UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

BÖHLER-EDELSTAHL GMBH & CO. KG.,
Petitioner,

v.

ROVALMA, S.A.
Patent Owner.

Case IPR2015-00150
Patent 8,557,056 B2

Before MICHAEL P. TIERNEY, RAMA G. ELLURU, and
ROBERT A. POLLOCK *Administrative Patent Judges*.

POLLOCK, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

I. INTRODUCTION

Petitioner, BÖHLER Edelstahl GmbH & Co. KG ("BÖHLER Edelstahl"), filed a Petition requesting *inter partes* review of claims 1–4 of U.S. Patent No. 8,557,056 B2 ("the '056 patent"). Paper 1 ("Pet."). Patent Owner, Rovalma, S.A. ("Rovalma"), filed a Preliminary Response. Paper 12 ("Prelim. Resp."). We determined that there was a reasonable likelihood that Petitioner would prevail in challenging those claims as unpatentable. Pursuant to 35 U.S.C. § 314, therefore, we authorized an *inter partes* review to be instituted, on April 22, 2015. Paper 14 ("Dec.").

After institution, Patent Owner filed a Patent Owner Response (Paper 25, "PO Resp."), and Petitioner filed a Reply (Paper 30, "Reply"). Patent Owner also filed objections to Petitioner's exhibits 1013, 1013 (corrected), and 1014. Paper 27.

An oral hearing was held on February 12, 2016. A transcript of the hearing has been entered into the record of the proceeding as Paper 41 ("Tr.").

We have jurisdiction under 35 U.S.C. § 6(b). This Final Written Decision is issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73.

For the reasons that follow, we determine that Petitioner has shown by a preponderance of the evidence that claims 1–4 of the '056 patent are unpatentable.

A. Related Matters

The ’056 patent is not currently asserted in any parallel proceeding. Pet. 2; Tr. 64:13–15.

B. The ’056 patent

The ’056 patent involves hot-work steel that has a high thermal conductivity for use as tool steel. Ex. 1001, Abstract. Hot-work steels are used for producing hot-work steel objects (e.g., extrusion and die-casting dies, forging tools, and punches) and, therefore, need to have special mechanical strength properties at high working temperatures. Ex. 1001, 1:18–25. For example, hot-work tools produced from hot-work steel, along with having adequate hardness and strength, “must have not only high mechanical stability at relatively high working temperatures[,] but also good thermal conductivity and good high-temperature wear resistance.” *Id.* at 1:31–37.

The Specification of the ’056 patent reveals that tool steels typically have a thermal conductivity of about 18 to 24 W/mK at room temperature, and “conductivities of the hot-work steels known from the prior art are approximately 16 to 37 W/mK.” *Id.* at 1:48–52. A problem that the ’056 patent sought to solve is the inadequacy of thermal conductivity for various applications. *Id.* at 4:11–19. The Specification addresses this problem by providing: (1) a hot-work steel composition having high thermal conductivity, as well as; (2) a process by which a specific thermal conductivity of hot-work steel can be achieved. *Id.* at 4:23–31; 6:41–44.

With respect to the former, the ’056 patent provides three general chemical formulas for hot-work tool steel compositions (*id*. at 5:1–60) and five Examples of hot-work steel alloys suitable for particular applications (*id*. at 14:20–16:28). In addition to iron and “unavoidable impurities,” “the tool steel according to the invention contains the elements C (or C and N or C, N, and B), Cr, Mo and W[1] in the ranges [>2% by weight, 0 to 10% by weight, and 0 to 15% by weight, respectively].” *Id.* at 5:64–6:1. High thermal conductivity may be achieved by minimizing chromium and carbon in the steel matrix. *Id.* at 6:5–9. “Chromium can only be kept out of the matrix, by not being present at all. Carbon can be bound in particular with carbide formers, where Mo and W are the lowest-cost elements and, both as elements and as carbides, have a comparatively high thermal conductivity.” *Id*. at 6:9–13; *see also id.* at 12:16–20 (“A depletion of chromium together with the reduction in the carbon content in the matrix leads to an improved thermal conductivity, in particular if this is brought about by tungsten and/or molybdenum carbides.”); 6:49–61 (disclosing additional carbide formers); 7:6–13.

Carbides are crystalline particles of carbon bonded to other elements such as tungsten, chromium, vanadium, and molybdenum and embedded within the solid solution steel matrix (*see, e.g.*, PO Resp. 2–3; Ex. 1001 6:49–61) as illustrated below in Figure 1 of the ‘056 patent.

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[1] Chromium, molybdenum, and tungsten, respectively.

FIG. 1

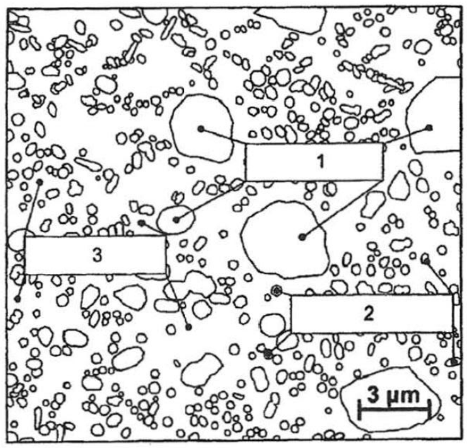

Figure 1 is a schematic of primary carbides 1 and secondary carbides 2 embedded in iron-rich metallic matrix 3. *Id.* at 7:41–51. The Specification discloses that the thermal conductivity depends largely on the structure of carbides within the matrix, wherein the generation of relatively large and elongated carbides is "particularly advantageous" in increasing the overall thermal conductivity of the steel. *See* Ex. 1001 at 6:62–65, 7:36– 8:35; PO Resp. 9, 22.

In addressing the process by which a specific thermal conductivity of hot-work steel can be achieved, the Specification teaches the selection of production conditions to "influence the resultant carbide size," and, thus affect the thermal conductivity of the steel. *See* Ex. 1001, 12:21–38. Table 6 of the Specification, for example, demonstrates that different heat treatments—in this case, austenitizing temperatures and cooling protocols—result in different thermal properties.[2] *Id.* at 17:47–55, 21:24–36.

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[2] We note, however, that the Specification does not indicate how, or whether, the differences in thermal conductivity shown in Figure 6 relate to

According to the Specification, the disclosed process for setting thermal conductivity in hot-work steel to a desired value entails metallurgically creating an internal structure of the steel "in a defined manner such that the carbidic constituents thereof have a defined electron and phonon[3] density and/or the crystal structure thereof has a mean free length of the path for the phonon and electron flow that is determined by specifically created lattice defects." *Id.* at 4:36–47. The resulting internal structure of carbidic constituents may thus provide:

> an increased electron and phonon density and/or which has as a result of a low defect content in the crystal structure of the carbides and of the metallic matrix surrounding them an increased mean free length of the path for the phonon and electron flow. This measure . . . allows the thermal conductivity of a steel to be set in a defined manner.

Id. at 4:50–63.

C. Illustrative Claim

Of the challenged claims, claims 1 and 4 are independent. Claim 1, reproduced below, is illustrative (italics added):

Figure 1 or any aspect of internal structure. *See* Tr. 101:21–103:7.

[3] "Heat is transported through metals and alloys by phonons and free electrons." Exhibit 2009, 265 (Bayati and Elliott, *Influence of matrix structure on physical properties of an alloyed ductile cast iron*, 15 MAT. SCI. TECH. 265 (1999)). According to Encyclopaedia Britannica online, a phonon is a discrete unit of vibrational mechanical energy arising from the oscillation of atoms within a crystal. "Whereas electrons are responsible for the electrical properties of materials, phonons determine such things as the speed of sound within a material and how much heat it takes to change its temperature." http://www.britannica.com/EBchecked/topic/457336/phonon (last visited April 20, 2015).

1. A process for setting a thermal conductivity of a hot-worksteel, which comprises the steps of:

   providing a hot-work steel, including carbidic constituents and, by weight, 2–10% Mo+W+V;

   metallurgically creating an internal structure of the steel in a defined manner such that carbidic constituents thereof have at least one of a defined electron and phonon density and a crystal structure thereof having a mean free length of a path for a phonon and electron flow being determined by specifically created lattice defects;

   selecting:

   a) a surface fraction and thermal conductivity of the carbidic constituents and a particular surface fraction and thermal conductivity of a matrix material containing the carbidic constituents; or

   b) a volume fraction and thermal conductivity of the carbidic constituents and thermal conductivity of the matrix material containing the carbidic constituents; and

   setting the thermal conductivity of the steel at room temperature to more than 42 W/mK.

Ex. 1001, 21:59–22:14. Depending from claim 1, claims 2 and 3 recite the steps of setting the thermal conductivity of the steel at room temperature to more than 48 W/mK and 55 W/mK, respectively.

D. *Instituted Grounds of Unpatentability*

We instituted the instant trial based on the following grounds of unpatentability (Dec. 18–19):

Claims	**Basis**	**References**
1–4	§ 103(a)	EP ’813[4] and CH ’893[5]
1–4	§ 103(a)	EP ’813 and JP ’241[6]
1–4	§ 103(a)	EP ’813 and JP ’650[7]
1, 2, and 4	§ 103(a)	EP ’813 and JP ’706[8]

II. ANALYSIS

A. Claim Construction

In an *inter partes* review, the Board interprets a claim term in an unexpired patent according to its broadest reasonable construction in light of the specification of the patent in which it appears. 37 C.F.R. § 42.100(b); *In re Cuozzo Speed Techs., LLC*, 793 F.3d 1268, 1275–79 (Fed. Cir. 2015), *cert. granted sub nom. Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 890 (mem.) (2016). Under that standard, and absent any special definitions, we assign claim terms their ordinary and customary meaning, as would be understood by one of ordinary skill in the art at the time of the invention, in the context of the entire patent disclosure. *In re Translogic Tech., Inc.*, 504

[4] European Patent EP 0,787,813 B1. Ex. 1003.
[5] Swiss Patent CH 165,893. Ex. 1002.
[6] Japanese Patent App. Pub. JP 1988-282241. Ex. 1004.
[7] Japanese Patent Publication H11-222650. Ex. 1005.
[8] Japanese Patent App. Pub. H04-147706. Ex. 1006.

F.3d 1249, 1257 (Fed. Cir. 2007). An inventor may rebut that presumption by providing a definition of the term in the specification with reasonable clarity, deliberateness, and precision. *In re Paulsen*, 30 F.3d 1475, 1480 (Fed. Cir. 1994). In the absence of such a definition, limitations are not to be read from the specification into the claims. *In re Van Geuns*, 988 F.2d 1181, 1184 (Fed. Cir. 1993). Only terms which are in controversy need to be construed, however, and then only to the extent necessary to resolve the controversy. *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999).[9]

For the reasons provided below, we construe the challenged process claims 1–4 to require carbidic constituents and by weight 2–10% Mo+W+V (molybdenum + tungsten + vanadium). Additionally, we construe the challenged process claims as requiring the setting of the thermal conductivity at room temperature to more than 42 W/mK (watts per square meter of surface area). Based on the evidence of record, however, we hold that that the claims are not limited to particular heat-treatment (thermo-mechanical) processing conditions. Tr. 53:24–56:5. We also hold that the claims are not limited to specific amounts of chromium, carbon, combined amounts of carbon and nitrogen, or combined amounts of carbon, nitrogen and boron. Pet. 6. Specifically, Petitioner has failed to demonstrate on this record that we are required to read limitations into the claims from the specification. *Comark Commc'ns, Inc. v. Harris Corp.*, 156 F.3d 1182, 1186

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[9] In considering the meaning and patentability of the challenged claims, we do not address indefiniteness or enablement under 35 U.S.C. § 112.

(Fed. Cir. 1998) ("[F]ine line between reading a claim in light of the specification, and reading a limitation into the claim from the specification.").

In the instant proceeding, BÖHLER Edelstahl proposes a construction of the process steps in claims 1–4 in terms of the composition of the hot-work steel as set forth in the '056 patent. BÖHLER Edelstahl states that

> [a]ccording to the '056 specification, the claimed process for selecting a thermal conductivity of a hot-work steel, and the individual process steps, are carried out by selecting a specific composition of the steel. Aside from selecting the steel composition, the '056 specification enables no other way to carry out the process steps.

Pet. 4. For instance, BÖHLER Edelstahl asserts that the '056 patent Specification provides no measuring techniques, values, or range of values for electron density, phonon density, mean free path length for phonon and electron flow, surface fraction of carbidic constituents, thermal conductivity of carbidic constituents, particular surface fraction of matrix material, thermal conductivity of matrix material, or volume fraction of carbidic constituents. *Id.* at 8–9.

Specifically, BÖHLER Edelstahl posits that the following steps of the process of claim 1 should be construed to mean a particular hot-work steel composition: (1) step 2 — "metallurgically creating an internal structure of the steel in a defined manner such that carbidic constituents thereof have at least one of a defined electron and phonon density and a crystal structure thereof having a mean free length of a path for a phonon and electron flow being determined by specifically created lattice defects;" and (2) step 3 —

"selecting: (a) a surface fraction and thermal conductivity of the carbidic constituents and a particular surface fraction and thermal conductivity of a matrix material containing the carbidic constituents; or (b) a volume fraction and thermal conductivity of the carbidic constituents and thermal conductivity of the matrix material containing the carbidic constituents." Ex. 1001, 21:64–22:11. To construe these limitations, BÖHLER Edelstahl relies on the statement in the '056 patent that carbon and chromium in the solid solutions state lead to matrix distortion, and therefore, a matrix depleted of carbon and chromium increases the thermal conductivity of the steel. Pet. 6 (citing Ex. 1001, 6:14–28).

Because the amounts of Mo, W, and V are separately recited in claim 1 and no values or ranges are provided for electron density, phonon density, mean free path length for phonon and electron flow, surface area, or volume fraction (which depends on the steel composition), BÖHLER Edelstahl asserts that these steps are limited to the remaining elements of the hot-work steel composition other than Mo, W, and V, and correspond to "providing said hot-work steel composition further including less than 2% by weight Cr and any of (a) 0.26 to 0.55% by weight C, (b) 0.25 to 1.00% by weight C and N in total, or (c) 0.25 to 1.00% by weight C, N and B in total." Pet. 6, 8–9, 13.

BÖHLER Edelstahl asserts that this same hot-work steel composition also corresponds to the following steps in claim 4: (1) step 2a — "metallurgically creating an internal structure of the steel in a defined manner such that it has in its carbidic constituents an increased electron and phonon density and/or which has a result of a low defect content in a crystal structure of carbides and of a metallic matrix surrounding them an increased mean free length of a path for a phonon and electron flow;" and (2) step 3 — "selecting: (a) a surface fraction and thermal conductivity of the carbidic constituents and a particular surface fraction and thermal conductivity of a matrix material containing the carbidic constituents; or (b) a volume fraction and thermal conductivity of the carbidic constituents and thermal conductivity of the matrix material containing the carbidic constituents." Ex. 1001, 22:26–60; *see* Pet. 7–10, 14. As support, BÖHLER Edelstahl notes that the recited optional "low defect content in a crystal structure of carbides and of a metallic matrix surrounding them," requires at least some defects in the crystal structure, which is minimized by reducing the chromium content. Pet. 7–8 (quoting Ex. 1001, 10:16–27).

As to the fourth and final step that claims 1 and 4 have in common, "setting the thermal conductivity of the steel at room temperature to more than 42 W/mK," BÖHLER Edelstahl posits that this limitation should be construed as follows:

> [A] fair construction of process step (4) is to provide a hot-work steel composition (already limited by the compositions defining process steps (1)–(3)) that is further limited by the additional ingredients and ranges defining the three operable compositions:
>
> > providing said hot-work steel composition, wherein the content of W and Mo in total amounts to at least 1.8% by weight and the amount of V is from 1 to 4% by weight, further including carbide-forming elements Ti, Zr, Hf, Nb, Ta with a content of from 1 to 3% by weight individually or in total,
> >
> > > 0 to 6% by weight Co,
> > > 0 to 1.6% by weight Si,

> 0 to 2% by weight Mn,
> 0 to 2.99% by weight Ni,
> 0 to 1% by weight S, and
> remainder, iron and unavoidable impurities.

Pet. 10–11, 13–15. As support, BÖHLER Edelstahl notes that the ’056 patent Specification describes how thermal conductivity is affected not only by the type and amount of carbide forming elements and the amount of chromium, but also the additional elements in the matrix. Pet. 10 (quoting Ex. 1001, 9:56–65). BÖHLER Edelstahl concludes that “[a]side from selecting a specific steel composition, the ’056 specification reveals no specific manufacturing techniques needed to practice the claimed process.” Pet. 12. BÖHLER Edelstahl’s constructions for the two independent claims 1 and 4 are identical.

Finally, BÖHLER Edelstahl proposes a construction of the limitation of claim 2, “setting the thermal conductivity of the steel at room temperature to more than 48 W/mK,” as requiring a chromium content of 0.5% by weight or less, and the limitation of claim 3, “setting the thermal conductivity of the steel at room temperature to more than 55 W/mK,” as requiring a chromium content of 0.3% by weight or less. Pet. 12.

Rovalma responds that the challenged claims are process claims, not composition claims, and should be construed as such, not limited to a particular composition. Specifically, Rovalma states that

> [t]he thermal conductivity of the material is set in accordance with the claimed invention, namely, by selecting the components Mo+W+V, by metallurgically creating the specific internal structure to define the conductance behavior of the carbidic constituents, by selecting either a given surface fraction and thermal conductivity of the carbidic constituents or the relative

> volume fractions and thermal conductivity of the carbidic constituents and the matrix, and by setting the thermal conductivity to more than 42 W/mK.

Prelim. Resp. 6–7. Rovalma asserts that the thermal conductivity of a steel having carbidic constituents can be set by acting on the internal structure of the steel *regardless* of the specific steel composition. *Id.* at 6, 10, 13. "In other words, the thermal conductivity of a steel having a specific composition can be set to different values by following the process steps claimed in the '056 Patent." *Id.* at 13. Consistent with their plain language, we construe the "setting" step of the challenged claims as requiring the setting of the thermal conductivity at room temperature to more than, e.g., 42 W/mK.

Rovalma further argues that the step of "metallurgically creating an internal structure of the steel in a defined manner" should be construed to mean "heat treating the steel . . . under specific conditions selected to achieve the desired internal structure[,]" "and hence thermal conductivity." PO. Resp. 38, 39. Rovalma argues that "the 'defined manner' will differ based on the steel composition used, the desired thermal conductivity, and the specific hot-work application for the tool steel." *Id.* at 39–40.

In support of this construction, Rovalma asserts that one of ordinary skill in the art would have known that chemical "composition is just one factor that affects the steel's final internal structure. It is a fundamental principle that the thermal processing conditions applied to the tool steel will affect the internal structure of the finished tool steel." *Id*. at 39 (citing Ex.

2006 43); *see* Tr. 49:18–51:16, 52:20–23, 53:24–54:6.[10] Rovalma further argues that the subsequent "selecting" and "setting" steps of the challenged claims further inform the "defined manner" in which the steel is treated to create the final internal structure and thermal conductivity. PO. Resp. 46–47. With the limited exception of Table 6, discussed above, the '056 Specification discloses no specific manufacturing protocol for the practice of the invention. Consistent with this lack of guidance regarding how to treat steel to create the desired internal structure and thermal conductivity, we do not find the claims limited to particular heat-treatment (thermo-mechanical) processing conditions.

Prior art cited by Rovalma, however, underscores that one of ordinary skill in the art recognized that thermal processing conditions affect internal structure and, thus, thermal properties. Bayati and Elliot, for example, teach that heat transport "depends on lattice defects, microstructure, impurities, and the processing of the metal or alloy," and that matrix structure "play[s] a significant role" in determining thermal conductivity. Ex. 2009, 265; *see also id.* (noting that matrix structure changes "which occur during heating and promote ferrite formation (such as tempering of martensite and the stage II reaction in the austempered matrix structure) increase the thermal conductivity" of ductile iron); *id* at 266 ("The results for the ductile iron

[10] Rovalma further demonstrates this principle using the Netzsch Report (Ex. 2003) (showing that thermo-mechanical processing of a steel composition can affect microstructure and thermal conductivity). *See* PO Resp. 25–27.

show that the matrix structure makes a significant contribution to the thermal conductivity").

Moreover, as discussed at pages 2–4 of the Patent Owner Response, the generation of carbides in metal matrices was well understood such that by "[u]sing equilibrium phase diagrams and knowing the effects of processing operations, those skilled in the art can predict which carbides will be present in a given steel and their microstructural distributions following various heat treatments." PO. Resp. 4 (citing Exs. 2005,[11] 2006[12]). Similarly, readily available tools such as the Thermo-Calc software package enabled "those skilled in the art to model the formation and precipitation of carbides in multi-component alloys." *Id*. at 5 (citing Ex. 2006). Accordingly, we accept Rovalma's assertion that at the time of the invention, "one skilled in the art could model the formation and precipitation of carbides within steel as a function of time and temperature." PO Resp. 5, n.1.

BÖHLER Edelstahl, relying on Table 6 and column 17, lines 43 through 46 of the Specification, argues that the '056 patent Specification teaches that the *basic setting* of thermal conductivity is obtained by *chemical composition*, and only an additional *fine setting* is achieved by different thermal treatments." Reply 9–11. To the extent this may be true, the challenged claims merely require that the chemical composition of the steel

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[11] ASM Materials Engineering Dictionary, pages 57, 156, 448, 449, 477, 490, and 491 (J. R. Davis ed., 1992).
[12] George Roberts et al., Tool Steels 45–107 (5^{th} ed. 1998).

include carbidic constituents and 2–10% by weight of molybdenum, tungsten, and/or vanadium. In the present case, we are not persuaded that additional compositional limitations should be imported into the claims. *See SuperGuide Corp. v. DirecTV Enters., Inc.*, 358 F.3d 870, 875 (Fed. Cir. 2004). ("Though understanding the claim language may be aided by the explanations contained in the written description, it is important not to import into a claim limitations that are not a part of the claim. For example, a particular embodiment appearing in the written description may not be read into a claim when the claim language is broader than the embodiment.")

Read in the context of the understanding of one of ordinary skill in the art at the time of the invention, we do not agree with BÖHLER Edelstahl that the claims should be construed to correspond to specific compositions set forth in the Specification of the '056 patent, or that the claims are limited to specific amounts of chromium, carbon, combined amounts of carbon and nitrogen, or combined amounts of carbon, nitrogen and boron. Rather, we construe the step of "metallurgically creating an internal structure of the steel in a defined manner" as "heat treating the steel under conditions selected to achieve the internal structure defined by the 'selecting' steps, and which result in the recited thermal conductivity of the steel at room temperature."

B. *Obviousness of Claims 1–4 over EP '813 in Combination With Other References*

BÖHLER Edelstahl asserts that claims 1–4 are unpatentable under 35 U.S.C. § 103(a) as obvious over the EP '813 used in individual combination with four other references. Pet. 32–59.

a. Overview of Asserted References

EP ’813 discloses low chromium, heat-resistant ferritic steels having advantages including “higher toughness, thermal conductivity and weldability” as compared to high chromium ferritic steels. Ex. 1003, 2:16–20, 4:7–16. Tables 2 and 3 of the reference disclose the chemical composition of low chromium steels having a carbon component. *Id.* 10–11. Example 8 comprises, by weight, 1.07% chromium, 0% molybdenum, 2.61% tungsten, and 0.21% vanadium. *Id.* at 10. Example 32 comprises, by weight, 0.98% chromium, 1.05% molybdenum, 1.01% tungsten, and 0.23% vanadium. *Id.* at 11. Accordingly, we find that EP ’813 Examples 8 and 32 each include “carbidic constituents” (i.e., carbon in conjunction with carbide formers such as chromium, tungsten, and vanadium) and, “by weight, 2–10% Mo+W+V” as set forth in the challenged claims. *See* PO. Resp. 58 (admitting that “the prior art disclosed ‘providing a hot-work steel, including carbidic constituents and, by weight, 2-10% Mo+W+V’—step 1 of the challenged claims”).

As with EP ’813, CH ’893 discloses low-chromium steel compositions having valuable characteristics including “relatively high hot tensile strength, toughness and resistance against temperature variations.” Ex. 1002, p. 1 ¶3, p. 3, ¶ 6. The second embodiment disclosed on page 4 of the reference comprises 0.27% carbon, 3.32% tungsten, and no chromium, molybdenum or vanadium. CH ’893 thus discloses the benefit of high thermal conductivity (“resistance against temperature variations”) and at least one embodiment comprising “carbidic constituents and, by weight, 2–10% Mo+W+V” as set forth in the challenged claims.

JP ’241 discloses low chromium steels having, e.g., improved high temperature abrasion. Ex. 1004, 2–3. Claim 2 of the reference encompasses a steel composition comprising, by weight, “C: 0.10–0.40%, Si: 0.10–1.00%, Mn: 0.20–2.00%, Cr: less than 0.95%, Mo: 0.50–3.50%, W: 0.50–3.50% and Nb: 0.10–1.00%, and further containing more than one or two variations selected from Ni: 0.50-3.50%, Co: 0.50–3.50% and V: 0.10–1.00%.” *Id.* at 2, claim 2. JP ’241 thus discloses steel compositions comprising “carbidic constituents and, by weight, 2–10% Mo+W+V” as set forth in the challenged claims.

JP ’706 discloses a low chromium steel plug compositions B and C for seamless pipe manufacturing comprising 0.30% carbon, 0.5% chromium, 1.50% molybdenum, 2.00% and 3.00% tungsten, respectively, and no vanadium. Ex. 1006, Table 1. Accordingly, JP ’706 discloses steel compositions comprising “carbidic constituents and, by weight, 2–10% Mo+W+V” as set forth in the challenged claims.

JP ’650 discloses alloy steel having excellent forgeability and wear resistance comprising, e.g., M_6C carbides and amounts of molybdenum, tungsten, and vanadium within the claimed range. Ex. 1005 ¶ 4. As set forth in Table I of the reference, composition No. 2 comprises 0.31% carbon, 0.03% chromium, 6.01% molybdenum, 0.87% tungsten, and 3.04% vanadium. *Id.* ¶ 16. Accordingly, JP ’650 discloses steel compositions comprising “carbidic constituents and, by weight, 2–10% Mo+W+V” as set forth in the challenged claims.

b. Application of Asserted References in View of Knowledge in the Art

Rovalma argues that the ’056 patent “teaches you to go after microstructures [as shown in Figure 1] that have carbides that have high thermal conductivity, maximize their proportion in the overall final structure, and eliminate some of the defects in the matrix.” Tr. 50:4–24. According to Rovalma, “[o]nce you know the types of carbides you want and the types of crystalline structures in the various phases of steel you want, that can be predicted based on this simulation software that’s built on years of experimental analysis of the different phases and so on.” Tr. 75:2–8. In other words, concludes Rovalma, once the desired microstructure is known, “[t]he simulation software would tell you how hot you have to heat during austenitization, how quickly should you quench it.” *Id*. at 75:13–15.

Although the asserted references establish that steel formulations having the chemical composition required by the challenged claims were well known, Rovalma argues that:

> [n]one of the references consider that the thermal conductivity of a steel is a resultant characteristic of the steel’s microstructure, or more specifically, that it can be determined as a function of the area (or volume) fractions of the carbide and of the matrix material, together with the thermal conductivity of the matrix and the thermal conductivity of the carbides. Even more importantly, none of the references suggest setting the thermal conductivity of a hot-work steel by manipulating the steel’s microstructure in a defined manner.

PO. Resp. 56.

We do not find Rovalma’s argument persuasive.

As noted above, one of ordinary skill in the art at the time of the invention would have recognized that thermal processing conditions affect internal structure and, thus, thermal properties of steel. Bayati and Elliot, for example, teach that heat transport "depends on lattice defects, microstructure, impurities, and the processing of the metal or alloy," and that matrix structure "play[s] a significant role" in determining thermal conductivity. Ex. 2009, 265; Tr. 67:3–13. As Rovalma further explains at page 7 of its Patent Owner Response,

> Heat is transported through metals by phonons and free electrons. Ex. 2009 at 265. In pure metals, heat transfer is primarily influenced by the metal's free electrons. *Id.* Lattice defects and impurities in a metal or alloy scatter the electrons within the metallic matrix, thus reducing the rate that heat can transfer through the metal. *Id.* In non-metals such as carbides, thermal conductivity is primarily influenced by vibration within the lattice of atoms or molecules (these vibrations are referred to by the quantum mechanical term "phonon"). *Id.*; Paper 14 at 3.

Concurrent with this understanding of heat transfer through metallic matrices and metal carbide inclusions, one of ordinary skill in the art would also have understood that "optimization of the microstructure has been known for a long time." Tr. 66:9–16; *see* PO Resp. 5 (citing Ex. 2006); *id.* at n.1). Thus, "[u]sing equilibrium phase diagrams and knowing the effects of processing operations, those skilled in the art [could] predict which carbides will be present in a given steel and their microstructural distributions following various heat treatments." PO Resp. 4 (citing Exs. 2005, 2006). Similarly, "readily available thermo-chemical databanks and software programs such as Thermo-Calc, allow[ed] those skilled in the art to model the formation and precipitation of carbides in multi-component alloys." *Id.* at 5 (citing Ex. 2006) (referencing footnote 1); *see* Tr. 75:10–15.

Because EP '813 and other asserted references disclose steel compositions comprising the claimed "carbidic constituents and, by weight, 2-10% Mo+W+V," along with the desirability of steels having high thermal conductivity, the skilled artisan would have had reason to increase the thermal conductivity of these compositions. Given the understanding in the art regarding heat transfer through metallic matrices and entrained metal carbides, and the ability to model the effects of thermal processing on steel alloy microstructure, one of ordinary skill in the art would have had a reasonable expectation of success in arriving at the claimed invention. Having thus "set" the claimed "thermal conductivity of the steel at room temperature [of] more than [e.g.,] 42 W/mK," the skilled artisan would have at least inherently completed the "selecting" steps set forth in the challenged claims.

Accordingly, we find claims 1–4 of the '056 patent obvious over the asserted prior art as read in light of the knowledge of the ordinarily skilled artisan.

III. PATENT OWNER'S OBJECTIONS TO PETITIONER'S EXHIBITS

Rovalma objects to Exhibits 1013 (original), 1013 (corrected), and 1014 on grounds relating to the certification of translations. Paper 27. We dismiss Rovalma's objections as moot because we do not rely on any of the objected-to Exhibits in our Final Decision.

IV. CONCLUSION

Petitioner has demonstrated by a preponderance of the evidence that claims 1–4 of the ’056 patent are unpatentable under 35 U.S.C. § 103(a) as obvious over EP ’813 used in individual combination with CH ’893, JP ’241, JP ’650, or JP ’706.

V. ORDER

For the foregoing reasons, it is

ORDERED that claims 1–4 of the ’056 patent are held unpatentable;

FURTHER ORDERED that Patent Owner’s Objections to Petitioner’s Exhibits are dismissed as moot; and

FURTHER ORDERED that because this is a final decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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