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DECISION ON APPEAL

Appellant\(^1\) requests our review under 35 U.S.C. § 134(a) of the Examiner’s decision to reject claims 1–3.\(^2\) We have jurisdiction over this appeal under 35 U.S.C. § 6(b).

We REVERSE.

\(^1\) We use the word “Appellant” to refer to the “applicant” as defined in 37 C.F.R. § 1.42. Appellant identifies JFE Steel Corporation as the real party in interest. Appeal Brief filed January 15, 2019 (“Appeal Br.”) at 1.

\(^2\) Non-Final Office Action entered July 18, 2018 (“Office Act.”) at 1.
CLAIMED SUBJECT MATTER

Appellant claims a method of manufacturing a grain-oriented electrical steel sheet. Appeal Br. 1–3. Independent claims 1 and 3 illustrate the subject matter on appeal, and read as follows:

1. A method of manufacturing a grain-oriented electrical steel sheet, the method comprising:
   - measuring a thickness $t$, in millimeters, and a flux density of a first steel sheet;
   - determining an irradiation energy per unit scanning length $E_{w_{\text{min}}}(0.23)$, in Joules per meter, of a second steel sheet having a thickness of 0.23 millimeters that produces a minimum amount of iron loss from the second steel sheet, the flux density of the second steel sheet being the same as the flux density of the first steel sheet;
   - adjusting an irradiation energy per unit scanning length $E(t)$, in Joules per meter, of an electron beam to satisfy the following Expression (1) for the first steel sheet,
     \[
     E_{w_{\text{min}}}(0.23) \times (1.61 - 2.83 \times t) \leq E(t) \leq E_{w_{\text{min}}}(0.23) \times (1.78 - 3.12 \times t) \quad \ldots \quad \text{Expression (1)};
     \]
   - thereafter irradiating a surface of the first steel sheet to obtain a grain-oriented electrical steel sheet from the first steel sheet with an adjusted electron beam in a direction intersecting a rolling direction.

3. A method of manufacturing a grain-oriented electrical steel sheet, the method comprising:
   - measuring a thickness $t$, in millimeters, and a flux density of a first steel sheet, wherein the thickness $t$ of the first steel sheet is 0.23 mm or more;
   - determining a line spacing $s_{\text{min}}(0.23)$, in millimeters, for a second steel sheet having a thickness of 0.23 millimeters that produces a minimum amount of iron loss from the second steel sheet, the flux density of the second steel sheet being the same as the flux density of the first steel sheet;
   - adjusting a line spacing $s(t)$ in millimeters of an electron beam to satisfy the following Expression (2),
smin(0.23)/(1.78 - 3.12 x t) \leq s(t) \leq smin(0.23)/(1.61 - 2.83 x t) \ldots \text{Expression (2)}; \text{ and} 

thereafter irradiating a surface of the first steel sheet to obtain a grain-oriented electrical steel sheet from the first steel sheet with an adjusted electron beam in a direction intersecting a rolling direction.

Appeal Br. 16–17 (Claims Appendix) (emphasis added).

REJECTIONS

The Examiner maintains the following rejections in the Examiner’s Answer entered May 13, 2019 (“Ans.”):

I. Claims 1–3 under 35 U.S.C. § 112, first paragraph for failing to comply with the enablement requirement;

II. Claims 1–3 under 35 U.S.C. § 112, second paragraph as being indefinite for failing to particularly point out and distinctly claim the subject matter that the applicant regards as the invention; and

VI. Claims 1–3 under 35 U.S.C. § 103(a) as unpatentable over Inokuti et al. (US 5,411,604, issued May 2, 1995).

FACTUAL FINDINGS AND ANALYSIS

Upon consideration of the evidence relied upon in this appeal and each of Appellant’s contentions, we reverse the Examiner’s rejections of claims 1–3 for reasons set forth in the Appeal and Reply Briefs, and below.

Rejection I

We first address the Examiner’s rejection of claims 1–3 under 35 U.S.C. § 112, first paragraph for failing to comply with the enablement requirement.
Appellant’s Specification teaches that grain-oriented electrical steel sheets are used to form the cores of transformers. Spec. ¶¶ 1, 3. The Specification explains that energy loss occurs during operation of transformers due to iron loss from the core material. Spec. ¶ 3. The Specification indicates that irradiating a recrystallized steel sheet with an electron beam reduces such iron loss, but as the thickness of a steel sheet increases, the degree of iron loss reduction produced by laser irradiation decreases. Spec. ¶¶ 5, 7.

The Specification describes irradiating the surface of a grain-oriented electrical sheet with an electron beam in a straight line from one edge of the sheet in the width direction to the opposite edge of the sheet, and repeating such irradiation lines in the rolling (or length) direction of the sheet, with the spacing between the irradiation lines (line spacing(s) in the rolling direction, or RD line spacing) preferably from 3 mm to 12 mm. Spec. ¶ 37; see also Spec. ¶ 13. The Specification explains that when so irradiating a grain-oriented electrical sheet, the electron beam is set to a particular irradiation energy per unit scanning length (or beam acceleration voltage x beam current/scanning rate). Spec. ¶ 15.

Independent claim 1 recites a method of manufacturing a grain-oriented electrical steel sheet that comprises, in part, determining an irradiation energy per unit scanning length $E_{\text{wmin}}(0.23)$ in Joules per meter of a (second) steel sheet having a thickness of 0.23 millimeters and a flux density that is the same as a first steel sheet that produces a minimum amount of iron loss from the (second) steel sheet.

Independent claim 3 recites a method of manufacturing a grain-oriented electrical steel sheet that comprises, in part, determining a line
spacing smin(0.23) in millimeters for a (second) steel sheet having a thickness of 0.23 millimeters and a flux density that is the same as a first steel sheet that produces a minimum amount of iron loss from the (second) steel sheet.

The Examiner finds that the Specification “does not detail” how these “determining” steps recited in claims 1 and 3 are “done,” and how “to evaluate what constitutes a minimum iron loss.” Office Act. 5. The Examiner finds that although the Specification includes limited working examples that describe irradiating steel sheets with an electron beam, “the specification does not disclose a composition of any of the sheets or how to determine and what constitutes the ‘minimum’ iron loss for any or all compositions of steel.” Office Act. 5–6. The Examiner also finds that although Figure 2A of Appellant’s application “illustrates the relationship between irradiation energy and the amount of change in iron loss ΔW_{17/50} (W/kg) for an electron beam method” in which the irradiation energy per unit scanning length was varied from 0 to 30 J/m for sheet thicknesses of 0.20, 0.23, 0.27, and 0.30 mm, Figure 2A is directed to the “[a]mount of change in iron loss ΔW_{17/50} (W/kg)” for four specific sheet thicknesses at specific irradiation energy per unit scanning length and therefore does not define how to determine the ‘minimum iron loss.’” Office Act. 6.

The Examiner concludes that “[s]ince the instant specification does not detail the composition of the steel sheet and what is considered ‘minimum iron loss’ that would lead to a) Ewmin(0.23) that minimizes iron loss for material with a sheet thickness of 0.23 mm and b) line spacing...
smin(0.23) that minimizes iron loss for material with a sheet thickness of 0.23 mm, the specification fails to teach how to make and use the claimed invention without undue experimentation.” Office Act. 7.

On the record before us, however, in light of the description provided in Appellant’s Specification and drawings, the Examiner does not establish that one of ordinary skill in the art would be unable to make and use the full scope of the claimed methods without undue experimentation, for reasons expressed by Appellant and discussed below.

“[T]o be enabling, the specification of a patent must teach those skilled in the art how to make and use the full scope of the claimed invention without ‘undue experimentation.’” In re Wright, 999 F.2d 1557, 1561 (Fed. Cir. 1993). Some experimentation, even a considerable amount, is not “undue” if it is merely routine, or if the Specification provides a reasonable amount of guidance as to the direction in which the experimentation should proceed. In re Wands, 858 F.2d 731, 737 (Fed. Cir. 1988).

“In cases involving predictable factors, such as mechanical or electrical elements, a single embodiment provides broad enablement in the sense that, once imagined, other embodiments can be made without difficulty and their performance characteristics predicted by resort to known scientific laws.” In re Fisher, 427 F.2d 833, 839 (CCPA 1970); see also In re Vaeck, 947 F.2d 488, 496 (Fed. Cir. 1991) (“Where, as here, a claimed genus represents a diverse and relatively poorly understood group of microorganisms, the required level of disclosure will be greater than, for example, the disclosure of an invention involving a ‘predictable’ factor such as a mechanical or electrical element.”).
We point out initially that when explaining the basis for the enablement rejection, the Examiner addresses “a minimum amount of iron loss from the second steel sheet” as recited in claims 1 and 3 in isolation, without considering this phrase in the context of the entirety of claim in which it occurs. Claims 1 and 3 do not recite determining “the ‘minimum’ iron loss for any or all compositions of steel,” as the Examiner appears to assert. Rather, claim 1 recites determining an irradiation energy that produces a minimum amount of iron loss from a particular (second) steel sheet having a thickness of 0.23 mm and a flux density that is the same as a first steel sheet, and claim 3 recites determining a line spacing that produces a minimum amount of iron loss from a particular (second) steel sheet having a thickness of 0.23 mm and a flux density that is the same as a first steel sheet.

In addition, as Appellant points out, the claimed methods are “not directed to any specific type of steel sheets or composition,” but, rather are “directed to grain-oriented electrical steel sheets,” and, therefore, “there is no need for the specification to describe the composition of the steel sheets or a method for preparing the sheets, as one skilled in the art would appreciate that any grain-oriented electrical steel sheet can be used in the present invention.” Reply Br. 1–2.

Furthermore, as Appellant and the Specification explain, a steel sheet that has not been irradiated with an electron beam will undergo a particular amount of iron loss during operation, but after electron beam irradiation, the amount of iron loss decreases, resulting in a change—or reduction—in iron loss produced by the electron beam irradiation. Appeal Br. 5; Spec. ¶¶ 8, 15. Appellant’s Specification describes this effect, and describes a relationship
that Appellant discovered that allows determination of the irradiation energy per unit scanning length that produces a minimum amount of iron loss for sheets of differing thickness (Expression (1) recited in claim 1). Spec. ¶¶ 21, 22, 30, 31, 32.

Furthermore, Appellant’s Figure 2A is a graph illustrating the change in iron loss that resulted from irradiation of four steel sheets of differing thicknesses with increasing amounts of irradiation energy per unit scanning length. As Appellant explains, one of ordinary skill in the art would understand from viewing Figure 2A that each of the four lines in the figure has a lowest point that indicates the irradiation energy that results in the greatest change or reduction in iron loss relative to the iron loss before irradiation. Appeal Br. 4–6. As Appellant further explains, one of ordinary skill in the art would understand that the lowest point of each line thus corresponds to the irradiation energy that produces the minimum amount of iron loss for each sheet. Appeal Br. 5.

Therefore, in view of the description provided in Appellant’s Specification, and considering Appellant’s Figure 2A, one of ordinary skill in the art would understand that “each steel sheet of a known thickness has a level of irradiation energy per unit scanning length that produces a minimum amount of iron loss,” and would also understand how to determine this minimum iron loss for a given steel sheet of a particular thickness (0.23 mm) and flux density, as recited in claim 1. Appeal Br. 5.

The Specification also describes a relationship that Appellant discovered that allows determination of the irradiation line spacing that produces a minimum amount of iron loss for sheets of differing thicknesses (Expression (2) recited in claim 3). Spec. ¶¶ 23, 33.
As Appellant explains, one of ordinary skill in the art would understand, in view of the description provided in paragraph 33 of Appellant’s Specification, that Expression (2) recited in claim 3 can be derived from Expression (1) recited in claim 1. Reply Br. 2–4. And one of ordinary skill in the art would also understand that a steel sheet having a thickness of 0.23 mm and a given flux density can be irradiated with an electron beam using different levels of line spacing, and would understand how to determine the line spacing that results in the greatest change or reduction in iron loss relative to iron loss before irradiation, in view of Figure 2A. Spec. ¶¶ 33, 37; Appeal Br. 6–8; Reply Br. 4–5. In other words, one of ordinary skill in the art would understand that the line spacing that results in the greatest change or reduction in iron loss can be determined the same way that the irradiation energy that results in the greatest change or reduction in iron loss can be determined, as illustrated in Figure 2A.

Consequently, in view of the description provided in Appellant’s Specification, and considering Appellant’s Figure 2A, one of ordinary skill in the art would understand how to determine the line spacing for a given steel sheet of a particular thickness (0.23 mm) and flux density that produces a minimum amount of iron loss, as recited in claim 3.

On the record before us, in light of the description provided in Appellant’s Specification and drawings, the Examiner does not establish that one of ordinary skill in the art would be unable to determine an irradiation energy that produces a minimum amount of iron loss from a (second) steel sheet having a thickness of 0.23 mm and a flux density that is the same as a first steel sheet as recited in claim 1, and determine a line spacing that produces a minimum amount of iron loss from a particular (second) steel
sheet having a thickness of 0.23 mm and a flux density that is the same as a first steel sheet as recited in claim 3, without undue experimentation.

We, accordingly, do not sustain the Examiner’s rejection of claims 1–3 under 35 U.S.C. § 112, first paragraph for failing to comply with the enablement requirement.

Rejection II

We turn now to the Examiner’s rejection of claims 1–3 under 35 U.S.C. § 112, second paragraph as being indefinite for failing to particularly point out and distinctly claim the subject matter that the applicant regards as the invention.

The Examiner determines that the “minimum amount of iron loss from the second steel sheet” recited in claims 1 and 3 “is a relative term which renders the claims indefinite” because “the specification does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably apprised of the scope of the invention.” Office Act. 7–8. The Examiner explains that “[s]ince the calculation of the Ewmin(0.23) and smin(0.23) are dependent on a relative term which is not defined, the scope of the invention as claimed cannot be reasonably apprised for instant claims 1 and 3.” Office Act. 8.

It is well-established that relative terms, such as terms of degree, do not render claims inherently indefinite, and the Specification need not provide a precise numerical measurement for a recited term of degree. Sonix Tech. Co. v. Publ’ns Int’l, Ltd., 844 F.3d 1370, 1377 (Fed. Cir. 2017) (“[W]e have rejected the proposition that claims involving terms of degree are inherently indefinite. Thus, ‘a patentee need not define his invention with mathematical precision in order to comply with the definiteness
requirement.”) (quoting *Invitrogen Corp. v. Biocrest Mfg., L.P.*, 424 F.3d 1374, 1384 (Fed. Cir. 2005)).

Rather, if the Specification provides description or examples that teach how to measure the meaning or scope of a recited term of degree, the term of degree does not render a claim indefinite. *Seattle Box Co. v. Indust. Crating & Packing, Inc.*, 731 F.2d 818, 826 (Fed. Cir. 1984); *Enzo Biochem, Inc. v. Applera Corp.*, 599 F.3d 1325, 1335 (Fed. Cir. 2010) (“Because the intrinsic evidence here provides a general guideline and examples sufficient to enable a person of ordinary skill in the art to determine [the scope of the claims], the claims are not indefinite even though the construction of the term ‘not interfering substantially’ defines the term without reference to a precise numerical measurement.” (citations and internal quotation marks omitted)).

As discussed above for the enablement rejection (Rejection I), in view of the description provided in Appellant’s Specification, and in view of Appellant’s Figure 2A, one of ordinary skill in the art would understand that Appellant discovered a relationship that allows determination of the irradiation energy per unit scanning length that produces a minimum amount of iron loss for sheets of differing thicknesses (Expression (1) recited in claim 1). Spec. ¶¶ 21, 22, 30, 31, 32. One of ordinary skill in the art also would understand that Appellant discovered a relationship that allows determination of the irradiation line spacing that produces a minimum amount of iron loss for sheets of differing thicknesses (Expression (2) recited in claim 3). Spec. ¶¶ 23, 33.

As also discussed above, one of ordinary skill in the art would understand from viewing Figure 2A that the minimum point of each line
corresponds to the irradiation energy that produces the minimum amount of iron loss for each sheet. Figure 2A and the accompanying description in Appellant’s Specification (Spec. ¶¶ 19–23, 30–33) thus teach a standard for measuring the meaning of determining an irradiation energy that produces a “minimum amount of iron loss from the second steel sheet” as recited in claim 1.

The ordinarily skilled artisan would also understand from the description provided in Appellant’s Specification that the line spacing that results in the greatest reduction in iron loss can be determined the same way that the irradiation energy that results in the greatest reduction in iron loss can be determined, as illustrated in Figure 2A. Spec. ¶¶ 23, 33. Figure 2A and the accompanying description in Appellant’s Specification (Spec. ¶¶ 19–23, 30–33) thus teach a standard for measuring the meaning of determining a line spacing that produces a “minimum amount of iron loss from the second steel sheet” as recited in claim 3.

Contrary to the Examiner’s determination, recitation of a “minimum amount of iron loss from the second steel sheet” in claims 1 and 3, therefore, does not render the scope of the claims unclear.

The Examiner also determines that “claim 1 does not explicitly recite a thickness limitation of the sheet and a thickness of 0.6mm results in a negative value for E(t), thereby the claim being indefinite as it [i]s unclear how the E(t) that is to be set can be negative. Similarly, although claim 3 recites that the thickness of the first steel sheet is 0.23 mm or more, a thickness of 0.6mm results in a negative value for s(t), thereby the claim being indefinite as it [i]s unclear how the s(t), which is a line spacing, can be set to a negative value.” Office Act. 8.
As Appellant explains, however, one of ordinary skill in the art would understand that because \( E(t) \) is an irradiation energy per unit scanning length, \( E(t) \) has a positive value, and, therefore, would understand that Expression (1) recited in claim 1 only encompasses steel sheet thicknesses \( t \) that result in the right side and the left side of the expression having positive values. Appeal Br. 12. Similarly, one of ordinary skill in the art would understand that because \( s(t) \) is line spacing, \( s(t) \) has a positive value, and, therefore, one of ordinary skill in the art would understand that Expression (2) recited in claim 3 only encompasses steel sheet thicknesses \( t \) that result in the right side and the left side of the expression having positive values. Appeal Br. 12.

We, accordingly, do not sustain the Examiner’s rejection of claims 1–3 under 35 U.S.C. § 112, second paragraph as being indefinite.

Rejection III

Finally, we turn to the Examiner’s rejection of claims 1–3 under 35 U.S.C. § 103(a) as unpatentable over Inokuti.

The Examiner finds that Inokuti discloses a method of producing a grain-oriented steel sheet that comprises locally and intermittently applying an electron beam along a widthwise direction of the sheet using scan paths that cross the rolling direction of the sheet. Office Act. 9–10 (citing Inokuti Abst.; col. 1, l. 5–col. 12, l. 2; claims 1–7). The Examiner finds that Inokuti discloses adjusting parameters such as the beam acceleration voltage, beam current, beam diameter, scanning speed, and irradiation line spacing, “to attain the necessary iron loss characteristics for the grain oriented steel sheets.” Office Act. 11 (citing Inokuti col. 3, l. 45–col. 10, l. 25). The Examiner finds that Inokuti’s “Examples 1 and 2 along with Comparative
Examples 1 and 2 teach how sheets can be made by adjusting various parameters of the beam such as energy and line spacing to attain the characteristics of iron loss in an acceptable range.” Office Act. 11.

In view of these disclosures in Inokuti, the Examiner concludes that “subsequent application or in other words subsequent refinement of the parameters of the energy and line spacing to attain required characteristics as claimed in the instant claims are obvious over the teachings of the prior art since the prior art teaches adjustment of these parameters.” Office Act. 11.

On the record before us, however, as Appellant argues (Appeal Br. 14), the Examiner does not provide technical reasoning grounded in sound factual findings that explains why the relied-upon disclosures of Inokuti would have suggested the measuring, determining, and adjusting steps recited in claims 1 and 3.

Inokuti describes preparing a grain-oriented steel sheet, preparing 162 samples from the single sheet, and subjecting the samples to irradiation by an electron beam using a beam acceleration voltage of 130, 150, or 180 kV, a beam current of 0.6, 0.8, or 1.0 mA, a beam diameter of 0.20 or 0.30 mm, a scanning speed of 6, 8, or 10 m/sec, and an irradiation line spacing of 3, 5, or 7 mm. Inokuti col. 4, ll. 19–54. Inokuti discloses that levels of iron loss were measured on all 162 samples, but Inokuti does not disclose the results of the measurements for the individual samples. Inokuti col. 4, l. 55–col. 5, l. 55. Consequently, the effect of each of the irradiation parameters on iron loss, including the effect of beam acceleration voltage, beam current, and irradiation line spacing, cannot be ascertained from Inokuti’s disclosures. And although Inokuti’s experimental examples describe irradiating steel sheets with electron beams using different sets of irradiation conditions,
Inokuti does not disclose the effect of particular irradiation parameters—including beam acceleration voltage, beam current, and irradiation line spacing—on iron loss for the exemplary steel sheets. Inokuti col. 7, l. 45–col. 12, l. 2.

The Examiner does not identify any disclosure in Inokuti of measuring a thickness and flux density of a first steel sheet, determining an irradiation energy per unit scanning length of a second steel sheet having a thickness of 0.23 millimeters and the same flux density as the first steel sheet that produces a minimum amount of iron loss from the second steel sheet, and adjusting an irradiation energy per unit scanning length of an electron beam to satisfy Expression (1) recited in claim 1. The Examiner also does not identify any disclosure in Inokuti of measuring a thickness and flux density of a first steel sheet having a thickness of 0.23 mm or more, determining a line spacing of a second steel sheet having a thickness of 0.23 millimeters and the same flux density as the first steel sheet that produces a minimum amount of iron loss from the second steel sheet, and adjusting a line spacing of an electron beam to satisfy Expression (2) recited in claim 3.

Nor does the Examiner explain why Inokuti’s disclosure of irradiating a grain-oriented steel sheet using different beam acceleration voltage, beam current, and irradiation line spacing would have suggested the measuring, determining, and adjusting steps recited in claims 1 and 3. In particular, the Examiner does not explain why the relied-upon disclosures of Inokuti would have suggested adjusting an irradiation energy per unit scanning length of an electron beam to satisfy Expression (1) recited in claim 1, and would have suggested adjusting a line spacing of an electron beam to satisfy Expression (2) recited in claim 3.
We, accordingly, do not sustain the Examiner’s rejection of claims 1–3 under 35 U.S.C. § 103(a) as unpatentable over Inokuti.

CONCLUSION

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REVERSED