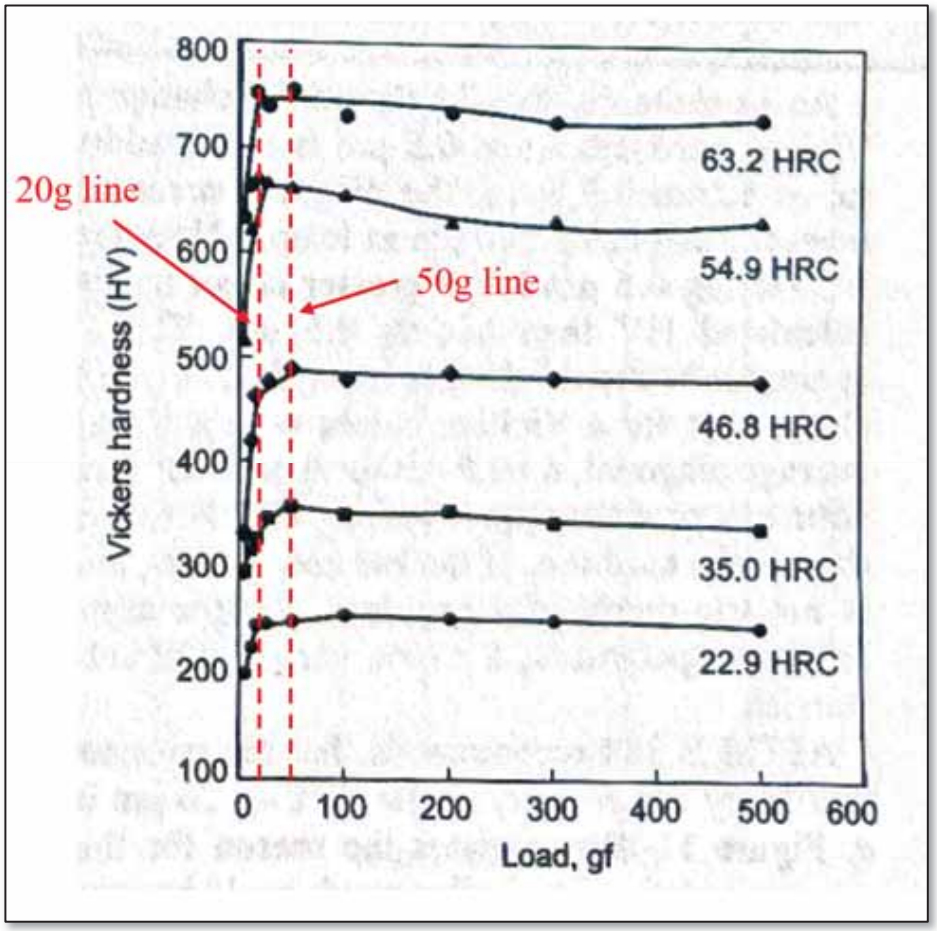


Annotated EX-1043 FIG. 2(b)

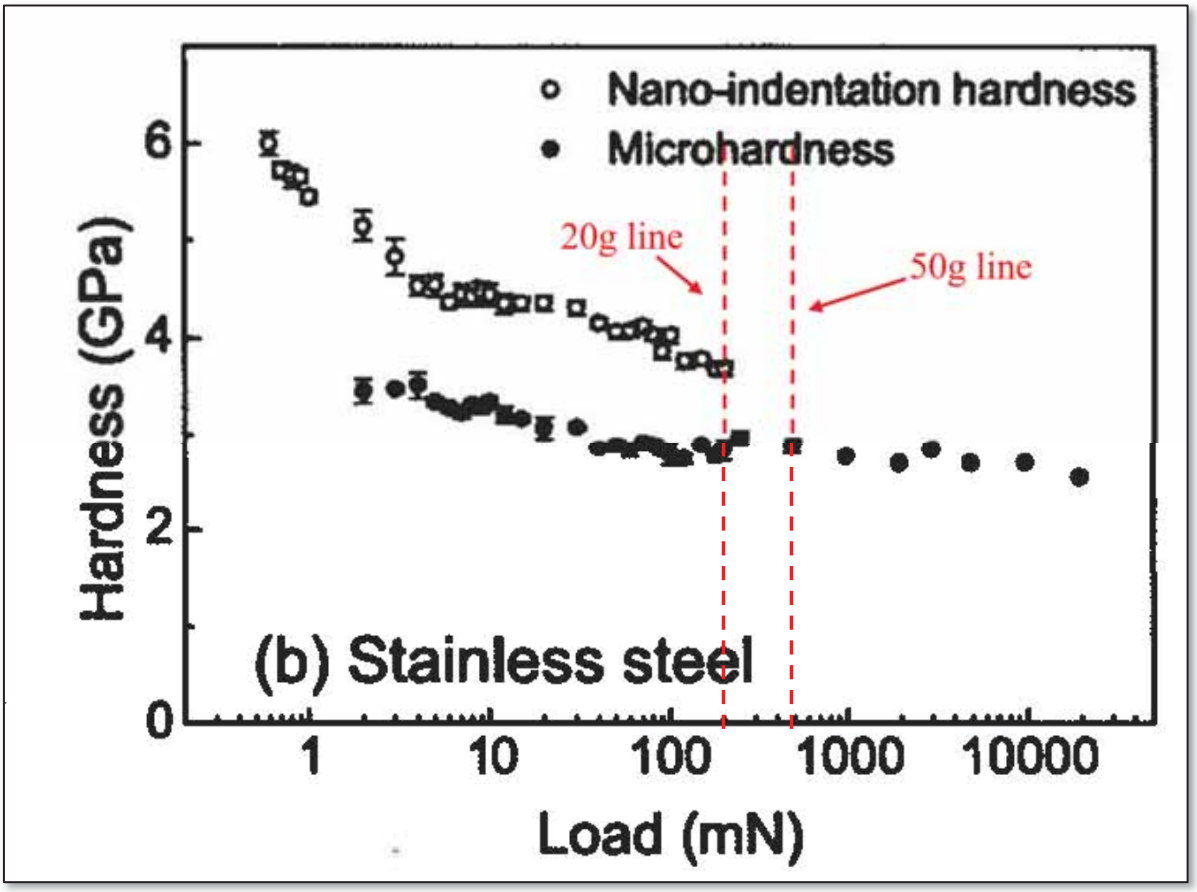
190. It is my assessment that a POSITA, following this literature, would have either (i) selected 50g, in which case Takagi's hardness values are directly applicable to those of the '227 Patent, or (ii) selected a load higher than 50g (such as 100g or 200g), in which case the literature suggests that the measured hardness would be very similar to an HV50g hardness. This latter choice would be consistent with the loads of 100g and 200g used in other hot-stamping-related documents I identified. *See* EX-1035's use of a 100g load for measurement of

Vickers hardness in a cross-section of a hot-stamped steel sheet (EX-1035, 53:28-31) and EX-1046's use of a 200g load for measurement of quenched, martensitic USIBOR 1500 steel (EX-1046, 4).

191. Moreover, based on the literature, even if Takagi's hardnesses were measured using a somewhat smaller load down to 20g, a POSITA would have expected them to differ less than 10% from hardnesses measured using 50g loads. This is evidenced in EX-1040 FIG. 13 and EX-1043 FIG. 2(b).



Annotated EX-1040 FIG. 13

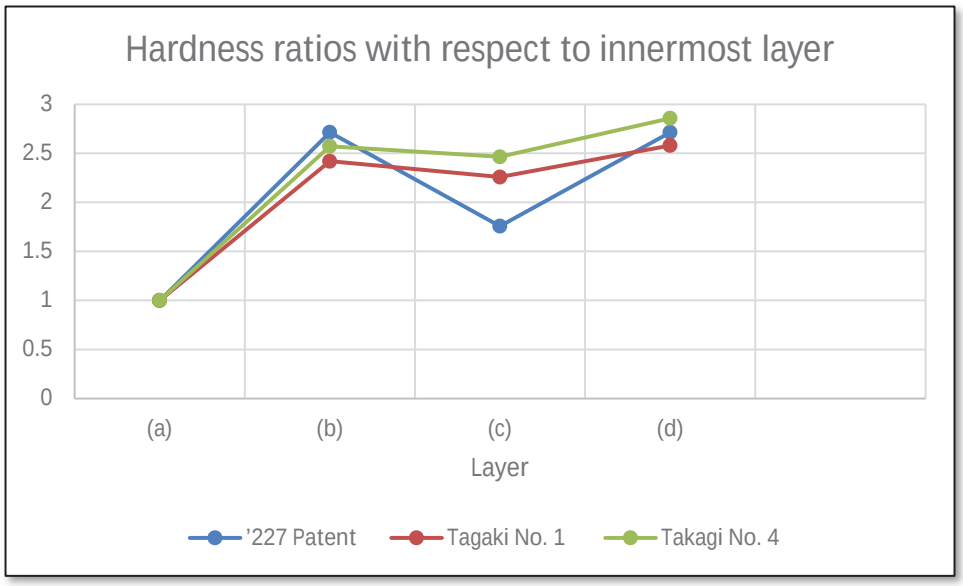


Annotated EX-1043 FIG. 2(b)

192. As such, I believe that the Hv hardness values disclosed by Takagi are almost certainly representative of HV50g hardness values, for example, to within 10% at most. Given the lack of criticality or unexpected results associated with the recited hardnesses, and given the reasonable expectation of success discussed above for achieving those hardnesses, the reasoning provided above for the obviousness of claim 3 applies equally whether Takagi's hardnesses are interpreted as HV50g hardnesses or are modified slightly to account for the use of a different load.

193. In addition, independent of the above reasoning, the specific numbers recited in claim 3, even with the recited load, can be given little weight. Vickers hardness measurements on thin layers are notoriously unreliable, with results varying substantially from tool-to-tool and even user-to-user for the same tool. EX-1040, 3. For this very reason, POSITAs typically report hardnesses not as absolute values but comparatively within a given part. For example, it is common for a POSITA to measure the hardness along a profile extending through a welded joint between two metal parts. In such cases, what the POSITA would typically report is the relative hardness of the joint region compared to areas adjacent to the joint, then extending into the base material that was not affected by the joining process. As such, the relative hardnesses provide information about the mechanical properties of the material after joining.

194. In terms of what would have been practically achievable to measure in 2006, a POSITA would have interpreted claim 3 merely as reciting a general pattern of hardness – soft, hard, medium, and hard – as one moves from the base steel to the coating surface. Takagi's coatings exhibit the same pattern and even quantitively similar hardness ratios with respect to the innermost layer to those of claim 3, as shown below (for the '227 Patent values, the chart uses the midpoints of the claimed ranges). For this additional reason, claim 3 is obvious over Takagi in view of Hein and GMW14400.



195. As an additional reason for the obviousness of claim 3, the layer compositions disclosed by Takagi (corresponding to the layer compositions of the modified Takagi coatings) are sufficiently similar to those disclosed in the '227 Patent, and Takagi's layers were processed in a manner sufficiently similar to those of the '227 Patent, to render obvious the claimed hardnesses. The hardnesses of claim 3 appear to derive from "Example 2" of the '227 Patent. As shown in the table below, the Takagi compositions and the Example 2 compositions are very similar to one another.

Layer	’227 Patent Example 2 Composition	Takagi No. 1 Composition	Takagi No. 4 Composition
Inner	7 Al% 3 Si% 90 Fe%	7.7 Al% 2.0 Si% 89.6 Fe%	6.0 Al% 1.5 Si% 90.7 Fe%
Inter 2	57 Al% 1 Si% 43 Fe%	48.4 Al% 1.2 Si% 50.1 Fe%	51.9 Al% 0.6 Si% 46.8 Fe%
Inter 3	31 Al% 4 Si% 65 Fe%	31.6 Al% 5.7 Si% 62.0 Fe%	30.4 Al% 5.3 Si% 63.1 Fe%
Outer	54 Al% 1 Si% 45 Fe%	54.8 Al% 0.8 Si% 44.5 Fe%	47.4 Al% 2.2 Si% 49.8 Fe%

196. I am advised that, where the claimed and prior art products are identical or substantially identical, or are produced by identical or substantially identical processes, the claimed product is obvious absent evidence to the contrary. Here, the prior art compositions are very similar to the Example 2 compositions and were obtained using substantially similar process parameters, as I discussed in Section XII.D. Hardness is a function of **composition** and **thermal history**. It follows that the layers of the Takagi-Hein-GMW14400 coating would have had the same or substantially the same hardnesses as those of the ’227 Patent’s Example 2 and, thus, of claim 3.

[4]: The hot stamped coated steel product according to claim 1, wherein said layer (a) has a thickness of 17 micrometers or less.

[5]: The hot stamped coated steel product according to claim 1, wherein said layer (a) has a thickness of 15 micrometers or less.

197. The Inner layers of the modified Takagi coatings (corresponding to layer (a)) have or at least render obvious the recited thicknesses. As discussed and shown in reference to [2] above, my measurements indicate that the deepest layer of the Hein FIG. 4 coating (and, accordingly, the Inner layers of the modified Takagi coatings) has a thickness of **14.8 µm**. To the extent any uncertainty in this measurement may permit arguments that the recited thicknesses are not explicitly disclosed, it would have been obvious to try varying the thickness of the layer to obtain a very-slightly thinner layer, thereby satisfying the recited thickness ranges. Similar arguments apply as given for [19] and [20] in Section VI.B, with layer thickness substituted for layer composition.

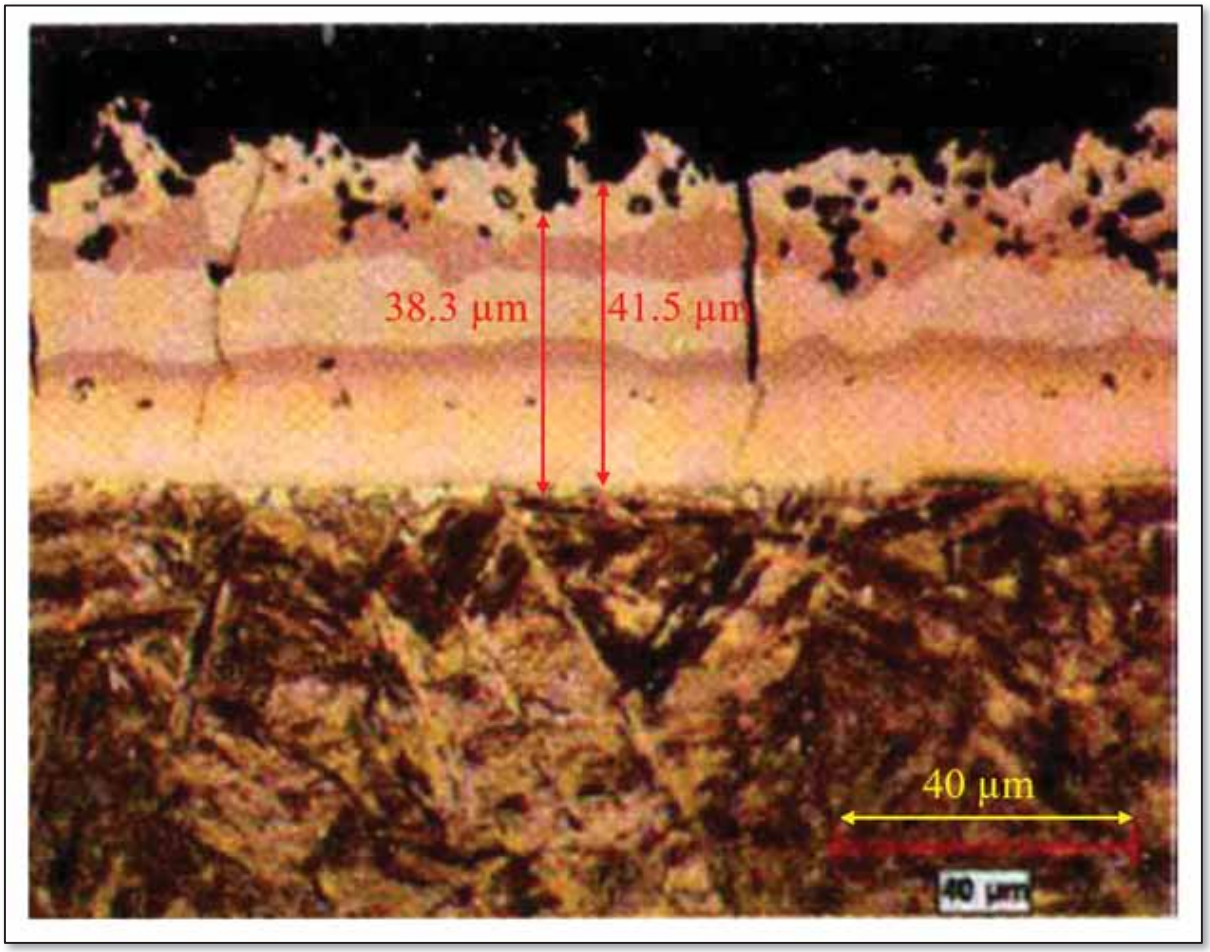
198. In the case where the Inner and Inter 1 layers are together applied as layer (a), the composite layer has a measured thickness of **18.9 µm** or **16.3 µm** (*see* annotated Hein FIG. 4 above), which renders obvious the claimed thicknesses absent evidence of criticality or unexpected results.

[6]: The hot stamped coated steel product according to claim 4, wherein the coating is 40 micrometers thick.

199. The Takagi-Hein-GMW14400 combination renders obvious that the coating is 40 µm thick. As discussed above in reference to element [1j],

GMW14400 explicitly requires a thickness greater than 35 µm, and my measurement of the Hein FIG. 4 coating (taken as a thickness of the modified Takagi coatings) gives a value of **41.5 µm**, very close to the recited value. Similar arguments apply as given for [6] in Section VI.B.

200. I also measured the thickness at another position in the Hein FIG. 4 coating and found a thickness of 38.3 µm. Because the coating thickness is a physical, continuous quantity, it follows that the thickness must be exactly 40 µm at at least one position.



Annotated Hein FIG. 4

[7]: The hot stamped coated steel product according to claim 1, wherein the interdiffusion layer has a first mean iron composition, the intermediate layer has a second mean iron composition less than the first mean iron composition; wherein the intermetallic layer has a third mean iron composition, the third mean iron composition less than the first mean iron composition and greater than the second mean iron composition, and the superficial layer has a fourth mean iron composition, the fourth mean iron composition begin less than the third mean iron

composition.

201. The layers of the modified Takagi coatings have or at least render obvious the relative compositions recited in claim 7. As discussed above with respect to claim 1 in Section XII.E, the Inner, Inter 2, Inter 3, and Outer layers of the modified Takagi coatings correspond to the Interdiffusion, Intermediate, Intermetallic, and Superficial layers, respectively. These layers have the recited relative compositions, as shown in the annotated Takagi Table 1 below. Further, as discussed with respect to claim 1 in Section VI.B, a POSITA would have understood Takagi's disclosures of "percent by mass" to be "mean" compositions. EX-1016, [0020].

Corresponding layers of '227 Patent

(a) (b) (c) (d)

TABLE 1

No.	PRODUCTION		COATING LAYER STRUCTURE & COMPOSITION (%)						STEEL BASE HARDNESS (Hv)	COATING LAYER HARDNESS (Hv)			OXIDE WEIGHT (mg/dm²)	FORMABILITY	CORROSION RESISTANCE	WELDABILITY
	RAISED TEMPERATURE (°C)	HOLD TIME (min.)	COMPONENT & HARDNESS	INNER	INTER 1	INTER 2	INTER 3	OUTER		SOFTEST	AVERAGE	SOFTER RANGE (%)				
1	920	3	Al	7.7	31.0	48.4	31.6	54.8	450	310	415	51	300	○	○	○
			Si	2.0	3.9	1.2	5.7	0.8								
			Fe	89.6	65.9	50.1	62.0	44.5								
			Hv	310	360	750	700	800								
2	900	2	Al	27.2	48.4	31.6	—	54.9	415	380	455	22	275	×	○	○
			Si	4.1	1.2	5.7		0.8								
			Fe	67.2	50.1	61.9		44.1								
			Hv	380	760	720	—	810								
3	930	10	Al	9.4	—	—	—	11.6	400	305	385	78	550	○	×	×
			Si	1.3				1.8								
			Fe	88.4				85.7								
			Hv	305	—	—	—	410								
4	950	5	Al	6.0	27.8	51.9	30.4	47.4	440	280	400	59	385	○	○	○
			Si	1.5	4.3	0.6	5.3	2.2								
			Fe	90.7	66.7	46.8	63.1	49.8								
			Hv	280	340	720	690	800								
5	900	4	Al	3.2	54.5	33.4	—	54.5	440	300	410	56	335	○	○	○
			Si	0.4	2.5	15.3		6.8								
			Fe	94.3	42.7	51.4		38.4								
			Hv	300	740	700	—	810								

Fe%(Inner) > Fe%(Inter 3) > [Fe%(Inter 2) and Fe% (Outer)]

(Layer (a)) (Layer (c)) (Layer (b)) (Layer (d))

Annotated Takagi Table 1

[8]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness that is greater than a thickness of layer (b).

[9]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness that is greater than a thickness of layer (c).

[10]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness that is greater than a thickness of layer (d).

[11]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness: that is greater than a thickness of layer (b); that is greater than a thickness of layer (c); and that is greater than a thickness of layer

(d).

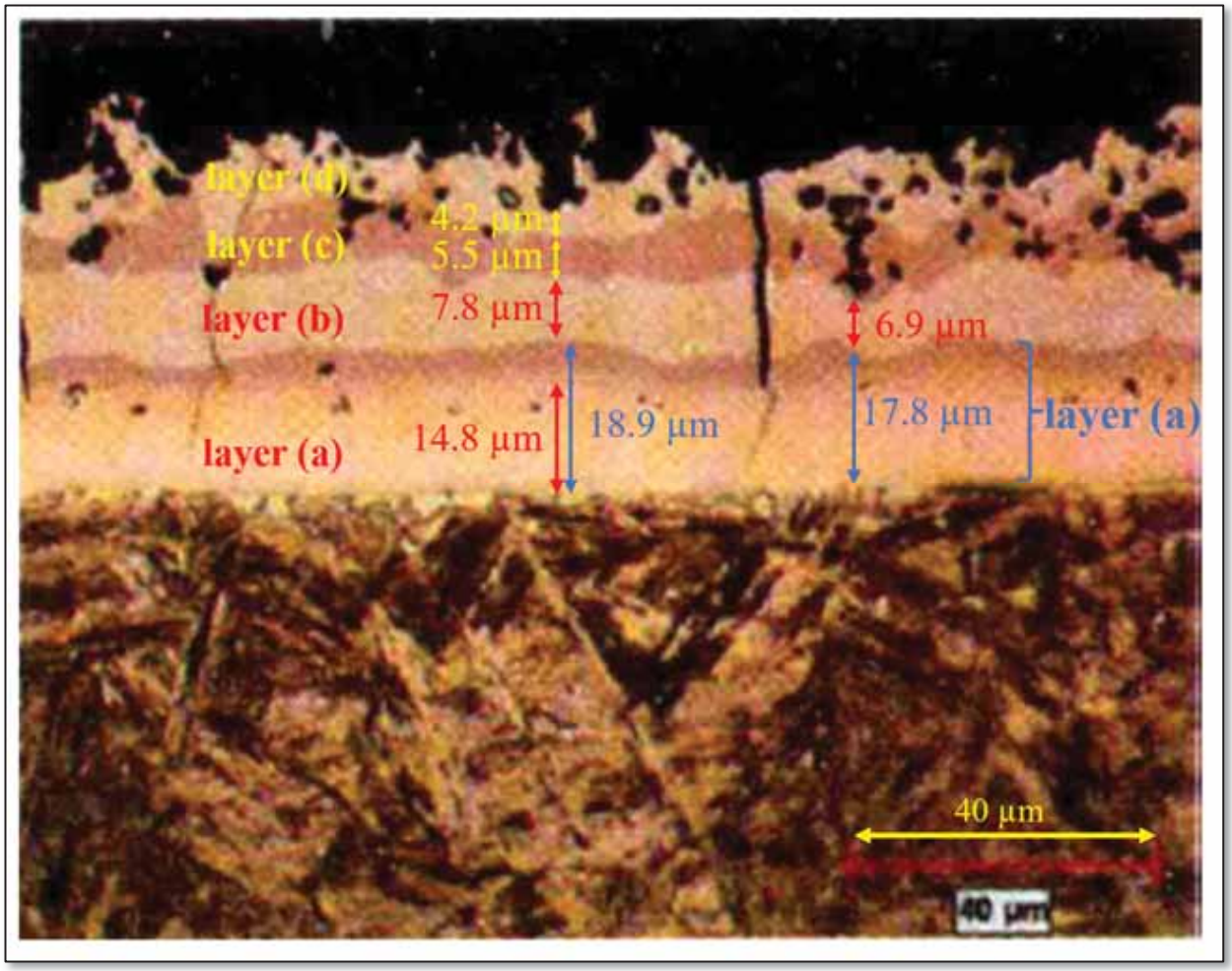
[12]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness that is more than twice a thickness of layer (b).

[13]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness that is more than twice a thickness of layer (c).

[14]: The hot stamped coated steel product according to claim 1, wherein layer (a) has a thickness that is more than twice a thickness of layer (d).

202. The modified Takagi coatings have or at least render obvious the recited relative layer thicknesses. My measurements in Hein FIG. 4 indicate thicknesses for the layers corresponding to layers (a), (b), (c), and (d) of **14.8 µm, 7.8 µm and 6.9 µm, 5.5 µm, and 4.2 µm**, respectively. These thicknesses satisfy the elements of claims 8-14.

- For [8], [9], [10], and [11], 14.8 µm is greater than each of 7.8 µm/6.9 µm, 5.5 µm, and 4.2 µm
- For [12], 14.8 µm is greater than twice 6.9 µm
- For [13] and [14], 14.8 µm is greater than twice 5.5 µm and greater than twice 4.2 µm



Annotated Hein FIG. 4

203. For claim 12, the 6.9 µm thickness of layer (b) is applied. Moreover, claim 12 is also obvious in the case where 7.8 µm is used as the thickness of layer (b), because only a small adjustment to the thicknesses of layer (a) and/or layer (b), well within the bounds of routine experimentation with respect to the layer thicknesses, would be necessary in order to satisfy claim 12. For example, an increase in the layer (a) thickness from 14.8 µm to 15.0 µm and a decrease in the layer (b) thickness from 7.8 µm to 7.4 µm would result in a coating satisfying

claim 12. *See* Section XII.D.

204. As discussed in Section XII.D, attaining any of these relative thicknesses would have required no more than routine experimentation with recognized result-effective variables.

205. In the case where Inner and Inter 1 are together applied as layer (a), the combined layer has thickness **18.9 µm** or **16.3 µm**, which also satisfy claims 8-14 in combination with the other measured thicknesses discussed above. Further, the combined layer has thickness **17.8 µm** at the position at which 6.9 µm was measured, also satisfying claims 8, 11, and 12 with respect to 6.9 µm.

[15]: The hot stamped coated steel product according to claim 1, wherein the hot stamped coated steel product is fully martensitic.

206. *See* Sections VI.B and IX.A. Hein's disclosure of a "martensitic transformation" in conjunction with a "cooling speed between 50˚C/s and 100˚C/s" renders obvious a "fully martensitic" structure. EX-1019, 164.

[16]: The hot stamped coated steel product according to claim 1, wherein the base steel consists of the following components by weight based on total weight: 0.15%<carbon<0.5%; 0.5%<manganese<3%; 0.1%<silicon<0.5%; 0.01%<chromium<1%; titanium<0.2%; aluminum<0.1%; phosphorus<0.1%; sulfur<0.05%; 0.0005%<boron<0.08%; a remainder being iron and impurities inherent in processing.

[17]: The hot stamped coated steel product according to claim 1, wherein the base steel consists of the following components by weight based on total weight: 0.15%<carbon<0.25%, 0.8%<manganese<1.8%, 0.10%<silicon<0.35%, 0.01%<chromium<0.5%, titanium<0.1% aluminum<0.1% phosphorus<0.1% 0.002%<boron<0.005%, a remainder being iron and impurities inherent in processing.

207. As shown in the table below, the steel compositions described by GMW14400 satisfy or at least overlap all composition ranges recited in claims 16 and 17. EX-1026, 2. It would have been obvious to a POSITA to use these steel compositions to satisfy General Motors' requirements. The POSITA would have been further motivated by the recognition that the values in GMW1400 are in agreement with the "Maximum-%" for C, Mn, Si, Cr, Ti, and B described by Hein for USIBOR 1500 steel, which provides "numerous" "technical and economic advantages [] for the manufacturers and the hot-stampers." EX-1019, 164, 165.

208. The "0.010 max. %" nitrogen disclosed by GMW14400 is an "impurit[y] inherent in processing." If too much nitrogen is present, the nitrogen will bond with boron, which is a critical element needed to increase hardenability. In the art, we generally seek to minimize the amount of nitrogen, which is considered to be an impurity.

209. Further, the disclosure of "steel" in GMW14400 would have been

understood by a POSITA as disclosing that the remainder of the material would be composed of iron and any trace impurities, iron being the primary component of steel.

210. Further, GMW1440's lack of disclosure of a Ti% range would have suggested to a POSITA that Ti would be present in small quantities if at all, such that this disclosure teaches a steel with Ti% of less than 0.1%. For example, because GMW14400 does not teach the inclusion of Ti and [16]-[17] recite ranges that include 0% Ti, GMW14400 teaches a Ti% within the claimed range.

211. The obviousness of these compositions is further corroborated, e.g., by EX-1050, Table 1.

Element	[16] composition	[17] composition	GMW1440 composition
C	0.15% < C < 0.5%	0.15% < C < 0.25%	0.20 to 0.25% C
Mn	0.5% < Mn < 3%	0.8% < Mn < 1.8%	1.00 to 1.35% Mn
Si	0.1% < Si < 0.5%	0.10% < Si < 0.35%	0.15 to 0.35% Si
Cr	0.01% < Cr < 1%	0.01% < Cr < 0.5%	0.11 to 0.35% Cr
Ti	Ti < 0.2%	Ti < 0.1%	[none (satisfied)]
Al	Al < 0.1%	Al < 0.1%	0.010 min. % Al
P	P < 0.1%	P < 0.1%	0.025 max. %
S	S < 0.05%	S < 0.05%	0.010 max. %
B	0.0005% < B < 0.08%	0.002% < B < 0.005%	0.0015 to 0.005 wt. %
Remainder	"iron and impurities inherent in processing"	"iron and impurities inherent in processing"	iron (implicit); 0.010 max. % N

[18]: The hot stamped coated steel product according to claim 1, wherein the Interdiffusion layer comprises the following components by weight based on total weight: 86 to 95% Fe, 4 to 10% Al, and 0 to 5% Si.

212. The Inner layers of the modified Takagi coatings, which correspond to the Interdiffusion layer, have or at least render obvious the recited compositions. Specifically, as taught in Takagi Table 1, the Inner layers of modified Takagi coating Nos. 1 and 4 have compositions of, or similar to, **89.6% Fe, 7.7% Al, 2.0% Si**, and **90.7% Fe, 6.0% Al, 1.5% Si**, respectively. All of these values are

within the recited ranges.

213. Further, Takagi's % are "mass %," which is equivalent to weight %. EX-1016, [0020]. *See* Section VI.A above. And, for reasons similar to those provided above with respect to [18] in Section VI.B, a POSITA would have understood the disclosed mass/weight % to be based on **total** mass/weight. For example, the disclosed Al%/Si%/Fe% for each layer of Takagi do not sum to 100%, suggesting the consideration of other elements when calculating the mass/weight %.

[19]: The hot stamped coated steel product according to claim 18, wherein the Intermediate layer comprises the following components by weight based on total weight: 39 to 47% Fe, 53 to 61% Al, and 0 to 2% Si.

214. The Inter 2 layers of the modified Takagi coatings, which correspond to the Intermediate layer, render obvious the recited compositions. Specifically, as taught in Takagi Table 1, the Inter 2 layers of modified Takagi coating Nos. 1 and 4 have compositions of, or similar to, **50.1% Fe, 48.4% Al, 1.2% Si**, and **46.8% Fe, 51.9% Al, 0.6% Si**, respectively. These values are within the recited ranges except for No. 1 Al% (deviation of 4.6%), No. 1 Fe% (deviation of 3.1%), and No. 4 Al% (deviation of 1.1%).

215. For reasons similar to those discussed with respect to [19] and [20] in Section VI.B, the disclosed compositions render obvious the claimed

compositions. Takagi describes both Fe% and Al% as result-effective, noting specifically Fe%'s relationship to hardness and Al%'s relationship to corrosion resistance. EX-1016, [0020]-[0021]. Takagi also describes the physical mechanism behind layer formation and how "the diffusion quantity of Fe [can be] varied" (which would correspond to control of Al% and Fe%) "by controlling the raised temperature of the heating and the holding time at the raised temperature." EX-1016, [0019]. By varying these parameters and the other parameters noted by Takagi and Hein (e.g., heating rate), it would have been obvious for a POSITA to arrive at the claimed compositions as a result of routine experimentation.

216. In addition, there is no criticality or unexpected behavior associated with the very small deviations noted above. Based on a POSITA's understanding of steel characteristics, the deviations would be associated with no qualitative differences and, indeed, would fall within manufacturing tolerances for the micron-scale layers under consideration, as discussed in Section VI.B.

[20]: The hot stamped coated steel product according to claim 19, wherein the Intermetallic layer comprises the following components by weight based on total weight: 62 to 67% Fe, 30 to 34% Al, and 2 to 6% Si.

217. The Inter 3 layers of the modified Takagi coatings, which correspond to the Intermetallic layer, have or at least render obvious the recited compositions. Specifically, as taught in Takagi Table 1, the Inter 3 layers of modified Takagi

coating Nos. 1 and 4 have compositions of, or similar to, **62.0% Fe, 31.6% Al, 5.7% Si**, and **63.1% Fe, 30.4% Al, 5.3% Si**, respectively. All of these values are within the recited ranges.

[21]: The hot stamped coated steel product according to claim 20, wherein the Superficial layer comprises the following components by weight based on total weight: 39 to 47% Fe, 53 to 61% Al, and 0 to 2% Si, and wherein said layer (a) has a thickness that is less than half of said thickness of the coating.

218. The Outer layers of the modified Takagi coatings, which correspond to the Superficial layer, have or at least render obvious the recited compositions. The Inner layers of the modified Takagi coatings, which correspond to layer (a), have or at least render obvious the recited thickness.

219. With respect to the thickness, see [2] above. With respect to the composition elements, as taught in Takagi Table 1, the Superficial layers of modified Takagi coating Nos. 1 and 4 have compositions of, or similar to, **44.5% Fe, 54.8% Al, 0.8% Si**, and **49.8% Fe, 47.4% Al, 2.2% Si**, respectively. All of the No.1 values are within the recited ranges, directly teaching the elements of claim 21. The No. 4 values deviate from the recited ranges by 2.8%, 5.6%, and 0.2% for Fe%, Al%, and Si%, respectively. Absent evidence of criticality or unexpected results, these values render obvious the claimed ranges for the reasons discussed with respect to [19] and [20] in Section VI.B.

[22]: See [19] above.

[23]: See [20] above.

[24]: The hot stamped coated steel product according to claim 1, wherein the hot stamped coated steel product has a mechanical strength in excess of 1000 MPa.

[25]: The hot stamped coated steel product according to claim 1, wherein the hot stamped coated steel product has a mechanical strength in excess of 1500 MPa.

220. The Takagi-Hein-GMW14400 combination renders obvious that the hot stamped coated steel product has a mechanical strength in excess of 1500 MPa. Hein teaches the benefits of using USIBOR 1500 steel, teaches the desirability of "high strength," and describes that hot-stamping such a steel, using the particular heating and quenching parameters described by Hein, provides "an ultimate tensile strength [UTS] of **1400 Mpa to 1600 MPa**," a range substantially overlapping with the claimed range. EX-1019, 163, 164. Further, GMW14400 requires a minimum tensile strength of 1475 MPa after hot-stamping. EX-1026, Table 3. It would have been obvious for a POSITA to seek to satisfy the requirements of GMW14400 and, with the foreknowledge that strengths of up to 1600 MPa were attainable and based on Hein providing examples of parameters for achieving such strengths, manufacture the modified Takagi parts with a UTS in excess of 1500

MPa. As I described above in Section VI.B, a POSITA would have understood UTS to be an example of "a mechanical strength."

XIII. GROUND 2B: Claim 15 is obvious over Takagi in view of Hein, GM14400, and Vaissiere

A. Combination of Takagi, Hein, GM14400, and Vaissiere and Analysis of [15]: The hot stamped coated steel product according to claim 1, wherein the hot stamped coated steel product is fully martensitic.

[15]: The hot stamped coated steel product according to claim 1, wherein the hot stamped coated steel product is fully martensitic.

221. Takagi, Hein, and GMW14400 in view of Vaissiere render obvious this claim. Vaissiere describes that "pre-coated USIBOR 1500" steel (the same type of steel used by Hein) "is transformed, at the end of forming, into **pure martensite** thus giving very high mechanical characteristics to then finished part." EX-1021, 9. Vaissiere further describes that "[t]he critical [minimum] quenching speed enabling a **completely martensitic structure** [] is **27˚C/s**." EX-1021, 6. This requirement is satisfied by Hein's disclosed "cooling speed **between 50˚C/s and 100˚C/s**" and by nearly all of Takagi's "cooling rate" range of **20˚C/s to 100˚C/s**. EX-1019, 164; EX-1016, [0028]. For reasons similar to those discussed in Section X.B, it would have been obvious to apply Vaissiere's teachings – which already accord with those of Takagi and Hein – to obtain a fully martensitic structure.

222. A POSITA would have naturally increased cooling rate if the microstructure obtained after quenching in the die were not fully martensitic. A POSITA has two levers to target a desired microstructure: composition and thermal history (including cooling rate as a primary factor).

XIV. GROUND 2C: Claims 16-17 are obvious over Takagi in view of Hein, GM14400, and Laurent

A. Combination of Takagi, Hein, GM14400, and Laurent and analysis of [16] and [17]

[16]: The hot stamped coated steel product according to claim 1, wherein the base steel consists of the following components by weight based on total weight: 0.15%<carbon<0.5%; 0.5%<manganese<3%; 0.1%<silicon<0.5%; 0.01%<chromium<1%; titanium<0.2%; aluminum<0.1%; phosphorus<0.1%; sulfur<0.05%; 0.0005%<boron<0.08%; a remainder being iron and impurities inherent in processing.

[17]: The hot stamped coated steel product according to claim 1, wherein the base steel consists of the following components by weight based on total weight: 0.15%<carbon<0.25%, 0.8%<manganese<1.8%, 0.10%<silicon<0.35%, 0.01%<chromium<0.5%, titanium<0.1% aluminum<0.1% phosphorus<0.1% 0.002%<boron<0.005%, a remainder being iron and impurities inherent in processing.

223. As shown in the table below, the "preferabl[e]" "composition by

weight" of Laurent's steel satisfies or renders obvious [16]-[17]. EX-1023, 1:66-2:10. As discussed with respect to these claims in Section XI.B, a POSITA would have found it obvious to try using a steel as disclosed by Laurent in order to realize the "very high mechanical resistance after thermal treatment" disclosed by Laurent. EX-1023, 1:47-62. This modification would have represented only a minor change from the steel composition already taught by GMW14400.

Element	**[16] composition**	**[17] composition**	**GMW1440 composition**	**Laurent composition (col.2)**
C	0.15% < C < 0.5%	0.15% < C < 0.25%	0.20 to 0.25% C	0.20% < C < 0.5%
Mn	0.5% < Mn < 3%	0.8% < Mn < 1.8%	1.00 to 1.35% Mn	0.8% < Mn < 1.5%
Si	0.1% < Si < 0.5%	0.10% < Si < 0.35%	0.15 to 0.35% Si	0.1% < Si < 0.35%
Cr	0.01% < Cr < 1%	0.01% < Cr < 0.5%	0.11 to 0.35% Cr	0.01% < Cr < 1%
Ti	Ti < 0.2%	Ti < 0.1%	[none (satisfied)]	Ti < 0.1%
Al	Al < 0.1%	Al < 0.1%	0.010 min. % Al	Al < 0.1%
P	P < 0.1%	P < 0.1%	0.025 max. %	P < 0.05%
S	S < 0.05%	S < 0.05%	0.010 max. %	S < 0.03%
B	0.0005% < B < 0.08%	0.002% < B < 0.005%	0.0015 to 0.005 wt. %	0.0015% < B < 0.01%
Remainder	"iron and impurities inherent in processing"	"iron and impurities inherent in processing"	iron (implicit); 0.010 max. % N	"iron and impurities inherent in processing"

XV. CONCLUSION

224. The findings and opinions set forth in this declaration are based on my work and examinations to date.

225. I may continue my examinations. I may also receive additional documentation and other factual evidence over the course of this IPR that will allow me to supplement and/or refine my opinions. I reserve the right to add to, alter, or delete my opinions and my declaration upon discovery of any additional information. I reserve the right to make such changes as may be deemed necessary.

226. In signing this declaration, I recognize that the declaration will be filed as evidence in an IPR before the PTAB. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

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

Dated: 9/6/2024 By:

Dr. Michael Miles
Springville, UT

Appendix A

Michael Miles

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Experience

9/19 – Present	Brigham Young University - Provo, UT Professor, Manufacturing Engineering Department
9/13 – 8/19	Brigham Young University - Provo, UT Professor, Manufacturing Engineering Technology Program
9/09 – 12/16	Brigham Young University - Provo, UT Program Chair/Coordinator, Manufacturing Engineering Technology Program
9/07 – 8/13	Brigham Young University - Provo, UT Associate Professor, Manufacturing Engineering Technology Program
7/01 – 8/07	Brigham Young University - Provo, UT Assistant Professor, Manufacturing Engineering Technology Program
1/00 – 7/01	Assistant Plant Manager, Rexam, PLC - Whitehouse, OH
12/98 – 12/99	Engineering Manager, American National Can - Whitehouse, OH
5/98 – 12/98	Senior Project Engineer, American National Can – Elk Grove Village, IL
1/96 – 4/98	Tooling Engineer, American National Can – Elk Grove Village, IL
2/95 – 1/96	Project Engineer, Pechiney Research Center - Voreppe, France

Education

1995, Ph.D. Materials Science and Engineering, Ecole des Mines de Paris

1991, M.S. Metallurgical Engineering, Ohio State University

1989, B.S. Metallurgical Engineering (French minor), University of Idaho

Professional Activities and Awards

2022 - 2025	Melvin and Maxine Chabries Professorship, BYU Ira A. Fulton College of Engineering
2021	American Welding Society, Adams Memorial Membership Award
2018	Excellence in Scholarship Award, BYU Ira A. Fulton College of Engineering
2011-2013	Nominating committee, The Minerals, Metals, and Materials Society (TMS)
2010	Outstanding Faculty Award, BYU School of Technology
2007- 2010	Chair, The Minerals, Metals, and Materials Society (TMS) Shaping and Forming Committee
2009 – 2011	Faculty advisor, Society of Manufacturing Engineers (SME)
2006	First place award in Society of Manufacturing Engineers (SME) manufacturing challenge competition (faculty team advisor)
2004- 2014	Treasurer and Board Member, Society for the Advancement of Materials and Process Engineering (SAMPE) - Utah Chapter
2003-2007	Faculty advisor for BYU chapter of the Society for Advancement of Materials and Process Engineering (SAMPE)
2003	First place award in Society of Manufacturing Engineers (SME) manufacturing challenge competition (faculty team advisor)
1997	Young Leader Intern for The Minerals, Metals, and Materials Society (TMS)

1990-91	Forming Limit Diagram User's Group, North American Deep Drawing Research Group (NADDRG)
1989-91	Parson's Foundation Fellow, National Science Foundation (NSF) Engineering Research Center for Net Shape Manufacturing, Ohio State University
1988	Member of Tau Beta Pi

Program Director - Asia Manufacturing Engineering Study Abroad Program

Began mentored internship study abroad in 2006 with one company in Shanghai, China. By summer of 2019, approximately 100 students had participated in this program at 13 different companies and three countries (China, Taiwan, Vietnam). Manufacturing engineering technology students were the primary participants, but students from mechanical engineering, chemical engineering, construction management, and nursing were also involved in this 6 week program.

Patents

T. Turner, R. Forrest, M. Miles: End Closure with Improved Openability, 2/15/2000, number 6,024,239.

S. Packer, R. Steel, J. Babb, M. Miles, K. Kohkonen: Three-body joining using friction stir processing techniques, 12/7/2010, number 7,845,545.

M. Miles, R. Fleck, R. Steel: Friction bit joining using a friction rivet, 9/19/2017, number 9,764,375.

M.P. Miles and T.W. Nelson: Friction stir additive processing, BYU disclosure 2016-017, 3/28/2016.

Michael P Miles, Rodney Dale Fleck, Russell J Steel, Kevin Alexander Shirley and Shane Forrest Wood: Systems and methods for friction bit joining, 7/11/2023, number 11,697,173.

Expert Witness

Expert for Freshfields, Bruckhaus, Deringer in patent infringement lawsuit, London, England, September 2008 – January 2009.

Expert for Foley & Lardner LLP in patent infringement lawsuit, Washington, DC, July 2008 – October 2009.

Expert for Reed Smith LLP in personal injury lawsuit, Los Angeles, CA, January 2010 – March 2010.

Expert for Lewis and Rocca LLP in breach of contract lawsuit, Albuquerque, NM, January 2011 – July 2011.

Expert for Burr & Forman LLP, Inter Partes Review, March 2015 – May 2015.

Expert for Covington & Burling LLP in trade secret lawsuit, Washington, D.C., December 2016.

Expert for Morgan, Lewis & Bockius, Inter Partes Review, March 2019 – June 2020.

Expert for Dinsmore & Shohl, patent infringement lawsuit, April 2023 – August 2023.

External Funding

PI: "Development of a finite element model to predict bending limits of thick plate AA 2519", Rockwell Scientific (DARPA subcontract), February 2003 ($15K).

PI: "Formability of Friction Stir Welded High Strength Steel Sheet", Society of Manufacturing Engineers Education Foundation, May 2005 ($15K).

PI (with Co-PI Kent Kohkonen): "SGER: Friction Bit Joining - A New Solid State Spot Joining Process", National Science Foundation, July 2008 ($99,435)

Co-PI (with PI David Fullwood and Co-PI Brent Adams): "GOALI: Defect Detection Microscopy: Microstructure Design for Formability of Wrought Magnesium Alloys", National Science Foundation, August 2009 ($319,937)

PI: "Impact of PCBN tool design performance and tool life for DP 980 steel", DOE PNNL subcontract, March 2010 ($36,864)

PI: "Tool life and joint performance for friction stir spot welding of ultra high strength steel using reduced vertical welding loads", DOE PNNL subcontract, July 2011 ($37,616)

PI: "Solid state spot joining of cast iron and aluminum", RE-EV Program, subcontract through Ulsan University, South Korea, August 2011 ($20K)

PI: "High speed friction stir spot welding: A new method for spot joining of ultra high strength steel", National Science Foundation, August 2011 ($260,000)

PI (with Co-PI Paul Higgins): "Friction Bit Joining: A Novel Solution to Dissimilar Metals Joining", TCIP State of Utah, with Megastir Technologies, January 2012 ($40,000)

Co-PI (with PI Zhili Feng): "Body-in-White Joining of Aluminum to Advanced High Strength Steel at Prototype Scale", DOE, with Oak Ridge National Lab and Honda, September 2013 ($240,000)

PI (with Co-PI David Fullwood): "Microscopic Fracture Mechanisms Evaluation for Advanced High Strength Steel", Auto/Steel Partnership, October 2013 ($35,000)

PI (with Co-PI Tracy Nelson): "GOALI: Crack Repair of Irradiated Stainless Steel by Friction Stir Processing", National Science Foundation, March 2014 ($304,999)

Co-PI (with PI David Fullwood): "Microstructural Foundations of Magnesium Performance: A Data Mining Approach to High-Throughput HREBSD", National Science Foundation, September 2014 ($346,362)

PI (with Co-PI David Fullwood): "Microscopic Fracture Mechanisms Evaluation for AHSS", Auto/Steel Partnership, October 2014 ($30,000)

Co-PI (with PI David Fullwood and Co-PI Eric Homer): "GOALI: Deformation Microscopy of Retained Austenite Transformation in TRIP Steels", National Science Foundation, July 2015 ($455,515)

PI (with Co-PIs Tracy Nelson and Carl Sorensen): "Development of a methodology for characterizing the tool/part interface in friction stir welding for improvement of predictive modeling in aluminum alloys" NASA, January 2019 ($500,000)

PI: "Solid-State Body-in-White Spot Joining of Al to AHSS at Prototype Scale (Phase III)", Department of Energy, March 2019 ($200,021)

PI (with Co-PI David Fullwood): “GOALI/Collaborative Research: Strain Gradient Plasticity Modeling to Link Microstructural Non-Local Effects of Dislocation/Interface Interactions with Ductility and Springback”, National Science Foundation, August 2019 ($299,855)

Co-PI (with PI Troy Munro): “Improvement of Modeling Predictions in Friction Stir Welding by More Accurate Measurement of Heat Transfer Between Tooling and Workpiece”, National Science Foundation, December 2019 ($348,402)

Co-PI (with PI Tracy Nelson and Co-PI Yuri Hovanski): “Investigation of friction stir additive repair techniques of AA 7050 for naval application”, Office of Naval Research, July 2020 ($494,916)

Co-PI (with PI David Fullwood): “Collaborative Research: GOALI: Understanding multiscale mechanics of cyclic bending under tension to improve elongation-to-fracture of hexagonal metals”, National Science Foundation, September 2022 ($314,745).

Co-PI (with PI Tracy Nelson): “A study on methods for obtaining materials flow data for the next generation inertia weld parameter optimization model”, General Electric Research Center, July 2023 ($90,000).

Co-PI (with PI Tracy Nelson): “Morphogenic Interfaces”, DARPA/MINT, April 2023 ($160,000).

PI: “Complex Internal Structures in Castings for Extreme Environmental Conditions”, Idaho National Laboratory, October 2023 ($29,545)

Peer-reviewed journal papers (2014-2024): BYU student co-authors underlined

Sajjad Izadpanah Najmabad, David Fullwood, Tristan Russell, Marko Knezevic, Michael Miles (2024). Interpretation of the stress dip test as a means of characterizing backstress: Experiments and backstress-aided crystal plasticity modeling of polycrystalline tantalum, International Journal of Plasticity, Volume 181, pp. 104089.

Nathan Miller, Nicholas Pitkin, Talukder Musfika Tasnim Oishi, Desmond Mensah, Marko Knezevic, Michael Miles, David Fullwood (2024). Multiscale characterization of dislocation development during cyclic bending under tension in commercially pure titanium, Journal of Materials Research and Technology, Volume 32, pp. 2513-2527.

Talukder Musfika Tasnim Oishi, Nick Pitkin, Nathan Miller, Desmond Mensah, David T. Fullwood, Michael P. Miles, Brad L. Kinsey, Marko Knezevic (2024). Influence of specimen width on the elongation-to-fracture in cyclic-bending-under-tension of commercially pure titanium sheets. International Journal of Mechanical Sciences, Volume 278, pp.109447.

Matthew Goodson, Ryan Melander, Michael P. Miles, Troy Munro (2023). Effect of workpiece/tool heat transfer and friction coefficients on accuracy of simulated temperatures and torques in a friction stir welding plunge. Materials 2024, 17, pp. 198

Dane Sargeant, Md Zahidul Sarkar, Rishabh Sharma, Marko Knezevic, David T. Fullwood, Michael P. Miles (2023). Effect of pre-strain on springback behavior after bending in AA 6016-T4: Experiments and crystal plasticity modeling. International Journal of Solids and Structures, Volume 283, pp. 112485.

Derrik Adams, Marcus Behling, Michael P. Miles, Eric R. Homer, Anil K. Sachdev, Emily V. White, David T. Fullwood (2023). Characterization of the Factors Influencing Retained Austenite Stability in Q&P Steels via In Situ EBSD. Metall Mater Trans A 54, pp. 1355–1363.

Rishabh Sharma, Dane Sargeant, Sowmya Daroju, Marko Knezevic, Michael P. Miles, David T. Fullwood (2022). Multi-strain path deformation behavior of AA6016-T4: Experiments and crystal plasticity modeling, International Journal of Solids and Structures, Volumes 244–245, pp.111536.

Sowmya Daroju, Toshihiko Kuwabara, Rishabh Sharma, David T. Fullwood, Michael P. Miles, Marko Knezevic (2022). Experimental characterization and crystal plasticity modeling for predicting load reversals in AA6016-T4 and AA7021-T79, International Journal of Plasticity, Volume 153, pp.103292.

Evan Berger, Michael Miles, Andrew Curtis, Paul Blackhurst, and Yuri Hovanski (2022). 2D Axisymmetric Modeling of Refill Friction Stir Spot Welding and Experimental Validation, Journal of Manufacturing and Materials Processing, 6(4) pp. 89.

Jie Wu, Yuri Hovanski, and Michael Miles (2022). Digital Image Correlation Characterization and Formability Analysis of Aluminum Alloy TWB during Forming, Materials 15(15), pp. 5291.

David Prymak, Michael Miles, Tracy Nelson, Fredrick Michael (2021). A High-Pressure Shear Testing Approach to Measure Flow Stresses Near a Friction Stir Welding Tool, Materials Performance and Characterization, 10(1), pp. 727-738.

Jie Wu, Yuri Hovanski, Michael Miles (2021). Investigation of the Thickness Differential on the Formability of Aluminum Tailor Welded Blanks, Metals, 11(6), pp. 875.

Rishabh Sharma, Camille M Poulin, Marko Knezevic, Michael P Miles, David T Fullwood (2021). Micromechanical origins of remarkable elongation-to-fracture in AHSS TRIP steels via continuous bending under tension, Materials Science and Engineering A, 825, pp. 141876.

Derrik Adams, Michael P Miles, Eric R Homer, Tyson Brown, Raj K Mishra, David T Fullwood (2021). Phase determination in dual phase steels via HREBSD-based tetragonality mapping, Journal of Microscopy, 282(1), pp. 60-72.

Daniel Ellis, Matthew Goodson, Michael Miles, Troy Munro (2021). Optimized Design for a Device to Measure Thermal Contact Conductance During Friction Stir Welding, International Journal of Thermophysics, 42(1), pp. 1-24.

Jason Weaver, John Linn, Michael Miles (2021). Interface Joint Strength between SS316L Wrought Substrate and Powder Bed Fusion Built Parts, Materials, 14(11), p. 3041.

Stephen Cluff, Marko Knezevic, Michael P Miles, David T Fullwood, Raja K Mishra, Anil K Sachdev, Tyson Brown, Eric R Homer (2021). Coupling kinetic Monte Carlo and finite element methods to model the strain path sensitivity of the isothermal stress-assisted martensite nucleation in TRIP-assisted steels, Mechanics of Materials, 154, pp. 1-14.

Derrik Adams, Shamoon Irfan, Jeff Cramer, Michael P Miles, Eric R Homer, Tyson Brown, Raj K Mishra, David T Fullwood (2020). Digital Image Correlation of Forescatter Detector Images for Simultaneous Strain and Orientation Mapping, Microscopy and Microanalysis, 26(4), pp. 641-652.

Isaac Chelladurai, Devin Adams, David T Fullwood, Michael P Miles, Stephen Niezgoda, Irene J Beyerlein, Marko Knezevic (2019). Modeling of trans-grain twin transmission in AZ31 via a neighborhood-based viscoplastic self-consistent model, International Journal of Plasticity, 117, pp. 21-32.

Jason M Weaver, TJ Barton, John Linn, Derrik Jenkins, Michael P Miles, Robert Smith (2019). Quantifying accuracy of a concept laser metal additive machine through the NIST test artifact, Rapid Prototyping Journal, 25(2), pp. 221-231.

M.P. Miles, T.W. Nelson, C. Gunter, F.C. Liu, L. Fourment, T. Mathis (2019). Predicting recrystallized grain size in friction stir processed 304L stainless steel, Journal of Materials Science & Technology, 35(4), pp. 491-498.

T.M. Rampton, S.I. Wright, M.P. Miles, E.R. Homer, R.H. Wagoner, D.T. Fullwood (2018). Improved twin detection via tracking of individual Kikuchi band intensity of EBSD patterns, Ultramicroscopy, 185, 5-14.

J. Cramer, D. Adams, M.P. Miles, D.T. Fullwood, E.R. Homer, T. Brown, R.K. Mishra, A. Sachdev (2018). Effect of strain path on forming limits and retained austenite transformation in Q&P 1180 steel. Materials Science and Engineering A, 734, pp. 192-199.

A. Orme, D.T. Fullwood, M.P. Miles (2018). Evolution of Mg AZ31 twin activation with strain: a machine learning study. Materials Discovery, 12, 20-29.

R. Sharma, I. Chelladurai, A.D. Orme, M.P. Miles, C.G. Giraud-Carrier, D.T. Fullwood (2018). A Step Towards Intelligent EBSD Microscopy: Machine Learning Prediction of Twin Activity in MgAZ31. Journal of Microscopy, 272(1), 67-78.

C.Gunter, M.P. Miles, F.C.Liu, T.W. Nelson (2018). Solid state crack repair by friction stir processing in 304L stainless steel, Journal of Materials Science & Technology, 34(1) 140-147.

F.C.Liu, Y.Hovanski, M.P.Miles, C.D.Sorensen, T.W.Nelson (2018). A review of friction stir welding of steels: Tool, material flow, microstructure, and properties. Journal of Materials Science & Technology, 34(1), 39-57.

Eun-Yeong Ahn, Hrishikesh Das, Sung-Tae Hong, Kyung-Sik Han, Michael Miles, Kwang-Jin Lee, Ju-Won Park, Heung Nam Ha (2017). Process responses and resultant joint properties of friction stir welding of dissimilar 5083 and 6061 aluminum alloys, Journal of Mechanical Science and Technology, 31(8), 3955-3960.

I. Chelladuari, M.P. Miles, D.T. Fullwood, J.E. Carsley, R.K. Mishra, I.J. Beyerlein, and M. Knezevic (2017). Microstructure Correlation with Formability for Biaxial Stretching of Magnesium Alloy AZ31B at Mildly Elevated Temperatures. JOM, 69(5), 907-914.

J-R. Kim, E-Y. Ahn, H. Das, Y-H. Jeong, S-T. Hong, M.P. Miles, and K-J. Lee (2017). Effect of tool geometry and process parameters on mechanical properties of friction stir spot welded dissimilar aluminum alloys, International Journal of Precision Engineering and Manufacturing 18, 445-452.

Y. C. Lim, L. Squires, T.-Y. Pan, M. P. Miles, J. K. Keum, G.-L. Song, Y. Wang, Z. Feng (2017). Corrosion behaviour of friction-bit-joined and weld-bonded AA7075-T6/galvannealed DP980. Science and Technology of Welding and Joining, 22(6), 455-464.

A. D. Orme, I. Chelladurai, T. M. Rampton, D. T. Fullwood, A. Khosravani, M. P. Miles, R. K. Mishra (2016). Insights into twinning in Mg AZ31: A combined EBSD and machine learning study. Computational Materials Science, 124, 353-363.

T. Ruggles, S. Cluff, M.P. Miles, D.T. Fullwood, C. Daniels, A. Avila, M. Chen (2016). Ductility of Advanced High-Strength Steel in the Presence of a Sheared Edge. JOM, 68(7), 1839-1849.

L. Squires, Y.C. Lim, M.P. Miles, Z. Feng (2015). Mechanical properties of dissimilar metal joints composed of DP 980 steel and AA 7075-T6. Science and Technology of Welding and Joining, 20(3), pp. 242-248.

Y.C. Lim, L. Squires, T.-Y. Pan, M.P. Miles, G.-L. Song, Y. Wang, Z. Feng (2015). Study of mechanical joint strength of aluminum alloy 7075-T6 and dual phase steel 980 welded by friction bit joining and weld-bonding under corrosion medium. Materials & Design, 69(15), pp. 37-43.

T. Hartman, M.P. Miles, S.-T. Hong, R. Steel, S. Kelly (2015). Effect of PCBN tool grade on joint strength and tool life in friction stir spot welded DP 980 steel. Wear, 328-329, pp. 531-536.

D.T. Fullwood, A. Khosravani, J. Scott, M.P. Miles, R. Mishra (2015). Nucleation and propagation of twins in AZ31 magnesium alloy. Acta Materialia, 100, pp. 202-214.

M.P. Miles, U. Karki, and Y. Hovanski (2014). Temperature and Material Flow Prediction in Friction Stir Spot Welding of Advanced High Strength Steel. JOM, 66 (10), pp. 2130-2136.

N. Saunders, M. Miles, T. Hartman, Y. Hovanski, S.T. Hong, R. Steel (2014). Joint Strength in High Speed Friction Stir Spot Welded DP 980 Steel. International Journal of Precision Engineering and Manufacturing, 15(5), pp. 841-848.

Md. Abu Mowazzem Hossain, Md. Tariqul Hasan, Sung-Tae Hong, Michael Miles, Hoon-Hwe Cho, Heung Name Han (2014). Mechanical Behaviors of Friction Stir Spot Welded Joints of Dissimilar Ferrous Alloys under Opening-Dominant Combined Loads. Advances in Materials Science and Engineering, pp. 179-193.

Md. Abu Mowazzem Hossain, Md. Tariqul Hasan, Sung-Tae Hong, Michael Miles, Hoon-Hwe Cho, Heung Name Han (2014). Failure Behaviors of Friction Stir Spot Welded Joints of Dissimilar Ferrous Alloys under Quasi-Static Shear Loads. International Journal of Materials and Product Technology, 48 (1-4), pp. 179-193.

Book Chapters with Peer Review

M. Miles: Formability Testing of Sheet Metals, ASM Handbook, vol. 14B, pp. 673-696 (2006). (Chapter was revised and updated)