

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

JinkoSolar Co., Ltd.,
Petitioner,

v.

LONGi Green Energy Technology Co. Ltd.,
Patent Owner.

Case No. IPR2025-00859
Patent No. 9,515,214

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 9,515,214**

LIST OF EXHIBITS

Exhibit	Description
1001	U.S. Patent No. 9,515,214
1002	File History for U.S. Patent No. 9,515,214
1003	Declaration of Dr. Hamid Toliyat
1004	J. E. Boretz et al., <i>Study To Establish Criteria For A Solar Cell Array For Use As A Primary Power Source For A Lunar-Based Water Electrolysis System</i> (1971) (“Boretz”)
1005	Certified Translation of Japanese Patent Application Publication No. JP H07-106619 (“Maehane”)
1006	Japanese Patent Application Publication No. JP H07-106619 (“Maehane”)
1007	Certified Translation of Chinese Patent Application Publication No. CN 201171051 Y (“Zhang”)
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1010	Indian Patent Application No. 1260/KOL/2008 (“Ravi260”)
1011	U.S. Patent Publication No. 2007/0295381A1 (“Fujii”)
1012	Narayanan Krishnamurthy, <i>Dynamic Modelling of CubeSat Project MOVE</i> (2008) (“Krishnamurthy”)
1013	Tom Markvart & Luis Castaner, <i>Solar Cells: Materials, Manufacture and Operation</i> (2005)
1014	Daniel Cunningham et al., <i>Reaching Grid Parity Using BP Solar Crystalline Silicon Technology</i> , IEEE (2010)
1015	U.S. Patent No. 8,709,154
1016	European Patent Application Publication No. EP 1796177 A1
1017	<i>Solar Cell Array Design Handbook</i> , Jet Propulsion Lab, Vol. 1 (Oct. 1976)
1018	U.S. Patent No. 8,871,169
1019	M. Gillanders, <i>Pilot Production and Testing of High Efficiency Wraparound Contact Solar Cells</i> , NASA CR-165302 (June 1981)
1020	European Patent Application Publication No. EP1564816 A1
1021	A. Goetzberger & V.U. Hoffmann, <i>Photovoltaic Solar Energy Generation</i> (2005)
1022	U.S. Patent No. 7,951,640

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c)	Limitation 10[b]: “includes a plurality of light-receiving-surface bus electrodes parallel to the short side of the substantial rectangle on a light receiving surface, and includes rear-surface bus electrodes each at a position on a non-light-receiving surface corresponding to each of the light-receiving-surface bus electrodes; and”	92
d)	Limitation 10[c]: “an interconnector that electrically connects the light-receiving-surface bus electrodes of a first one of the solar battery cells to the rear-surface bus electrodes of an adjacent second one of the solar battery cells,”	92
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I. INTRODUCTION

JinkoSolar Co., Ltd. (“Petitioner”) petitions for inter partes review seeking cancellation of claims 1-11 of U.S. Patent No. 9,515,214 (Ex-1001, “’214 patent”), assigned to LONGi Green Energy Technology Co., Ltd. (“Patent Owner”).

The ’214 patent relates to solar battery modules made of rectangular solar cells connected in a specific series-parallel configuration to reduce resistive losses and improve module efficiency. Ex-1001, 1:27-2:30; *see also* Ex-1003, ¶34. The use of rectangular or half-cut solar cells arranged in series-parallel configurations was well known in the art. Ex-1003, ¶202. Indeed, during prosecution of the ’214 patent, the applicants distinguished prior art only by the limitation “the n in the number of columns of the cell strings connected in parallel being equal to the n in the ratio of the long side length to the short side length.” Ex-1002, 546. However, even this aspect was not new. As early as 1971, Boretz disclosed solar arrays using rectangular solar cells with a 1:2 ratio of short-to-long sides, arranged in two parallel columns, matching the dimensional ratio and connection configuration. Ex-1004, 4-1-4-3, Fig. 2.2.

Additional limitations provided in the dependent claims were similarly already disclosed in the prior art. For example, prior references like Ravi328 and Zhang taught the same solar cell splitting and parallel connection techniques described in the ’214 patent. Fujii disclosed margin spacing around solar cells to prevent electrical shorts and mechanical failure, and Ravi260 described string

connectors extending continuously across solar cell arrays. Krishnamurthy also taught solar cells with asymmetrically chamfered corners to improve module layout.

II. STANDING, MANDATORY NOTICES AND FEE AUTHORIZATION

A. Grounds for Standing:

Pursuant to 37 C.F.R. § 42.104(a), Petitioner certifies that the '214 patent is available for inter partes review and that Petitioner is not barred or estopped from requesting an inter partes review challenging the '214 patent on the grounds set forth in this Petition.

B. Real Party-in-Interest:

Petitioner certifies that the real parties-in-interest of this Petition are JinkoSolar Co, Ltd., JinkoSolar Holding Co., Ltd., JinkoSolar (Vietnam) Industries Co. Ltd., and Jinko Solar Technology Sdn. Bhd.

C. Related Matters:

Patent Owner has asserted the '214 patent in litigation against Petitioner and the real parties-in-interest in *LONGi Green Energy Technology Co. Ltd. v. JinkoSolar Holding Co., Ltd. et al.*, Case No. 2-25-cv-00048 (E.D. Tex.).

D. Lead and Back-Up Counsel:

Petitioners designate the following counsel:

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Pursuant to 37 C.F.R. § 42.10 (b), Petitioners have filed a power of attorney with the above designation of counsel.

E. Service Information:

Service information is provided in the Designation of Counsel above. Petitioner consents to electronic service at the email addresses listed above and at jinko-longi-ipr@cov.com.

F. Fee Authorization:

The Patent Trial and Appeal Board is authorized to charge fees associated with this Petition, including any fees for filing, institution, and post-institution proceedings under 37 C.F.R. § 42.15, as well as any additional fees that might be due, to Deposit Account No. 60-3160.

III. SUMMARY OF CHALLENGE

Petitioner requests inter partes review of claims 1–11 of the '214 patent under 35 U.S.C. § 103 based on the following grounds:

Ground I: Claims 1–5, 8, and 11 are obvious over the combination of Boretz and Maehane.

Ground II: Claim 6 is obvious over the combination of Boretz, Maehane, and Ravi328.

Ground III: Claim 7 is obvious over the combination of Boretz, Maehane, and Ravi260.

Ground IV: Claims 9 and 10 are obvious over the combination of Boretz, Maehane, and Krishnamurthy.

Ground V: Claims 1-4, 6, 8, and 11 are obvious over the combination of Zhang and Ravi328.

Ground VI: Claim 5 is obvious over the combination of Zhang, Ravi328, and Fujii.

Ground VII: Claim 7 is obvious over the combination of Zhang, Ravi328, and Ravi260.

Ground VIII: Claims 9 and 10 are obvious over the combination of Zhang, Ravi328, and Krishnamurthy.

The earliest claimed priority date of the '214 patent is July 2, 2010. Each of the asserted references is available as prior art under 35 U.S.C. § 102 (pre-AIA)¹, as shown in the following table.

Exhibit	Reference	Date(s)	Availability as Prior Art
1004	J. E. Boretz et al., <i>Study To Establish Criteria For A Solar Cell Array For Use As A Primary Power Source For A Lunar-</i>	September 15, 1971 (published)	§§ 102(a) and (b)

¹ Because the application for the '214 patent was filed prior to March 16, 2013, the pre-AIA conditions for patentability apply.

Exhibit	Reference	Date(s)	Availability as Prior Art
	<i>Based Water Electrolysis System</i> (1971) (“Boretz”)		
1006	Japanese Patent Application Publication No. JP H07-106619 (“Maehane”)	October 7, 1993 (filed); April 21, 1995 (published)	§§ 102(a) and (b)
1008	Chinese Patent Application Publication No. CN 201171051 Y (“Zhang”)	January 31, 2008 (filed); December 24, 2008 (published)	§§ 102(a) and (b)
1009	Indian Patent Application No. 1328/KOL/2007 (“Ravi328”)	September 26, 2007 (filed); October 4, 2009 (published)	§§ 102(a) and (b)
1010	Indian Patent Application No. 1260/KOL/2008 (“Ravi260”)	July 23, 2008 (filed); January 29, 2010 (published)	§§ 102(a) and (b)
1011	U.S. Patent Publication No. 2007/0295381A1 (“Fujii”)	March 29, 2005 (PCT filed); December 27, 2007 (published)	§§ 102(a), (b), and (e)
1012	Narayanan Krishnamurthy, <i>Dynamic Modelling of CubeSat Project MOVE</i> (2008) (“Krishnamurthy”)	2008 (published)	§§ 102(a) and (b)

IV. OVERVIEW OF U.S. PATENT NO. 9,515,214

A. Summary

The ’214 patent (Ex-1001) is entitled “*Solar Battery Module and Manufacturing Method Thereof*” and names Koji Shimasaki and Masayoshi Suzuki as inventors. The ’214 patent was filed on July 2, 2010, and issued on February 16, 2016. It is generally directed to solar battery modules composed of a plurality of rectangular

solar cells, and methods for manufacturing such modules. Ex-1001, Abstract; Ex-1003, ¶33

The '214 patent purports to address the problem of increased resistive losses in solar modules caused by higher current levels associated with improved solar cell efficiencies. Ex-1001, 1:40-57; Ex-1003, ¶34. In particular, the patent explains that increasing the size of the interconnectors between cells to accommodate higher currents can lead to optical losses and shading. *Id.* The '214 patent aims to solve this problem through a design in which the output current through each interconnector is reduced without increasing its cross-sectional area. *Id.*, 1:27-30.

The '214 patent describes a solar battery module in which each solar battery cell has a substantially rectangular shape, with the ratio of the short side length to the long side length being $1/n:1$, where n is an integer equal to or greater than 2. *Id.*, 1:61-67; Ex-1003, ¶35. Each solar cell includes a plurality of light-receiving-surface bus electrodes parallel to the short side of the rectangle on the light-receiving surface, and corresponding rear-surface bus electrodes on the non-light-receiving surface. *Id.*, 1:67-2:9.

FIG.12

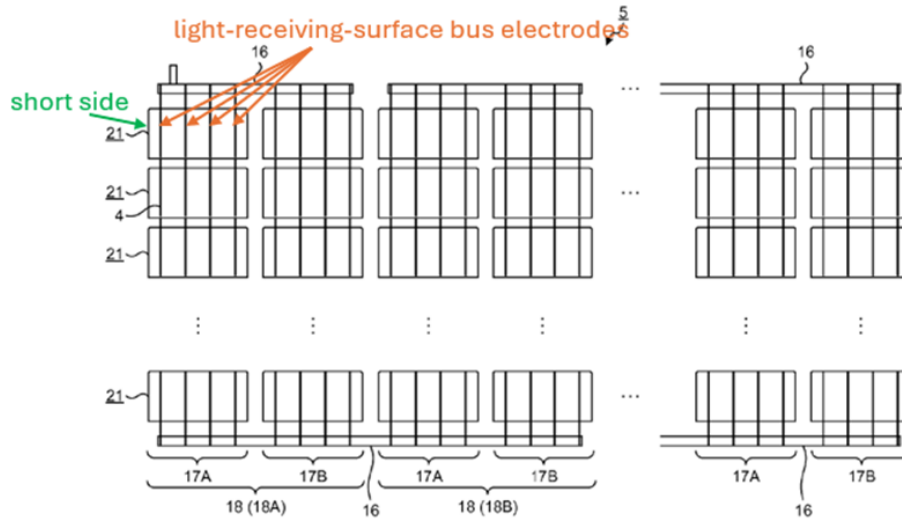
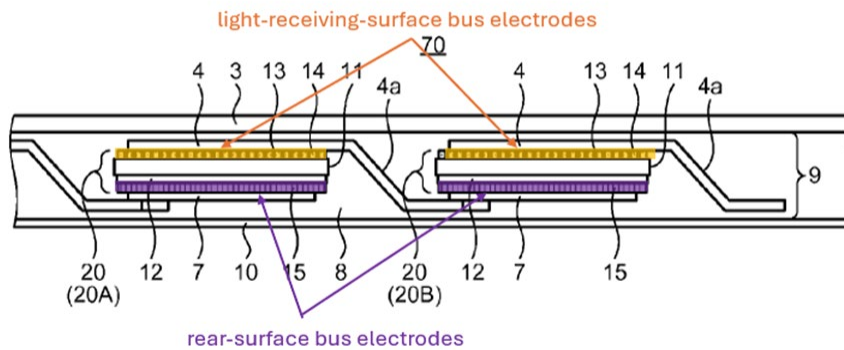


FIG.8



Ex-1002, Figs. 12, 8 (annotated).

As shown in Figures 8 and 12, the solar cells are arranged in strings, with each light-receiving-surface bus electrode of one cell electrically connected to a corresponding rear-surface bus electrode of an adjacent cell via an interconnector. *Id.*, 2:5-10; Ex-1003, ¶36. By dividing a conventional square solar cell into multiple rectangular cells and connecting them in this way, the patent teaches that the current

flowing through each interconnector is reduced, thereby reducing resistive losses without increasing the size of the interconnectors. *Id.*, 2:10-30; Ex-1003, ¶36.

The '214 patent includes eleven claims: two independent claims (claims 1 and 10) and nine dependent claims (claims 2-9 and 11).

B. Priority Date of the '214 Patent

The earliest possible priority date for the '214 patent is July 2, 2010, the filing date of related PCT Application No. PCT/JP2010/061334.

C. Level of Ordinary Skill in the Art

A person of ordinary skill in the art at the time of the alleged invention of the '214 patent would have had a bachelor's degree in engineering, physics, or a related field, and at least two years of experience researching, developing, designing, or evaluating photovoltaic cells or solar module systems. A person with less formal education but additional relevant practical experience, or vice versa, would also qualify as a person of ordinary skill in the art. Ex-1003, ¶¶39-41.

D. Claim Construction

In IPR proceedings, claims are construed “in accordance with their ordinary and customary meaning.” 37 C.F.R. § 42.100(b); *see Phillips v. AWH Corp.*, 415 F.3d 1303, 1313 (Fed. Cir. 2005). Petitioner does not believe that any specialized constructions are necessary at this stage of the proceeding. Ex-1003, ¶42.

V. OVERVIEW OF THE PRIOR ART

Both the structure of the solar modules claimed by the '214 patent and

techniques for improving current collection and mechanical integrity were well-known in the art before the earliest priority date of the '214 patent.

The prior art references discussed below—Boretz, Zhang, Ravi328, Fujii, Ravi260, and Krishnamurthy—disclose various features of solar cell modules highly relevant to the challenged claims. These references teach (1) the use of substantially rectangular solar cells, (2) the use of half-cut cells to reduce resistive losses, (3) front-to-back connections between adjacent solar cells, (4) series-parallel configurations of cell strings, (5) margin spacing techniques to improve lamination and reliability, and (6) cell chamfering and continuous string connector designs to maximize module efficiency.

A. Study To Establish Criteria For A Solar Cell Array For Use As A Primary Power Source For A Lunar-Based Water Electrolysis System (“Boretz”)

Boretz is prior art under 35 U.S.C. §§ 102 (a) and (b) because it was published on September 15, 1971, long before the earliest claimed priority date of the '214 patent. Boretz was not cited or discussed during prosecution of the '214 patent.

Boretz discloses the development of three prototype solar panel Engineering Test Models (ETMs) for NASA lunar applications, emphasizing the achievement of high power-to-weight ratios (12 to 18 watts per pound). Ex-1004, 3-1.

Importantly, Boretz discloses a flat laydown configuration of 2 cm x 4 cm silicon solar cells bonded onto a substrate using RTV-118 adhesive. The array includes

seven sub-groupings of cells, with each sub-grouping having two cells connected in parallel and 66 cells connected in series, totaling 924 cells. Interconnections between cells are made using Kovar ribbons. Ex-1004, 4-1- 4-3.

As shown in Boretz's Figure 2.2, the solar cell arrangement exhibits a highly organized structure with rectangular cells interconnected into series-parallel configurations:

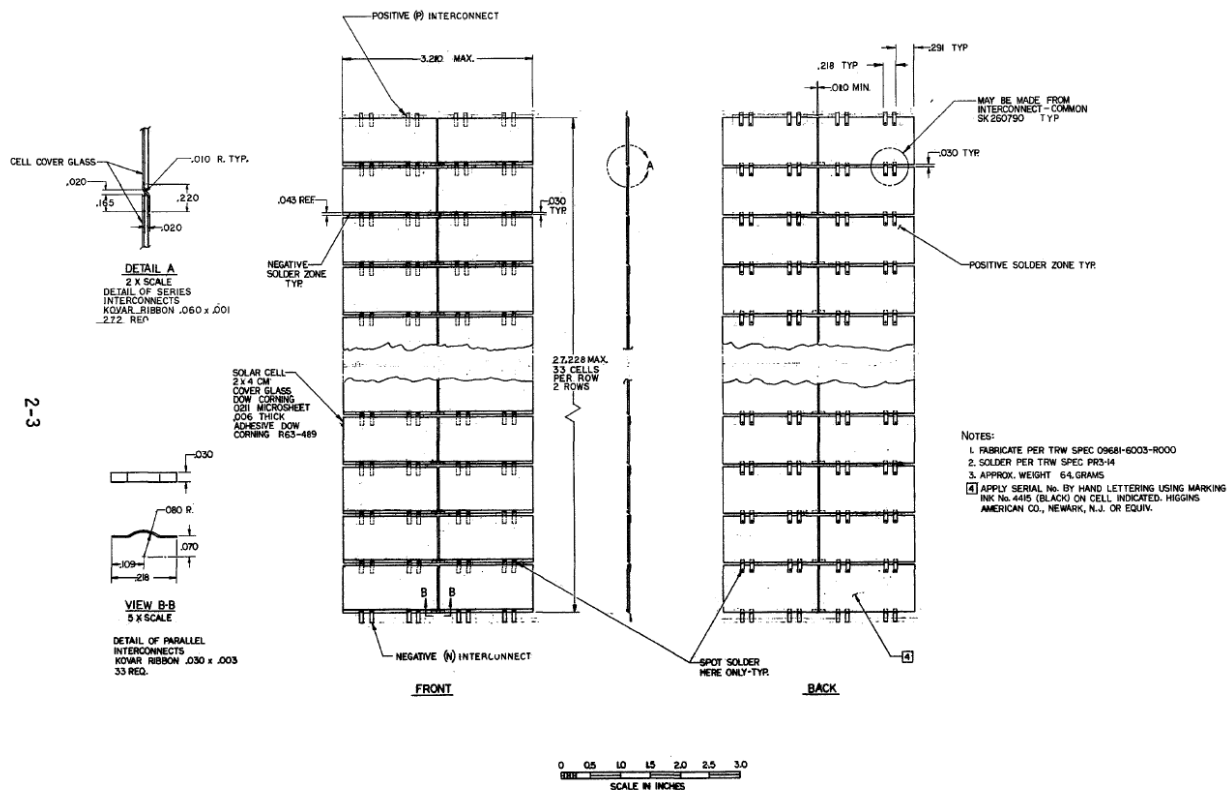


Figure 2.2 Prototype Test Module-Solar Cell Sub-Module Arrangement

Ex-1004, Fig. 2.2

B. JPH 07-106619 ("Maehane")

Maehane is prior art under pre-AIA 35 U.S.C. § 102(a) and (b) because it was filed on October 7, 1993, and published on April 21, 1995. Maehane was cited during

prosecution of the '214 patent.

Maehane discloses a method for manufacturing solar cells aimed at preventing short-circuiting during the electrical connection of segmented solar cell elements. Ex-1005, Abstract.

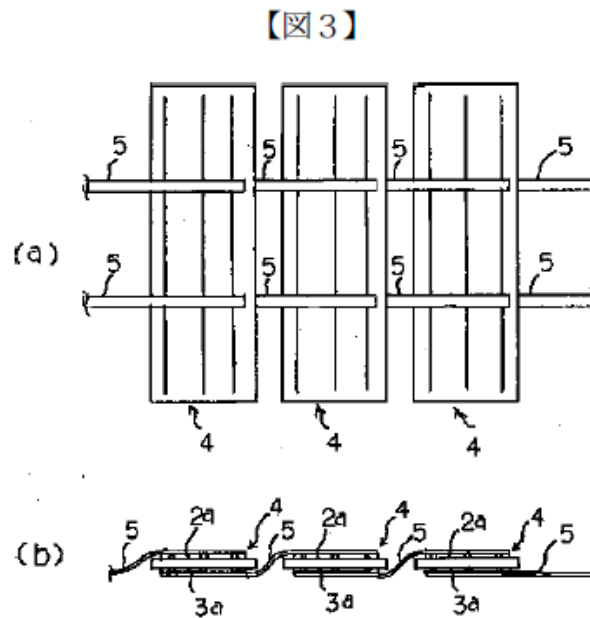
Maehane describes forming surface electrodes on the light-receiving side of a semiconductor substrate, where the connection regions terminate inside the periphery of the small power generation regions. Rear electrodes are similarly formed on the opposite side. The semiconductor substrate is then segmented into smaller solar cell elements. These elements are electrically connected using connection members that link the surface electrode of one element to the rear electrode of an adjacent element. Ex-1005, [0008].

Maehane addresses the problem of short circuits occurring when solder used for electrical connections overflows and inadvertently connects the surface and rear electrodes. By positioning the connection regions within the internal periphery of the solar cell elements, Maehane's method mitigates the risk of solder overflow causing short circuits. Ex-1005, Abstract; [0010].

Maehane further teaches that confining connection regions within the internal periphery increases the effective area available for power generation. Ex-1005, [0022]. Maehane also explains that its design improves connection strength, as soldering across the entire connection region ensures robust electrical connections. Ex-1005,

[0023].

Figure 3 of Maehane illustrates an embodiment showing segmented solar cell elements on a semiconductor substrate, highlighting the strategic placement of surface electrodes and split cells to prevent short circuits. Ex-1005, [0016]; *see also* Ex-1003, ¶52.



Ex-1005, Fig. 3.

C. CN 201171051 Y (“Zhang”)

Zhang is prior art under pre-AIA 35 U.S.C. § 102(a) and (b) because it was filed on January 31, 2008, and published on December 24, 2008, well before the earliest claimed priority date of the ’214 patent. Zhang was not cited or discussed during prosecution of the ’214 patent.

Zhang discloses a photovoltaic (PV) module designed to output higher power while reducing manufacturing costs. The module comprises photovoltaic glass, interconnect strips, and a packaging backplate, all encapsulated in a transparent laminating material. Ex-1007, Abstract. The photovoltaic cells used are 125 mm x 125 mm mono-crystalline or poly-crystalline solar cells. *Id.* These cells are connected in series to form series connection groups. *Id.* The two ends of these groups are then connected in parallel to form a series-parallel combination. This combination is subsequently connected in series to form the output terminal of the module. Ex-1007, 3.

Zhang addresses the challenge of increasing the power output of PV modules without significantly increasing manufacturing costs. By utilizing smaller 125 mm x 125 mm cells instead of larger ones, Zhang's design reduces the overall cost of production while maintaining high power output. The use of series-parallel connections allows for both an increase in output voltage and current, resulting in a more powerful module without relying solely on increasing the size of the cells or the number of cells in series. This method contrasts with traditional approaches, which either increase cell size (raising costs) or add more series-connected cells (which only boosts voltage, not current, limiting power output). Ex-1007, 3.

An exemplary embodiment from Zhang is depicted below.

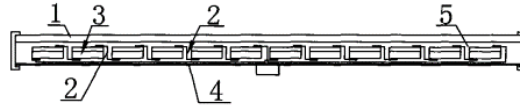


图 1

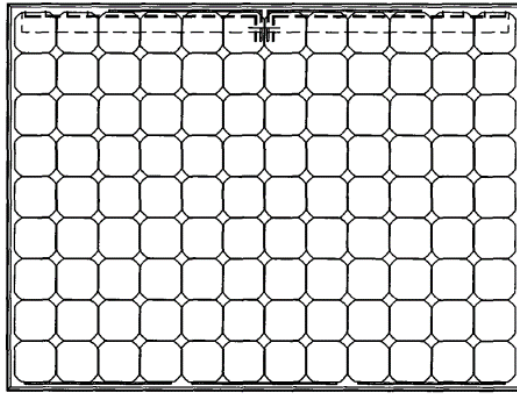


图 2

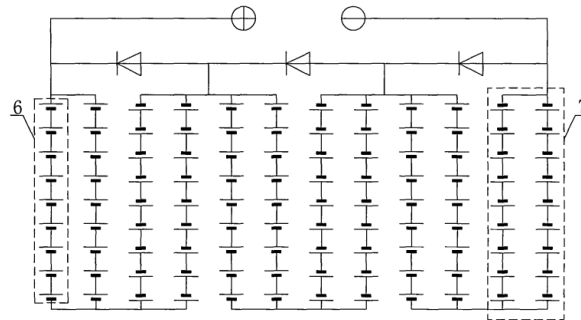


图 3

Ex-1007, Figs. 1-3.

D. Indian Patent Application No. 1328/KOL/2007 (“Ravi328”)

Ravi328 is prior art under pre-AIA 35 U.S.C. § 102(a) and (b) because it was filed on September 26, 2007, and published on October 4, 2009, before the earliest effective filing date of the '214 patent. Ravi328 was not cited or discussed during prosecution of the '214 patent.

Ravi328 discloses a PV module composed of 108 half-cut, 125-mm mono-

crystalline silicon solar cells, arranged into two sub-sets of cells, each comprising two parallel strings of 18 half-cells each, connected to each other in series to form a 12V, 120W module. Ex-1009, 5. The full-size square cells are laser-cut into rectangles and interconnected using tinned copper ribbons soldered to front and rear busbars, enabling front-to-back current flow. Ex-1009, 4-5.

Ravi328 addresses the material constraints posed by short supply of 156-mm wafers by replacing 36 full-size 156-mm cells with 108 half-cut 125-mm cells, yet maintaining output while reducing resistive losses and improving efficiency. Ex-1009, 3-4.

An exemplary embodiment from Ravi328 is depicted below.

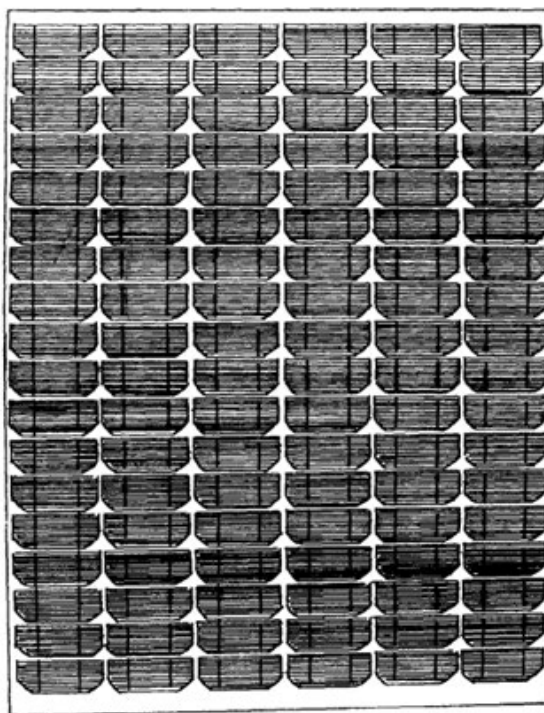


Fig. 6

Ex-1009, Fig. 6.

E. Indian Patent Application No. 1260/KOL/2008 (“Ravi260”)

Ravi260 is prior art under pre-AIA 35 U.S.C. § 102(a) and (b) because it was filed on July 23, 2008, and published on January 29, 2010, before the earliest effective filing date of the '214 patent. Ravi260 was not cited or discussed during prosecution of the '214 patent.

Ravi260 discloses a method for fabricating a 12V, 80W PV module using 72 one-third cut 156-mm multi-crystalline silicon cells. Ex-1010, 1. These cells are laser-cut, interconnected with tinned copper ribbons soldered to front busbars, and laminated between EVA, tempered glass, and a Tedlar backsheet. Ex-1010, 5–6.

The cells are arranged in two sets, each comprising two parallel strings (2×18), connected in series, achieving the target output while minimizing resistive losses. Ex-1010, 4-5. The design adapts to the industry shift toward 156-mm wafers, maximizing material usage and maintaining performance comparable to 125-mm modules. Ex-1010, 6.

An exemplary embodiment from Ravi260 is depicted below.

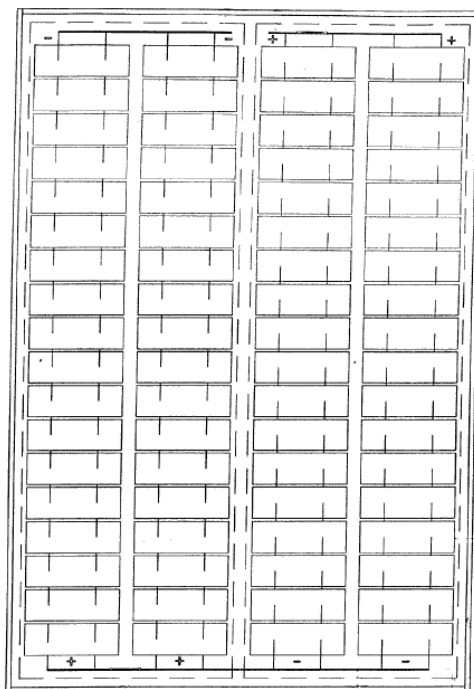


Fig. 6

60 WATTS PV MODULE MADE WITH 72 Nos.
OF ONE-THIRD CUT 156 mm SOLAR CELLS.

Ex-1010, Fig. 6.

F. U.S. Patent Publication No. 20070295381A1 (“Fujii”)

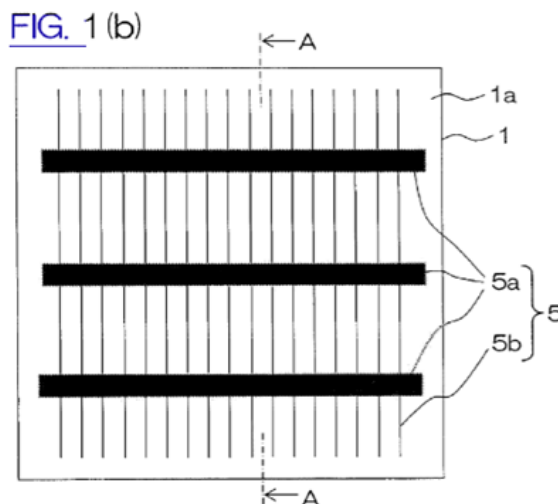
Fujii (U.S. Patent Publication No. 2007/0295381 A1) is prior art under pre-AIA 35 U.S.C. § 102(a),(b), and (e) because it was filed on March 29, 2005 (PCT), and published on December 27, 2007, before the earliest claimed priority date of the '214 patent. Fujii was not cited or discussed during prosecution of the '214 patent.

Fujii is directed to solar modules composed of interconnected solar battery cells.

Ex-1011, ¶[0012].

As shown in FIG. 1(b), Fujii discloses the light-receiving surface includes surface busbar electrodes and fine surface finger electrodes which are patterned

perpendicular to the busbars. Ex-1011, ¶[0120].



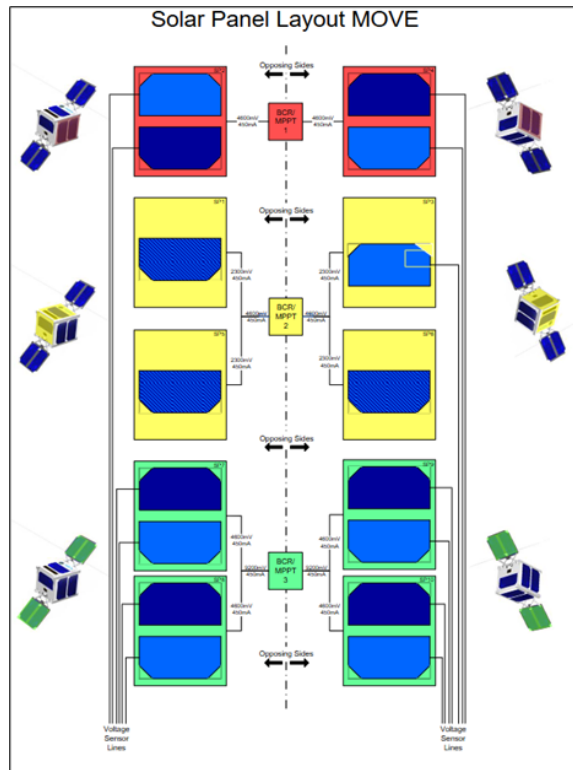
Ex-1011, Fig. 1(b). As shown in Fig. 1(b), Fujii discloses a small but intentional gap from the edge of the surface busbar electrodes to the perimeter of the cell.

G. *Dynamic Modelling of CubeSat Project MOVE* (“Krishnamurthy”)

Krishnamurthy is prior art under pre-AIA 35 U.S.C. § 102(a) and (b) because it was published in 2008, before the earliest claimed priority date of the '214 patent. Krishnamurthy was not cited or discussed during prosecution of the '214 patent.

Krishnamurthy is directed to photovoltaic systems composed of interconnected rectangular solar cells arranged in string configurations to optimize power generation. Krishnamurthy discloses the use of rectangular solar cells, each having dimensions of 40 mm × 80 mm. Ex-1012, 52.

Krishnamurthy teaches that only one long side of each solar cell has chamfered corners, while the opposite long side does not:



Ex-1012, Fig. 6-5.

Krishnamurthy further discloses a solar cell arrangement in which adjacent cells in a string are placed such that the first long side (with chamfered corners) of one cell does not face the second long side (without chamfered corners) of the next cell. Ex-1012, Fig. 6-5.

VI. APPLICATION OF PRIOR ART TO THE CHALLENGED CLAIMS

A. Ground 1: Claims 1-5, 8, and 11 Are Obvious over Boretz and Maehane

Claims 1-5, 8, and 11 are obvious over the combination of Boretz and Maehane.

Boretz discloses a solar module comprising solar battery cells arranged in a series-parallel configuration, but does not describe the detailed shape or orientation of

the electrodes on the front and rear surfaces of the solar cells. Ex-1004, Fig. 2.2; Ex-1003, ¶85.

Maehane discloses a solar battery cell structure including light-receiving-surface bus electrodes and rear-surface bus electrodes formed in symmetrical arrangements to facilitate series interconnection while avoiding short circuits. Ex-1006, [0013]; Ex-1003, ¶86.

As explained below, it would have been obvious for a POSITA to incorporate Maehane's electrode structures into Boretz's solar module to improve current collection efficiency and simplify the interconnection of cells. Ex-1003, ¶86. A POSITA would have recognized that Maehane's teachings would have provided a predictable and advantageous improvement to Boretz's system, with a reasonable expectation of success. Ex-1003, ¶87.

1. Motivation to Combine Boretz and Maehane

It would have been obvious to combine Boretz and Maehane. Boretz discloses a solar module comprising solar cells but does not explicitly describe the structure or orientation of the electrodes on the front and rear surfaces of each cell. Ex-1003, ¶85. Maehane discloses an electrode configuration common in the industry, wherein grid electrodes across the cell surface collect current, and bus electrodes direct the current to adjacent cells. Ex-1003, ¶86. Incorporating Maehane's design into Boretz's module would improve current collection and connection efficiency. Ex-1003, ¶86. A POSITA

would have considered incorporating Maehane's electrode configuration with Boretz as simply applying a known technique to a known device ready for improvement to yield predictable results. *See KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007).

A POSITA would have reasonably expected success in making this combination. Ex-1003, ¶87. Maehane's configuration was well-known and would constitute a routine, predictable improvement to Boretz's system, enhancing electrical performance without introducing uncertainty. Ex-1003, ¶87.

2. Claim 1

Boretz in view of Maehane renders claim 1 obvious. Ex-1003, ¶¶88-120.

a) Limitation 1[pre]: "A solar battery module comprising:"

To the extent the preamble is limiting, Boretz teaches it. Boretz describes the design and manufacturing specifications of a solar battery module titled "Study to Establish Criteria for a *Solar Cell Array* for Use as a Primary *Power Source* for a Lunar-Based Water Electrolysis System," disclosing a "Solar Array Module" comprised of 924 solar cells. Ex-1004, 5-2; *see also* Ex-1003, ¶¶89–90.

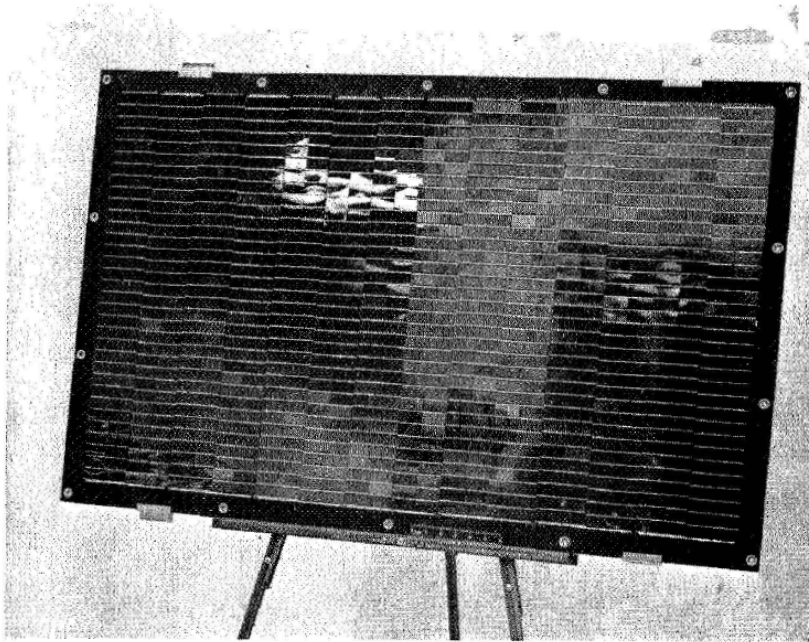


Figure 5.1 Phase IV Prototype Solar Array Module

Ex-1004, Figure 5.1.

Accordingly, Boretz teaches or suggests limitation 1[pre].

- b) Limitation 1[a]: “a plurality of solar battery cells, a plain shape of each being a substantial rectangle, and a ratio of a short side length and a long side length of the substantial rectangle being 1/n:1 (n is an integer equal to or larger than 2),”**

Boretz teaches this limitation. Ex-1003, ¶¶91–92. Boretz teaches a solar battery module including a “cellstack design [that] was based upon the use of 2 cm x 4 cm silicon cells utilized in a flat laydown configuration.” Accordingly, and as Dr. Toliyat explains, Boretz teaches a solar battery cell with a ratio of a short side length to long side length of 1/2:1 (i.e., 2 cm:4 cm). Ex-1004, 2-1; Ex-1003, ¶¶91-92. Figure 2.2

further shows that each solar battery cell has a substantial rectangular shape (as depicted by a single cell annotated in red):

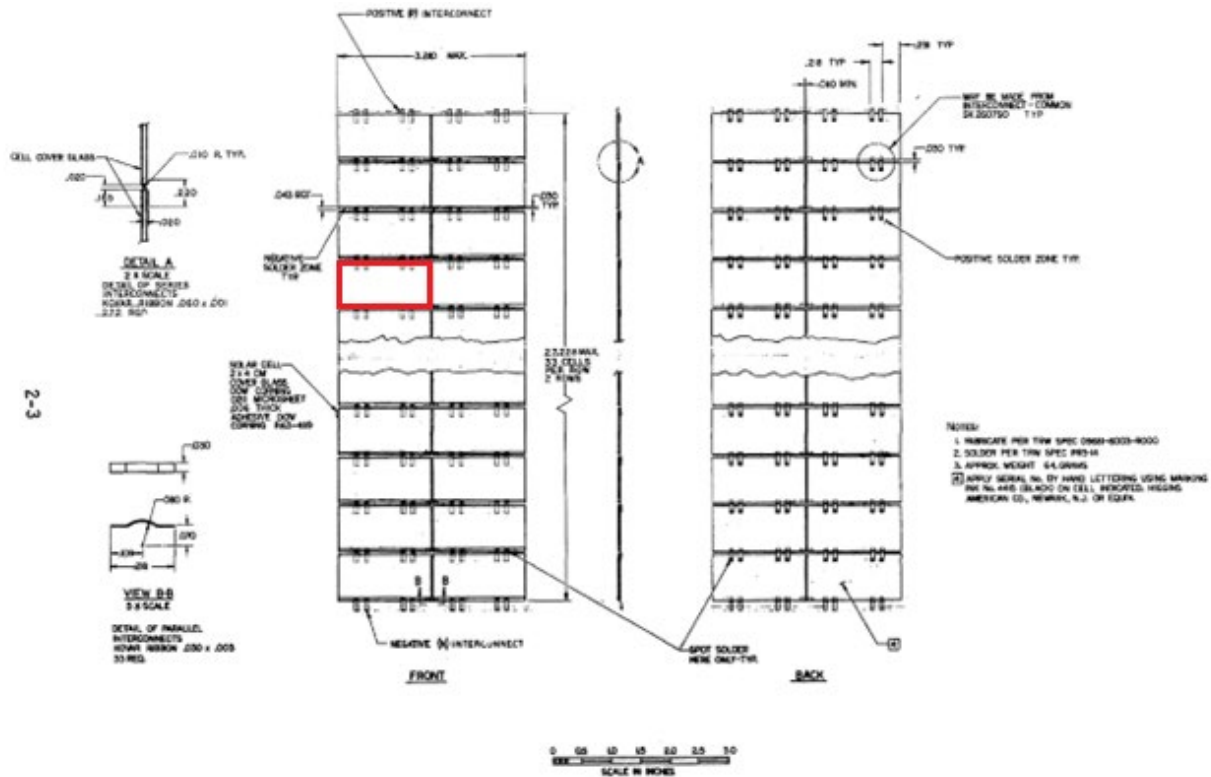


Figure 2.2 Prototype Test Module-Solar Cell Sub-Module Arrangement

Ex-1004, Figure 2.2 (annotated).

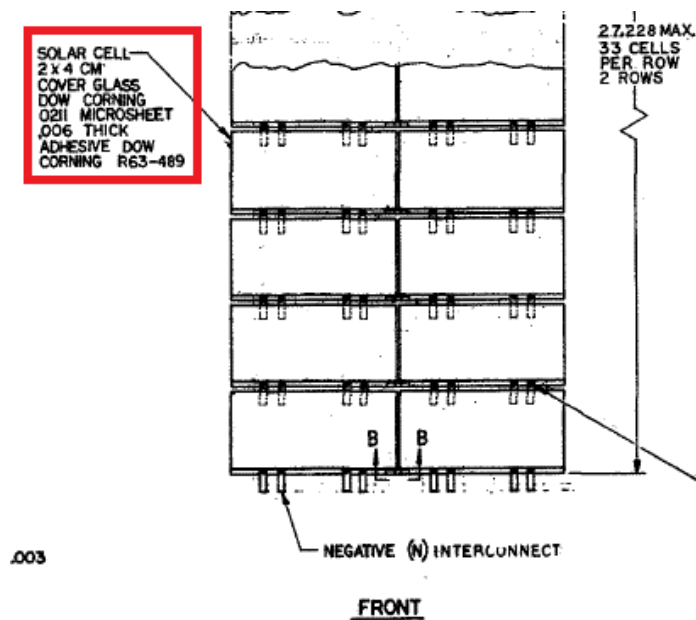
Accordingly, Boretz teaches or suggests limitation 1[a].

- c) Limitation 1[b]: “includes a plurality of light-receiving-surface bus electrodes parallel to the short side of the substantial rectangle on a light-receiving surface, and includes rear-surface bus electrodes each at a position on a non-light-receiving surface corresponding to each of the light-receiving-surface bus electrodes; and”**

Boretz in view of Maehane teaches or suggests this limitation. Ex-1003, “94—

Boretz teaches “a plurality of light-receiving-surface bus electrodes . . . on a light-receiving surface” and “rear-surface bus electrodes . . . on a non-light-receiving surface.”

The front face of Boretz’s solar cells is a light-receiving surface. Ex-1004, 2-1; Table 2.1; Fig. 2.2. As Dr. Toliyat explains, this is further evidenced by the application of a coverglass to the front face to protect it from UV degradation while allowing sunlight to pass through. Ex-1003, ¶96; *see also, e.g.*, Ex-1004, 2-1; Table 2.1; Fig. 2.2.



Ex-1004, Fig. 2.2 (excerpt) (annotated).

Cellstack

◦ Coverglass	Dow Corning 0211 microsheet; 0.006 in. thick.
◦ Coverglass Adhesive	Dow Corning R6-3489.
◦ Silicon Cell	2 cm. x 4 cm. x 0.014 inches thick.
◦ Cell-to-Substrate Adhesive	G.E. RTV-118
◦ Dielectric	0.001 in. thick Kapton.
◦ Interconnects	0.0015 in. Kovar.
◦ String Collector Bars	0.003 in. Kovar.

Ex-1004, Table 2.1 (excerpt).

Boretz further discloses that the rear face of the cells is a non-light-receiving surface. In particular, Boretz teaches that the rear faces are bonded to a substrate made of opaque materials, including a lightweight aluminum honeycomb core with graphite composite face sheets.

Substrate

◦ Face Sheets	Morganite Type II; 2 plies of 0.003 in. thick unidirectional graphite fibers crosslaid with 1 ply of No. 112 fiberglass cloth between graphite composite plies using Narmco No. 5505 Epoxy impregnation; total thickness approximately 0.009 in.
◦ Core	1/4" x 5052 x .007P-16 x 0.375" thick aluminum honeycomb; approximately 1.6 lb./ft ³ .
◦ Adhesive	Narmco No. 252; approximately 0.0015 thick.

Ex-1004, Table 2.1 (excerpt); *see also* Ex-1003, ¶¶97–99. Further, Boretz confirms that the cells were “bonded to [the substrate]” using adhesives. Ex-1004, 4-2. This substrate material is also depicted in Figure 5.1, around the edges of the cellstack where the cells are mounted onto the substrate:

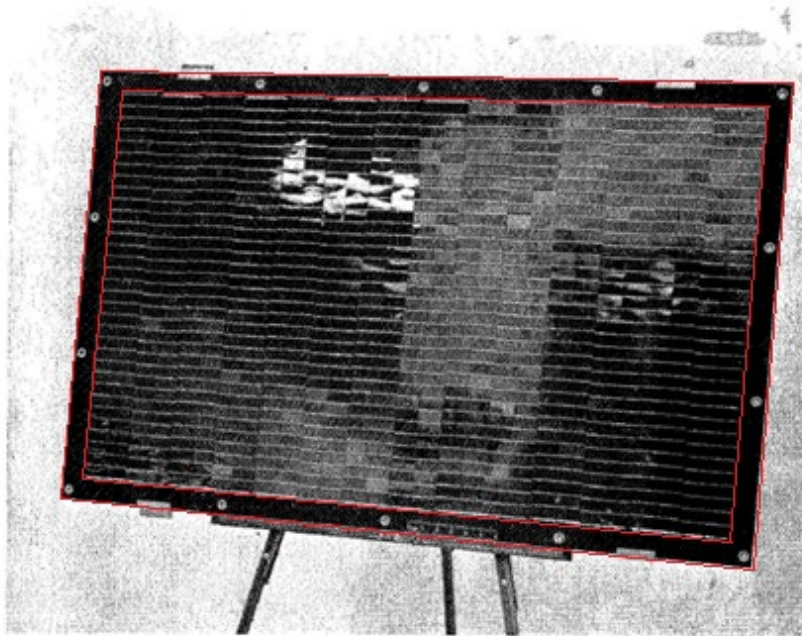
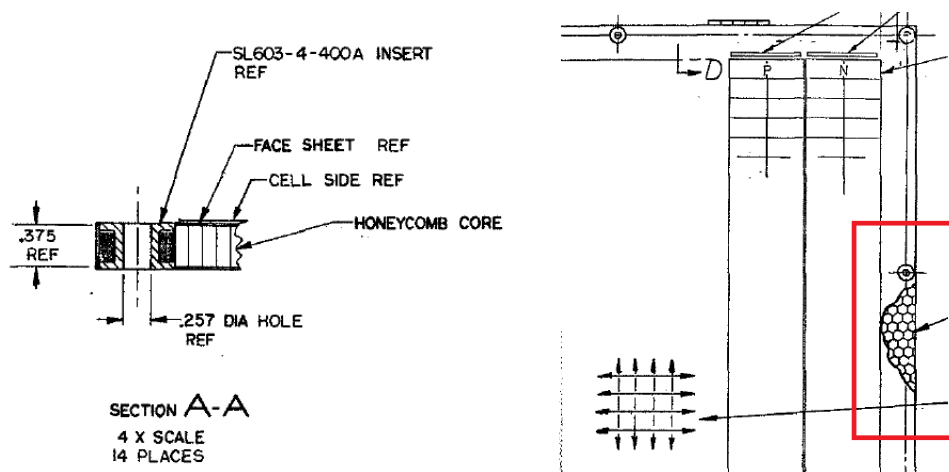


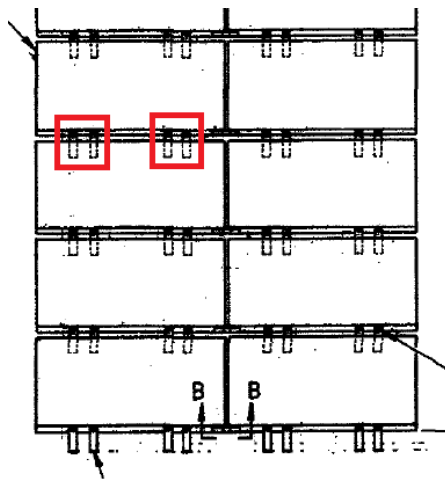
Figure 5.1 Phase IV Prototype Solar Array Module

Ex-1004, Fig. 5.1 (annotated); Ex-1003, ¶99. Figure 2.1 further confirms this configuration, where the cells are mounted onto a substrate comprising a contact face sheet and a honeycomb core:



Ex-1004, Fig. 2.1 (excerpts) (annotated). As Dr. Toliyat explains, a POSITA would readily understand from these teachings that the rear faces are non-light receiving. Ex-1003, ¶99.

A POSITA would understand that both the front “*light-receiving surface[s]*” and the rear “*non-light-receiving surface[s]*” each include a surface bus electrode. Ex-1003, ¶100. As explained for limitation 1[c], below, Boretz discloses that an interconnector electrically connects the front and rear surfaces of adjoining cells in series along a cell string. Ex-1004, Fig. 2.2; Ex-1003, ¶100. As Dr. Toliyat explains, to enable current flow through the series-connected cells, the interconnectors must connect to electrodes located on both the front and rear surfaces. Ex-1003, ¶100. A POSITA would further understand that these electrodes would be aligned with the four interconnector ribbons connecting each adjoining cell in the cell string. Ex-1004, Fig. 2.2; Ex-1003, ¶100.

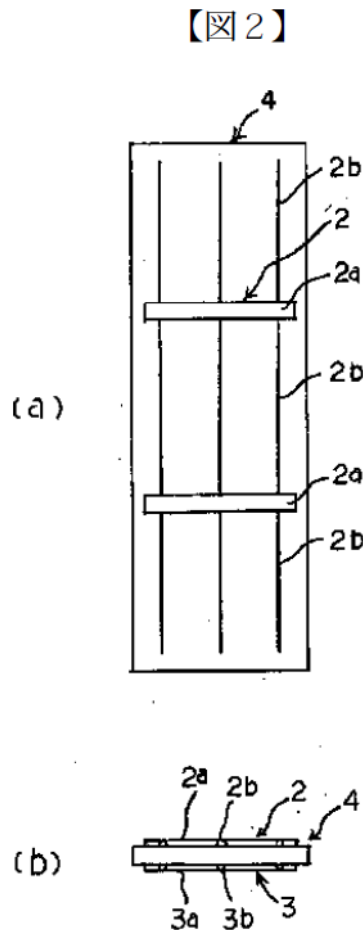


Ex-1004, Fig. 2.2 (excerpt) (annotated).

Thus, Boretz teaches “a plurality of light-receiving-surface bus electrodes . . . on a light-receiving surface” and “rear-surface bus electrodes . . . on a non-light-receiving surface.”

Boretz does not expressly disclose the precise orientation and positioning of its bus electrodes. As Dr. Toliyat explains, a POSA would have looked to Maehane’s teachings relating to its bus electrode orientation. Ex-1003, ¶102.

Specifically, Figure 2 of Maehane discloses the front face of an exemplary solar cell in an array of cells connected in series:



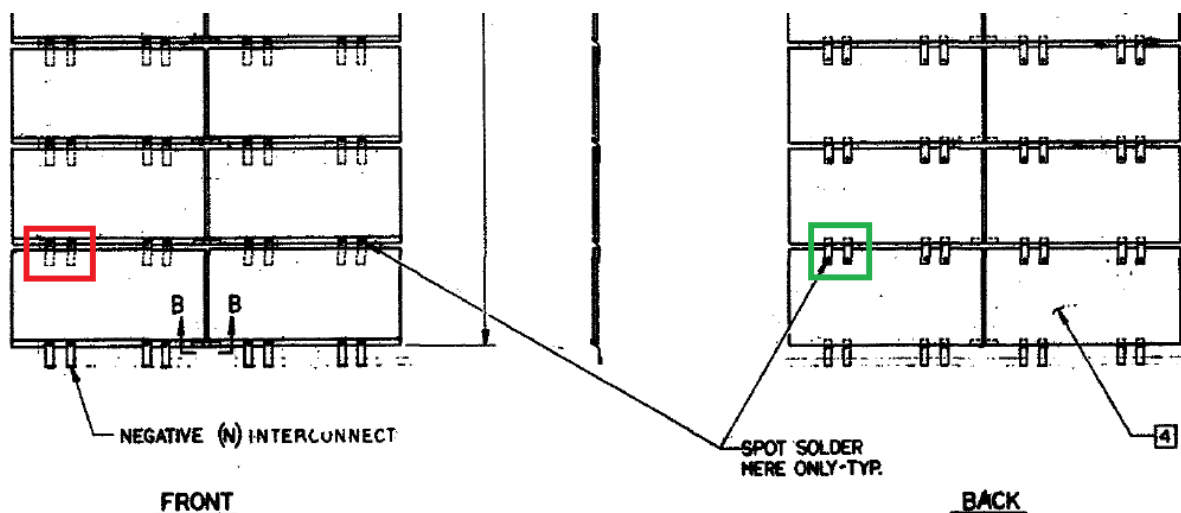
Ex-1005, Fig. 2. Maehane discloses that elements 2a are electrode “connection region[s]” on a front face of the cell. Ex-1005, ¶[0013]; Ex-1003, ¶103. Maehane further discloses that elements 3a are electrode connection regions formed on the rear surface with the same “aforementioned shape” as the front-side electrodes. Ex-1005, ¶[0013]; *see also, e.g.*, Ex-1003, ¶103. Both sets of electrodes are parallel to the short side of the substantially rectangular solar cell. *Id.*

Accordingly, Boretz in view of Maehane teaches or suggests limitation 1[b].

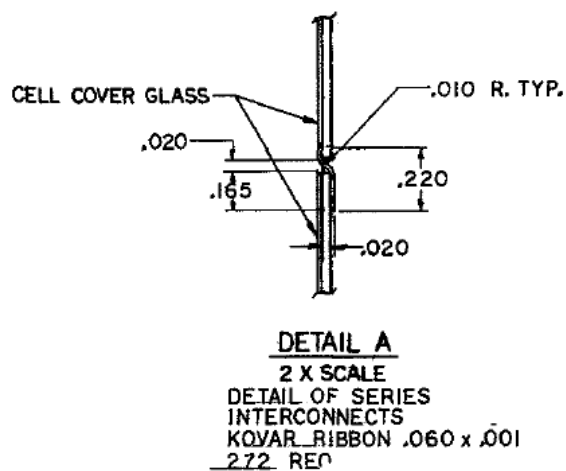
- d) **Limitation 1[c]: “an interconnector that electrically connects the light-receiving-surface bus electrodes of a first one of the solar battery cells to the rear-surface bus electrodes of an adjacent second one of the solar battery cells,”**

Boretz teaches or suggests this limitation.

Boretz discloses an interconnector that electrically connects the light-receiving-surface bus electrodes of a first solar battery cell to the rear-surface bus electrodes of an adjacent second solar battery cell. Ex-1004, 2-1; *see also, e.g.*, Ex-1003, ¶106. Boretz teaches that the solar module is composed of columns of cells, with each column comprising 66 cells connected in series. Ex-1004, 2-1; Ex-1003, ¶106. Figure 2.2 of Boretz shows interconnectors connecting the front face (light-receiving surface) of one cell to the rear face (non-light-receiving surface) of the next cell. Ex-1004, Fig. 2.2; Ex-1003, ¶106.



Ex-1004, Fig. 2.2 (excerpt) (annotated). The excerpted view of Figure 2.2 shows interconnector ribbons connecting a bus electrode on the front surface of a first cell (red connection point) to a bus electrode on the rear surface of an adjacent cell (green connection point). Ex-1004, Fig. 2.2 (Detail A); Ex-1003, ¶106.



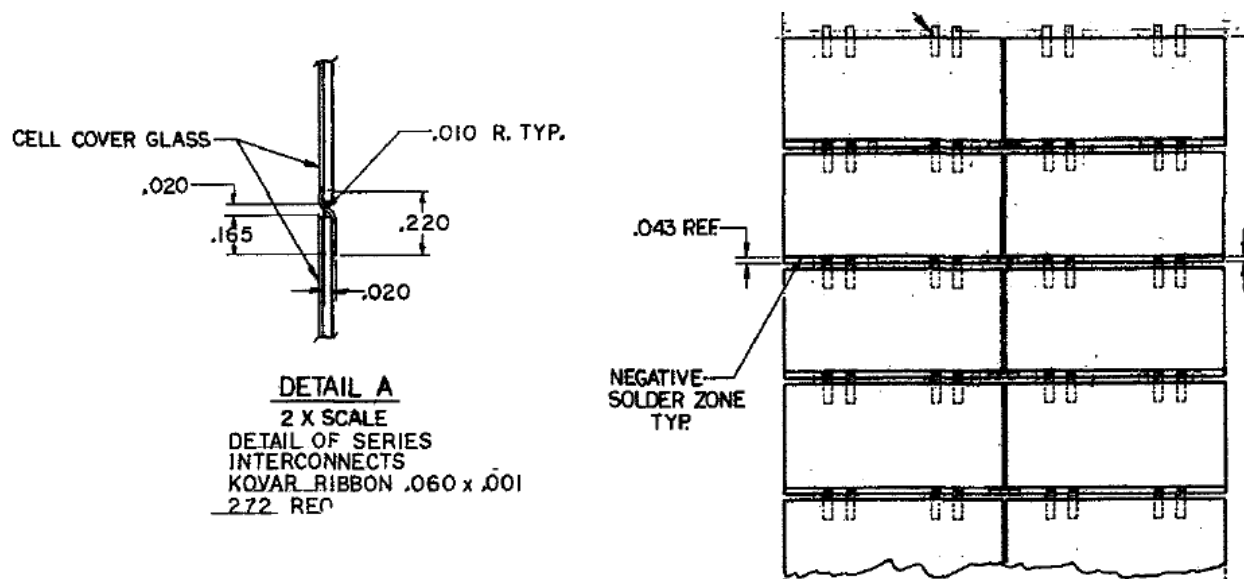
Ex-1004, Fig. 2.2 (excerpt). As discussed above for limitation 1[b], and as Dr. Toliyat explains in greater detail, these interconnectors are connected to the light-receiving-surface bus electrodes and rear-surface bus electrodes. Ex-1003, ¶106.

Accordingly, Boretz teaches limitation 1[c].

- e) **Limitation 1[d]: “wherein a predetermined number of the solar battery cells are serially connected to each other, thereby configuring a cell string,”**

Boretz teaches or suggests this limitation.

As described above for limitation 1[c], Boretz discloses that a predetermined number of solar battery cells are serially connected to each other to form a cell string. Ex-1004, 2-1, 4-1, 5-1, Fig. 2.2; *see also, e.g.*, Ex-1003, ¶109. Boretz teaches that the solar module is composed of columns of cells, with each column comprising 66 cells connected in series. *Id.* Figure 2.2 of Boretz depicts this configuration, showing multiple cells stacked along each column.



Ex-1004, Fig. 2.2 (excerpt); *see also* Ex-1003, ¶109. As “Detail A” of Figure 2.2 reflects, the interconnectors connect the front face of a first cell to the rear face of an

adjacent second cell, confirming serial electrical connection along each column, thus configuring a cell string. Ex-1004, Fig. 2.2 (Detail A); Ex-1003, ¶109.

Accordingly, Boretz teaches limitation 1[d].

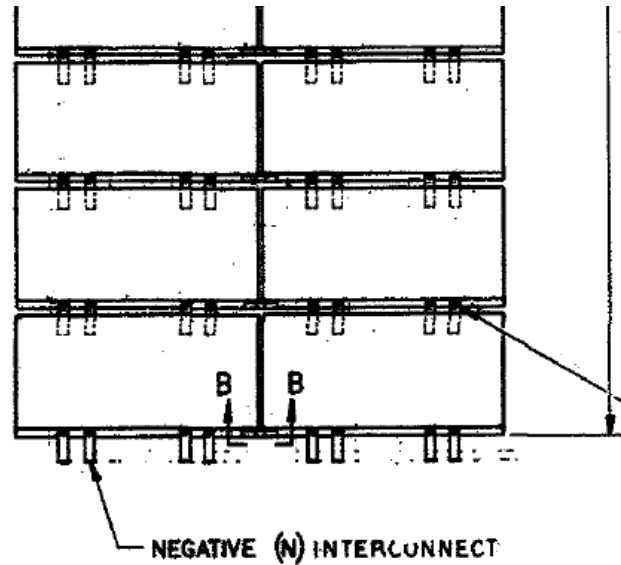
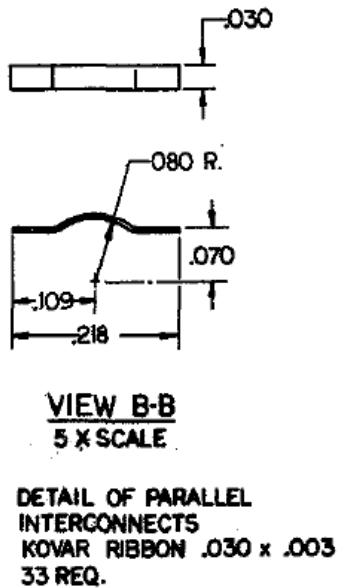
- f) **Limitation 1[e]: “n columns of the cell strings are connected in parallel by a first string connector at one end of the n columns, the n in the number of columns of the cell strings connected in parallel being equal to the n in the ratio of the long side length to the short side length, and”**

Boretz teaches or suggests this limitation.

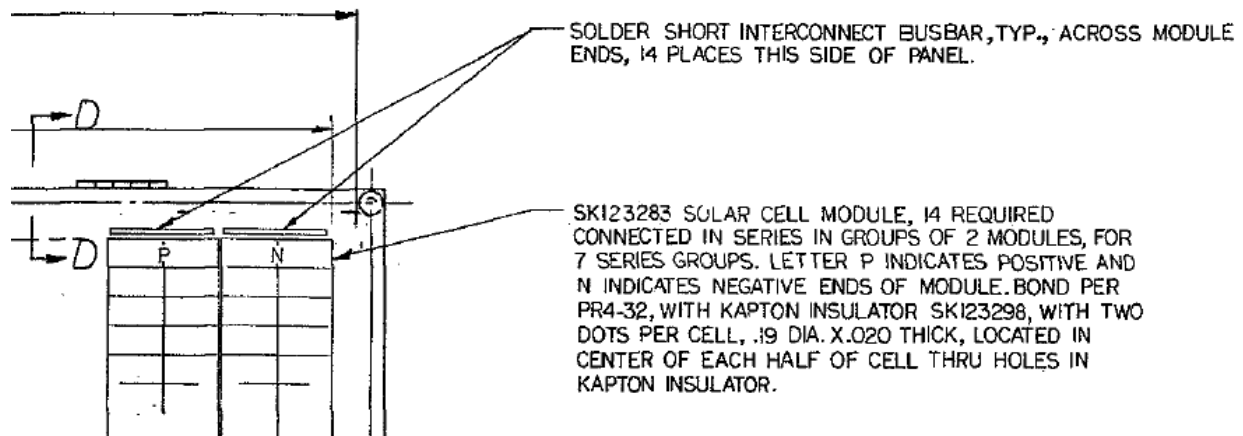
Boretz teaches that its depicted solar module comprises n columns of cell strings connected in parallel by a first string connector at one end of the n columns, where the n in the number of columns of cell strings connected in parallel is equal to the n in the ratio of the long side length to the short side length. Ex-1003, ¶112.

As explained above for limitation 1[a], the solar cells in the Boretz module are 2 cm x 4 cm (i.e., a ratio of 1/n:1 where $n = 2$). Boretz discloses 2 columns ($n = 2$) of cell strings connected in parallel by a first string connector at one end of the 2 columns. In particular, Boretz teaches that the solar module is comprised of a series of sub-modules, and that each sub-module “employ[s] two cells in parallel and 66 cells in series.” Ex-1004, 2-1; *see also* Ex-1004, 4-1, 5-1 (disclosing same); Ex-1003, ¶¶111-114.

This parallel configuration is further depicted in Figure 2.2:



Ex-1004, Fig. 2.2 (excerpt). As described in Detail B, each sub-module contains a parallel interconnect (first string connector) at one end of 2 columns. Figure 2.1 further shows two such sub-modules inset into the larger solar module:



Ex-1004, Fig. 2.1 (excerpt). As shown in the excerpt, 2 sub-modules are depicted, each with 2 columns of cell strings. A first sub-module is oriented such that both positive ends of the 2 columns of cell strings are at the top, and a second sub-module is oriented such that both negative ends of the 2 columns of cell strings are at the top.

Ex-1003, ¶114. Each sub-module includes an interconnect busbar (first string connector) connecting both positive ends (the first sub-module, on the left) or both negative ends (the second sub-module, on the right) of the 2 columns of cell strings to each other in parallel. Ex-1004, Fig. 2.1; *see also, e.g.*, Ex-1003, ¶114.

Accordingly, Boretz teaches limitation 1[e].

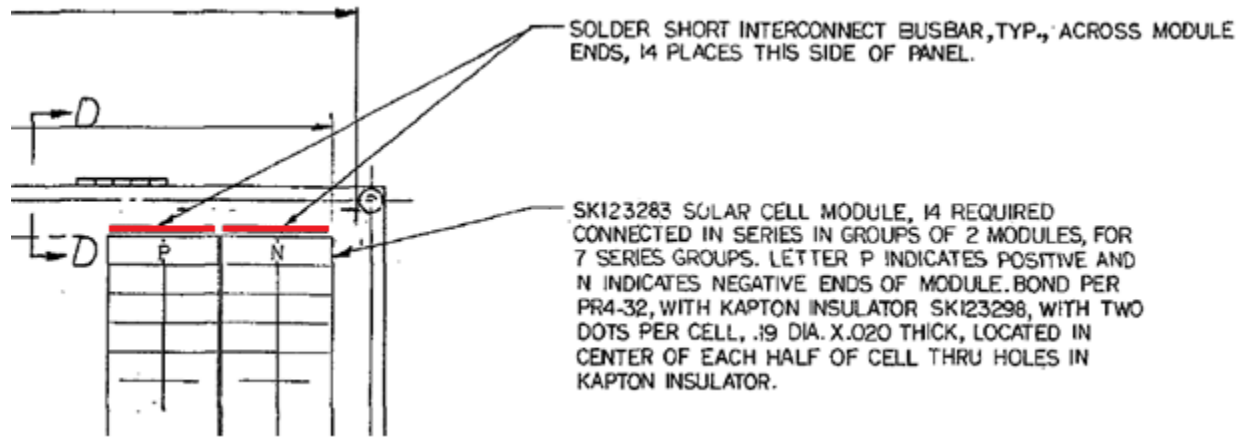
- g) **Limitation 1[f]: “the n-column parallel-connected cell strings are further serially connected to another n-column parallel-connected cell strings by a second string connector at an opposite end of the n columns, thereby configuring an entire cell array.”**

Boretz teaches or suggests this limitation.

Boretz teaches that its solar module comprises n columns of cell strings connected in parallel by a first string connector at one end of the n columns, where the n in the number of columns connected in parallel matches the n in the ratio of the long side length to the short side length of the solar cells. Ex-1004, 2-1; Ex-1003, ¶117.

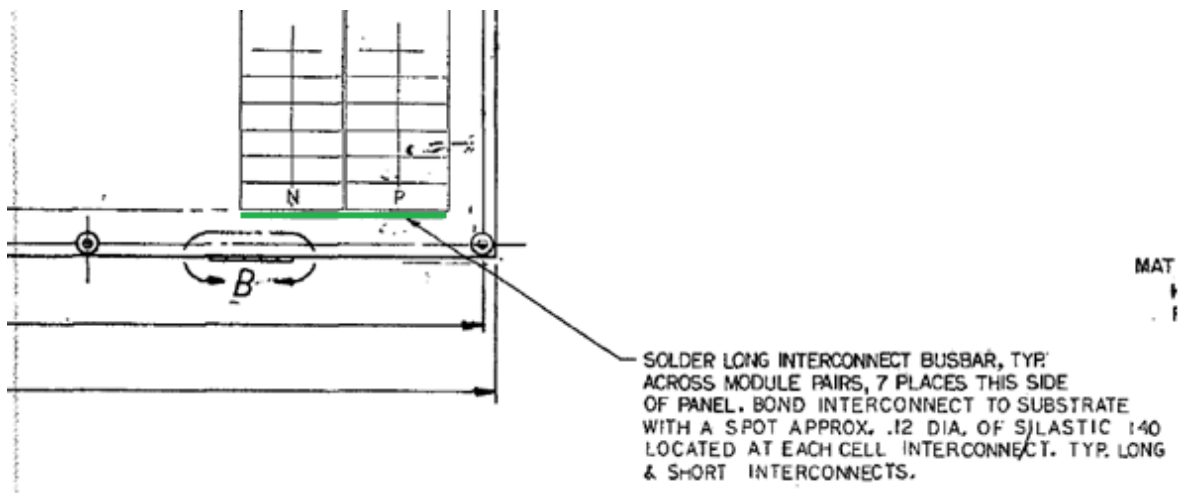
As explained above for limitation 1[a], Boretz discloses solar cells measuring 2 cm × 4 cm, corresponding to a ratio of 1/2:1 where n = 2, matching the claim requirement, as Dr. Toliyat explains in greater detail. Ex-1004, 2-1; Ex-1003, ¶118. Boretz further discloses 2 columns (n = 2) of cell strings connected in parallel by a first string connector at one end of the 2 columns. Specifically, Boretz teaches that each sub-module “employ[s] two cells in parallel and 66 cells in series.” Ex-1004, 2-1, 4-1, 5-1; Ex-1003, ¶118. Figure 2.1 further depicts two such parallel interconnects (first

string connector, in red) connecting 2 adjacent columns of cells each:



Ex-1004, Fig. 2.1 (excerpt) (annotated); Ex-1003, ¶118.

As Figure 2.1 depicts, at the opposite end of these columns, a second string connector (green below) further connects adjoining sub-modules to each other in series:



Ex-1004, Fig. 2.1 (excerpt) (annotated); Ex-1003, ¶119. Figure 2.1 shows that the long interconnect busbar (second string connector) provides a positive-to-negative

series connection between the two illustrated sub-modules, as Dr. Toliyat further describes. Ex-1003, ¶¶117-119.

Accordingly, Boretz teaches limitation 1[f].

3. **Claim 2: “The solar battery module according to claim 1, wherein a predetermined number of the solar battery cells are serially connected, thereby configuring a cell string, two columns of the cell strings are connected in parallel, and the two-column parallel-connected cell strings are further serially connected, thereby configuring an entire cell array.”**

Boretz in view of Maehane renders claim 2 obvious. Ex-1003, ¶¶121-23.

As discussed above, Boretz in view of Maehane renders obvious claim 1. Boretz in view of Maehane teaches or suggests the further requirements of claim 2 that the solar battery module specifically include two columns of cell strings connected in parallel (i.e., $n=2$), and that the two-column parallel-connected cell strings are further serially connected to configure an entire cell array.

As discussed above for limitation 1[e], Boretz teaches two columns ($n=2$) of cell strings connected in parallel by a first string connector. Ex-1004, 2-1; Ex-1003, ¶123. As further discussed above for limitation 1[f], Boretz teaches that these two-column sub-modules are connected in series by a second string connector to form an entire solar cell array. Ex-1004, Fig. 2.1; Ex-1003, ¶123.

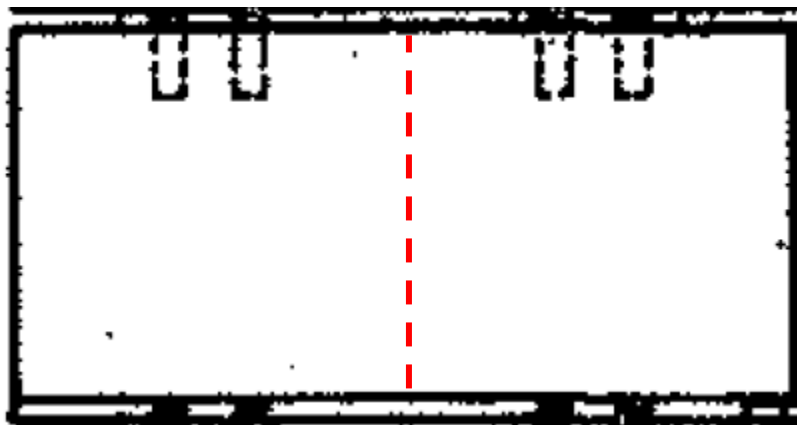
Accordingly, Boretz in view of Maehane renders claim 2 obvious. Ex-1003, ¶123.

4. **Claim 3: “The solar battery module according to claim 1, wherein the light-receiving-surface bus electrodes of each solar battery cell are formed at positions that are line-symmetrical with respect to a line passing through a middle point of a side perpendicular to an extended line of the light-receiving-surface bus electrodes and parallel to the light-receiving-surface bus electrodes.”**

Boretz in view of Maehane renders claim 3 obvious. Ex-1003, ¶¶124-28.

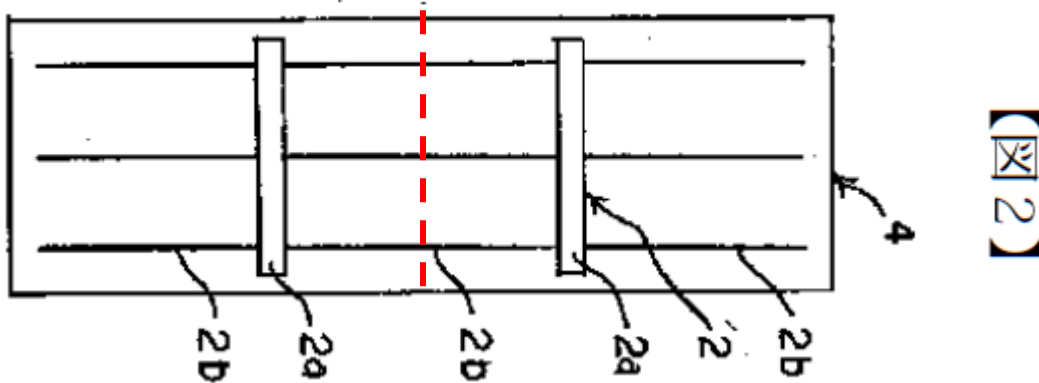
As discussed above, Boretz in view of Maehane renders obvious claim 1. Boretz in view of Maehane teaches or suggests the further requirements of claim 3 that the light-receiving-surface bus electrodes are positioned line-symmetrically with respect to a line through the midpoint of a side perpendicular to and parallel with the bus electrodes.

As explained above for limitation 1[b], a POSITA would understand that Boretz teaches light-receiving-surface bus electrodes which connect to the interconnector tabs on the front face of each cell, as depicted in Figure 2.2:



Ex-1004, Fig. 2.2 (excerpt) (annotated); *see also*, Ex-1003, ¶126. Dr. Toliyat explains that these electrodes are line-symmetrical with respect to the dashed red line shown in Figure 2.2. Ex-1003, ¶126.

Boretz does not expressly disclose the exact shape of the bus electrodes. However, as Dr. Toliyat explains, Maehane depicts line-symmetrical bus electrodes positioned as claimed.



Ex-1005, Fig. 2 (excerpt) (rotated) (annotated); *see also, e.g.*, Ex-1003, ¶127. Thus, the bus electrodes 2a are line-symmetrical with the dashed red line, which passes through a middle point of a side perpendicular to an extended line of the light-receiving-surface bus electrodes and parallel to the light-receiving-surface bus electrodes. *Id.*

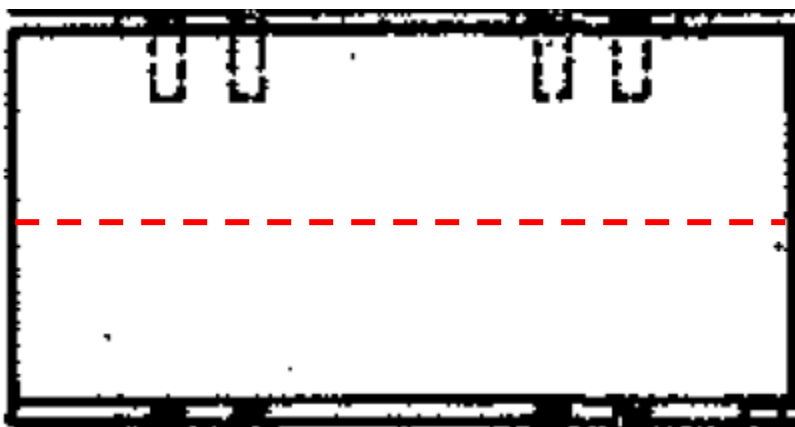
Accordingly, Boretz in view of Maehane renders obvious claim 3. Ex-1003, ¶127.

5. **Claim 4: “The solar battery module according to claim 1, wherein the light-receiving-surface bus electrodes of each solar battery cell are formed at positions that are line-symmetrical with respect to a line passing through a middle point of a side parallel to the light-receiving-surface bus electrodes and perpendicular to the light-receiving-surface bus electrodes.”**

Boretz in view of Maehane renders claim 4 obvious. Ex-1003, ¶¶129-33.

As discussed above, Boretz in view of Maehane renders obvious claim 1. Boretz in view of Maehane further teaches or suggests the additional limitation of claim 4 that the bus electrodes are line-symmetrical with respect to a line passing through the midpoint of a side that is parallel to and perpendicular to the bus electrodes Ex-1003, ¶130.

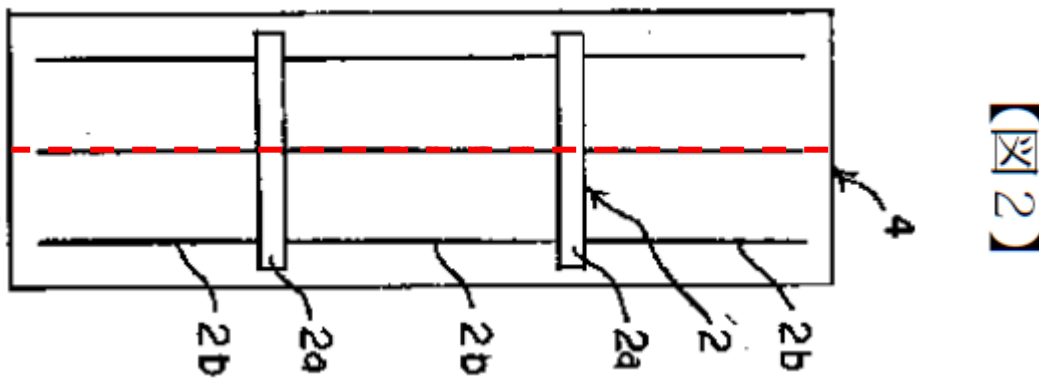
As explained above for limitation 1[b], a POSITA would understand that Boretz teaches light-receiving-surface bus electrodes which connect to the interconnector tabs on the front face of each cell. Ex-1003, ¶131. Figure 2.2 depicts this arrangement:



Ex-1004, Fig. 2.2 (excerpt). As annotated, the four bus electrodes connected to the interconnectors are symmetrically positioned relative to a dashed red line, which

passes through the middle of a side that is parallel to the light-receiving-surface bus electrodes and perpendicular to the light-receiving-surface bus electrodes. Ex-1003, ¶131.

Boretz does not expressly disclose the precise symmetry of the bus electrode arrangement. Maehane depicts bus electrodes 2a that are line-symmetrical with respect to a line passing through the midpoint of a side that is parallel and perpendicular to the electrodes.



Ex-1005, Fig. 2 (excerpt) (rotated) (annotated); Ex-1003, ¶132.

Accordingly, Boretz in view of Maehane renders obvious claim 4. =

6. **Claim 5: “The solar battery module according to claim 1, wherein each of the solar battery cells includes an area where the light-receiving-surface bus electrodes and the rear-surface bus electrodes are not formed within a predetermined dimension from an edge toward a central direction of the cell at an outer circumferential edge portion thereof.”**

Boretz in view of Maehane renders claim 5 obvious. Ex-1003, ¶¶134-39.

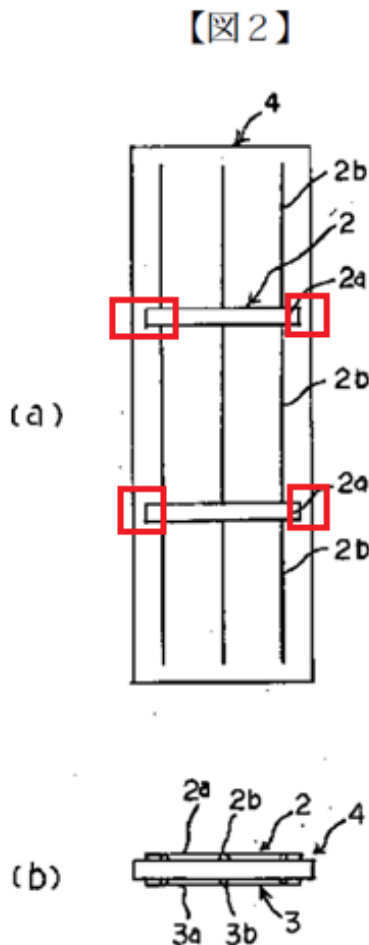
As discussed above, Boretz in view of Maehane renders obvious claim 1. Boretz in view of Maehane further teaches or suggests the additional limitation of claim 5 that each solar cell includes an outer circumferential area where neither the front nor rear bus electrodes are formed. Ex-1003, ¶135.

As explained above for limitation 1[b], a POSITA would understand that Boretz teaches light-receiving-surface bus electrodes which connect to the interconnector tabs on the front face of each cell:



Ex-1004, Fig. 2.2 (excerpt); Ex-1003, ¶136.

As explained above for limitation 1[b], Boretz does not expressly disclose the exact shape of the bus electrodes connected to each interconnector. However, Maehane teaches forming the light-receiving-surface bus electrodes and the rear-surface bus electrodes such that there is an area near the outer circumferential edge of the cell where the electrodes are not formed:



Ex-1005, Fig. 2 (annotated); Ex-1003, ¶137.

Maehane expressly teaches leaving this portion of the cell uncovered by the bus electrode to help prevent short circuits. Specifically, Maehane discloses that “the connection region portion is located immediately inside the outer periphery of the solar cell element, so that an undesired short circuiting does not occur.” Ex-1005, [0010]; *see also* Ex-1005, [0017]; Ex-1003, ¶138. Maehane teaches that this same cell region uncovered by the bus electrodes is present on the back face (rear-surface bus electrodes) as well, Ex-1005, [0018]; Ex-1003, ¶138, which have the same “aforementioned shape”

as the light-receiving-surface bus electrodes on the front face, Ex-1005, [0013]; Ex-1003, ¶138.

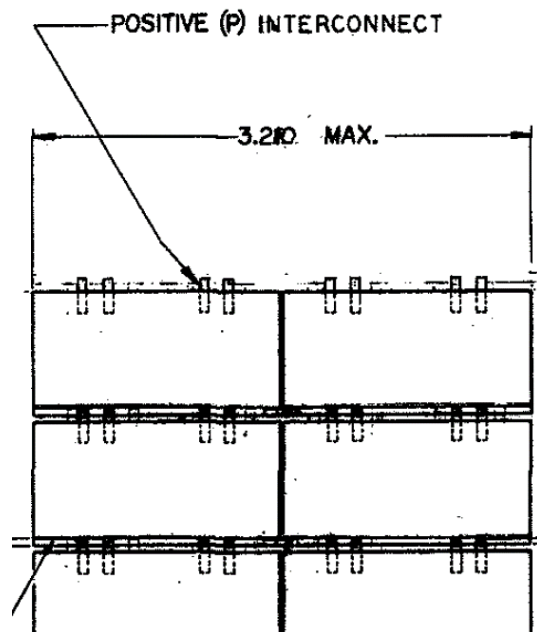
Accordingly, Boretz in view of Maehane renders obvious claim 5.

7. **Claim 8: “The solar battery module according to claim 1, wherein the interconnector is joined to the light-receiving-surface bus electrode of a solar battery cell nearest to the second string connector of the n-column parallel-connected cell strings, and is connected to the second string connector, and the second string connector is connected to a rear surface lead at the rear-surface bus electrode of a head solar battery cell nearest the second string connector of the another n-column parallel-connected cell strings.”**

Boretz in view of Maehane renders claim 8 obvious. Ex-1003, ¶¶140-44.

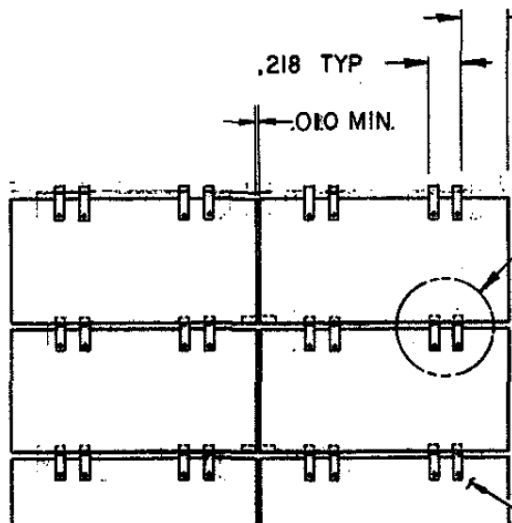
As discussed above, Boretz in view of Maehane renders obvious claim 1. Boretz further teaches or suggests the additional limitation of claim 8 that (1) the interconnector connects the front bus electrode of the end cell to the second string connector, and (2) the second string connector is connected to a rear surface lead at the rear electrode of a head cell from a different string. Ex-1003, ¶141.

As shown in Figure 2.2 of Boretz, the interconnector is joined to the light-receiving-surface bus electrode of the solar battery cell nearest to the second string connector of the two-column parallel-connected cell strings. Ex-1004, Fig. 2.2; Ex-1003, ¶142.



Ex-1004, Fig. 2.2 (excerpt). The cells located at the ends of the cell strings (depicted at the top) are connected to the second string connector. As explained above for limitation 1[f], the interconnects extending from these end cells necessarily connect with the long interconnect busbars (second string connectors) to allow the flow of electrical current between sub-modules, as Boretz teaches. Ex-1003, ¶142.

Figure 2.2 also depicts the rear surface leads at the head of the solar battery cells nearest the second string connector:



Ex-1004, Fig. 2.2 (excerpt). Dr. Toliyat explains that Boretz teaches this interconnection structure through its layout and electrical pathway design. Ex-1003, ¶143.

Accordingly, Boretz in view of Maehane renders obvious claim 8.

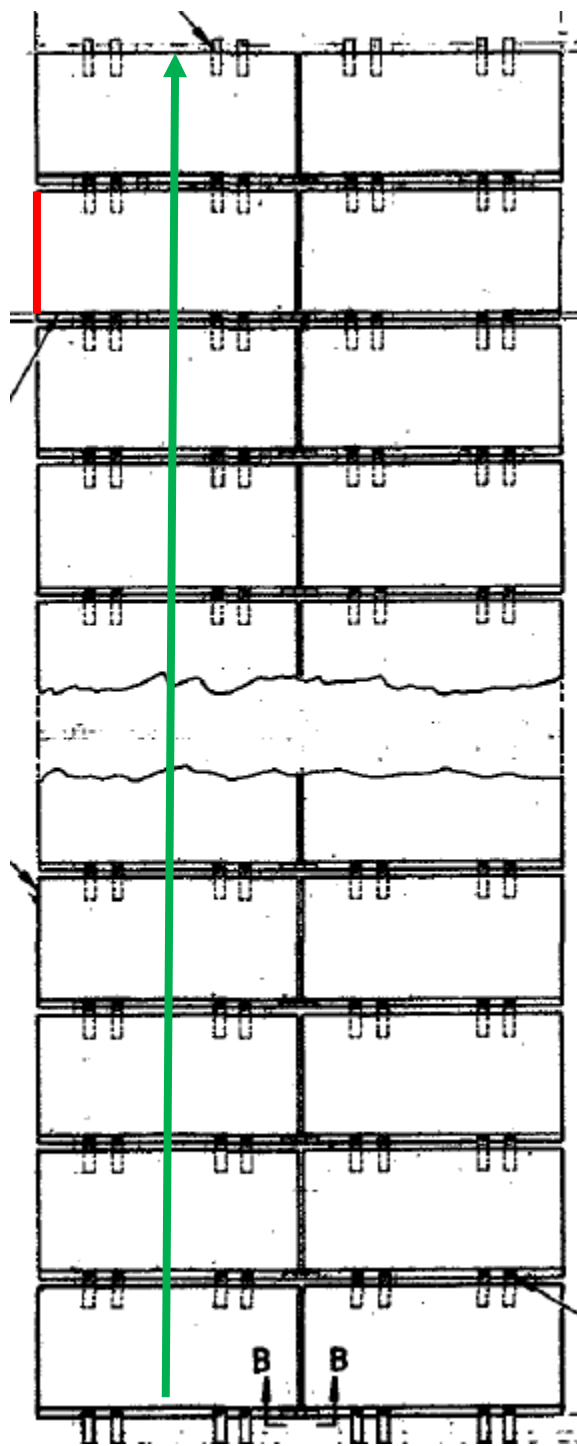
8. **Claim 11: “The solar battery module according to claim 1, wherein the solar battery cells in the cell array are arranged so that the short side lengths are parallel to the extension of the n-column parallel-connected cell strings.”**

Boretz in view of Maehane renders claim 11 obvious. Ex-1003, ¶¶145-48.

As discussed above, Boretz in view of Maehane renders obvious claim 1. Boretz further teaches or suggests the additional limitation of claim 11 that the short sides of the solar cells are oriented parallel to the direction of the n-column (e.g., two-column) parallel-connected strings. Ex-1003, ¶146.

Specifically, Boretz teaches that the solar battery cells in the cell array are arranged such that their short side lengths are parallel to the extension of the two-

column parallel-connected cell strings. Ex-1004, Fig. 2.2; Ex-1003, ¶¶146-7. An excerpt of Figure 2.2 of Boretz, annotated for clarity, is reproduced below:



Ex-1004, Fig. 2.2 (excerpt) (annotated). As the excerpt shows, the short side lengths

of the solar battery cells (highlighted in red) extend parallel to the overall direction of the two-column parallel-connected cell strings (highlighted in green). Ex-1003, ¶147. As Dr. Toliyat explains, this arrangement would have been apparent to a POSITA viewing the configuration disclosed in Boretz. Ex-1003, ¶147.

Accordingly, Boretz in view of Maehane renders obvious claim 11 of the '214 patent.

B. Ground 2: Claim 6 is Obvious over Boretz, Maehane, and Ravi328

1. Motivation to Combine Boretz, Maehane, and Ravi328

It would have been obvious to combine Boretz with Maehane and Ravi328. Ex-1003, ¶¶149-54.

A POSITA would have considered incorporating Ravi328's disclosure of splitting a square-shaped solar cell in half with Boretz as simply applying a known technique to a known device ready for improvement to yield predictable results. *See KSR*, 550 U.S. at 417. It is a common practice in the solar industry to produce solar cells by forming and cutting silicon wafers into a square or "pseudo-square" shape (with rounded, or, "chamfered" corners). Ex-1003, ¶¶149-150. When a module's design specifies cells comprising half of these squares, it is common to simply cut the squares in half. Ex-1003, ¶151. A POSITA would thus recognize that half-cells such as those disclosed in Boretz may be conveniently produced through splitting a substantially square cell, such as taught by Ravi328. Ex-1003, ¶152. Applying this

basic cell splitting process from Ravi328 to Boretz would yield the predictable outcome a POSITA would have expected to achieve with this common technique. *Id.*

A POSITA would have further been motivated to combine Boretz and Ravi328 with Maehane for the same reasons discussed above in Section VI.A.1.

A POSITA would have reasonably expected success in making this combination. Ex-1003, ¶154. Ravi328's cell splitting process would constitute a routine, predictable improvement to Boretz's system, utilizing a common and well-understood technique for producing solar cells in the dimensions desired in Boretz. *Id.*

2. Claim 6

Boretz in view of Maehane and Ravi328 renders claim 6 obvious. Ex-1003, ¶155.

a) Limitation 6[pre]: “The solar battery module according to claim 1,”

As discussed above, Boretz in view of Maehane renders obvious claim 1. Ex-1003, ¶156.

b) Limitation 6[a]: “which is obtained by dividing a basic solar battery cell with a plane shape thereof being a substantial square,”

Ravi328 teaches or suggests the additional limitation of claim 6[a]. Ex-1003, ¶¶157-59.

Ravi328 discloses “laser cutting of 125-mm full solar cells into two half solar cells.” Ex-1009, 3; Ex-1003, ¶158. An excerpt of Figure 4 of Ravi328 is reproduced

below:

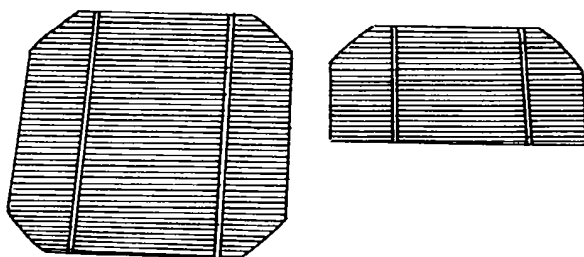


Fig. 4

Ex-1009, Fig. 4.

Accordingly, Ravi328 teaches limitation 6[a] of the '214 patent.

- c) **Limitation 6[b]: “which includes n light-receiving-surface electrode areas in each of which a plurality of light-receiving-surface bus electrodes parallel to a side of the substantial square . . . are provided”**

Ravi328 teaches or suggests the additional limitation of claim 6[b]. Ex-1003, ¶¶160-63.

As shown in Figure 4 of Ravi328, the full-sized square cell is split into two light-receiving-surface electrode areas ($n = 2$ in the illustrated half-cut case). Ex-1003, ¶161.

An excerpt of Figure 4 is reproduced below.

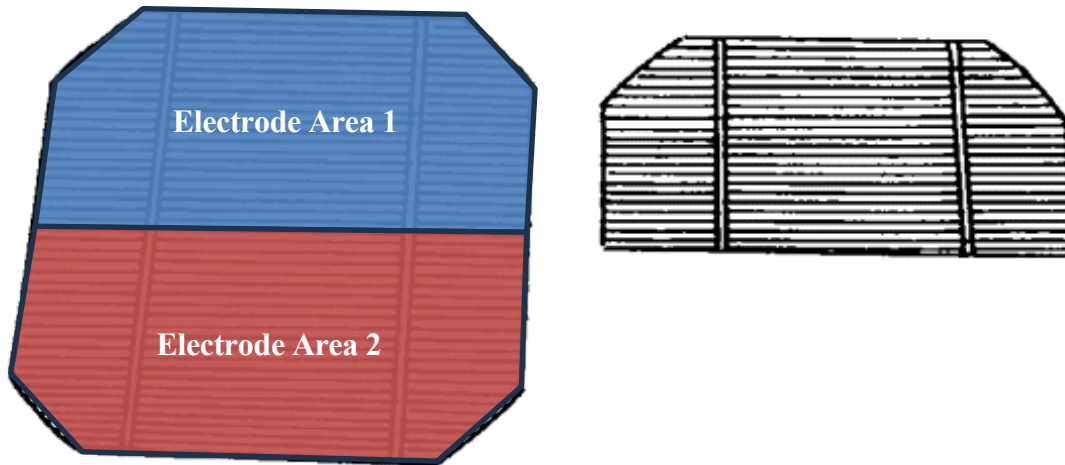


Fig. 4

Ex-1009, Fig. 4 (annotated).

Ravi328 further states that “[t]inned copper interconnects are soldered on the front busbars of matched solar cells in terms of output current.” Ex-1009, 5; Ex-1003, ¶162. As shown in Figure 4 of Ravi328, each of the light-receiving-surface bus electrodes (annotated in red) in the two electrode areas is parallel to a side of the substantial square (annotated in green). Ex-1003, ¶162.

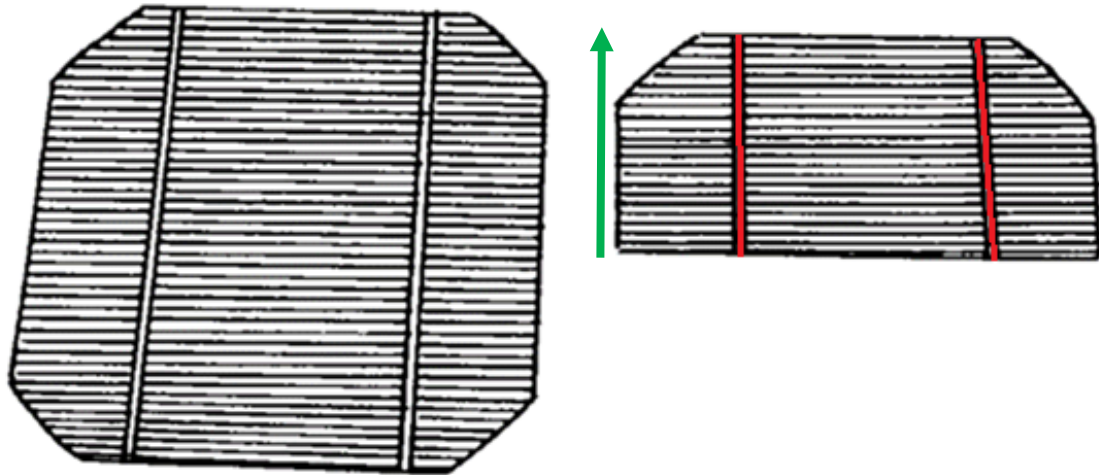


Fig. 4

Ex-1009, Fig. 4 (annotated).

Accordingly, Ravi328 teaches limitation 6[b].

- d) **Limitation 6[c]: “and a plurality of grid electrodes perpendicular to the light-receiving-surface bus electrodes are provided on a light-receiving surface side and includes rear-surface bus electrodes each at a position on a non-light-receiving surface side corresponding to each of the light-receiving-surface bus electrodes into n respective boundaries of the n light-receiving-surface electrode areas.”**

Ravi328 teaches or suggests the additional limitation of claim 6[c]. Ex-1003,

¶164-68.²

² For purposes of this petition, Petitioner interprets “*n respective boundaries*” to refer to the *n* cell regions created by splitting the basic solar battery cell with a plane shape thereof being a substantial square cell of limitation 6[a], not the number of boundaries between those *n* cell regions.

As shown in Figure 4 of Ravi328, the front surface of each solar cell includes a conventional grid layout, where fine grid electrodes (depicted in green) are arranged perpendicular to the light-receiving-surface bus electrodes (depicted in red). This forms a standard front contact pattern on crystalline silicon solar cells. Ex-1009, Fig. 4; Ex-1003, ¶165. An excerpt of Figure 4 is reproduced below:

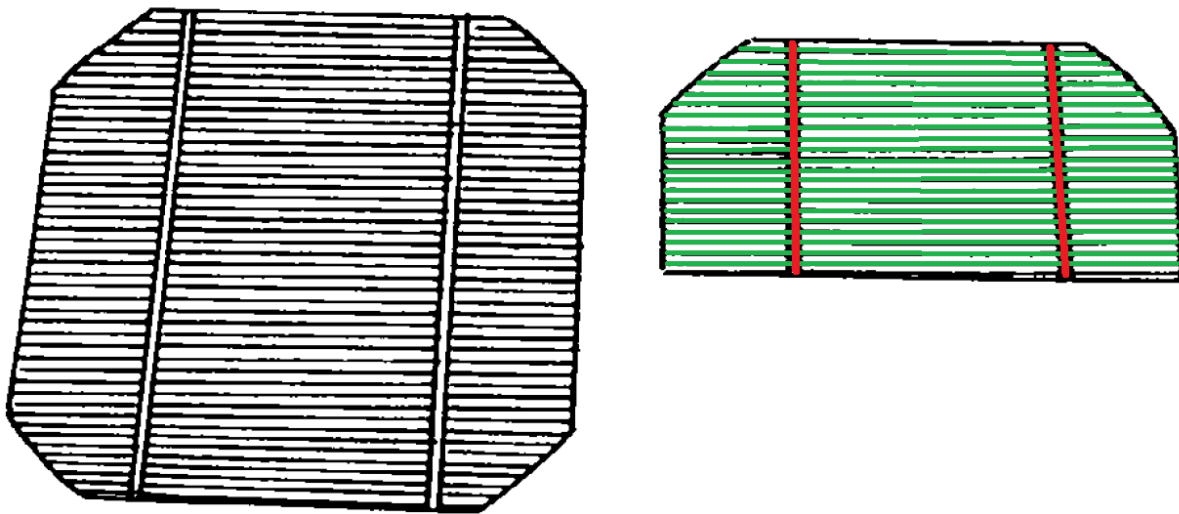


Fig. 4

Ex-1009, Fig. 4 (annotated).

Ravi328 further discloses that “[b]usbars (Silver-aluminium) are printed on the back side for facilitating solder contacts, and rest of the area is covered with aluminium paste to create the back surface field (BSF).” Ex-1009, 5–6; Ex-1003, ¶165.

As Dr. Toliyat explains, a POSITA would understand that these rear-side busbars correspond in position to the front-side busbars, such that each front busbar

has a matching rear busbar located at the same position on the rear surface. This front-to-back correspondence is consistent with standard crystalline silicon cell architecture to enable efficient front-to-back connections. Ex-1003, ¶167.

Accordingly, Ravi328 teaches limitation 6[c], and Boretz in view of Maehane and Ravi328 renders obvious claim 6.

C. Ground 3: Claim 7 is Obvious over Boretz, Maehane, and Ravi260

1. Motivation to Combine Boretz, Maehane, and Ravi260

It would have been obvious to combine Boretz with Maehane and Ravi260.

Boretz teaches the use of certain connectors as the '214 patent's claimed "second string connector." Section VI.A.2.g. However, Boretz acknowledges the problem of reinforcing the mechanical strength of these connectors. Ex-1003, ¶169. A POSITA would recognize that extending the second string connector in Boretz continuously across the entire cell array like in Ravi260 would help to reinforce the connector. *Id.* Boretz itself suggests such a motivation by acknowledging that the connection points on the connector where it is joined with each cell string help to improve the mechanical strength. *Id.* Ravi260 discloses such a string connector extending across the entire length of the cell array. *Id.* Thus, in addition to the express teaching, suggestion, and motivation for applying Ravi260's disclosure of the second string connector extending continuously across the entire cell array, a POSITA would have considered incorporating Ravi260's disclosure of a continuous second string

connector with Boretz as simply applying a known technique to a known device ready for improvement to yield predictable results. *See KSR*, 550 U.S. at 417; Ex-1003, ¶169. A POSITA would have further been motivated to combine Boretz and Ravi260 with Maehane for the same reasons discussed above in Section VI.A.1.

A POSITA would have reasonably expected success in making this combination. Ex-1003, ¶170. Ravi260's extension of the second string connector continuously across the entire cell array was well-known and would constitute a routine, predictable improvement to Boretz's system, utilizing a common and well-understood technique to improve the mechanical strength of the connector in a manner expressly suggested by Boretz itself. *Id.*

2. Claim 7: “The solar battery module according to claim 1, wherein the second string connector extends continuously across the entire cell array.”

Boretz in view of Maehane and Ravi260 renders obvious claim 7. Ex-1003, ¶¶171-75.

As discussed above, Boretz in view of Maehane renders obvious claim 1. Ravi260 teaches or suggests the additional limitation of claim 7. Ex-1003, ¶¶172-73.

Ravi260 discloses an array of solar cells in a series-parallel configuration, wherein the second string connector (which serially connects each group of two columns of parallel-connected cell strings) extends continuously across the entire cell array:

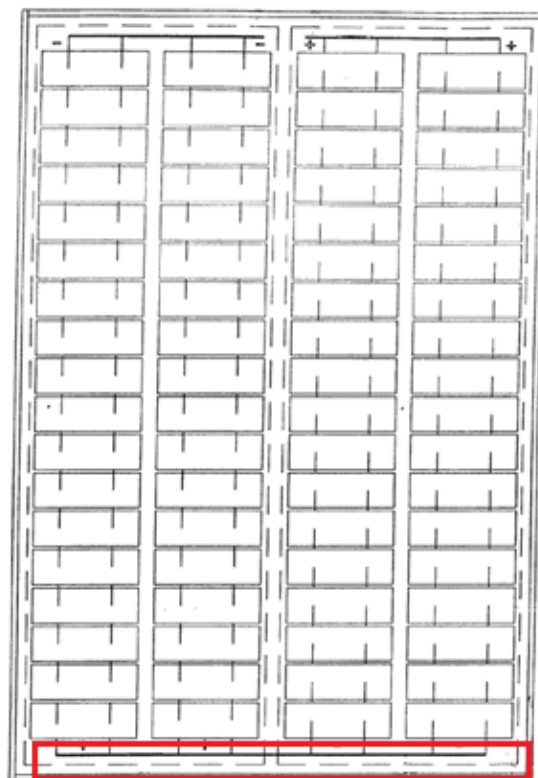


Fig. 6

60 WATTS PV MODULE MADE WITH 72 NOS.
OF ONE-THIRD CUT 156 mm SOLAR CELLS.

Ex-1010, Fig. 6 (annotated); Ex-1003, ¶173. The annotated red box depicts this second string connector.

As discussed above, and as Dr. Toliyat explains, a POSITA would recognize that replacing the multiple second string connectors used in Boretz with a single continuous second string connector as taught in Ravi260 would increase the mechanical strength of the connector. Ex-1003, ¶174.

Accordingly, Boretz in view of Maehane and Ravi260 renders obvious claim 7.

D. Ground 4: Claims 9 and 10 Are Obvious over Boretz, Maehane, and Krishnamurthy

1. Motivation to Combine Boretz, Maehane, and Krishnamurthy

It would have been obvious to combine Boretz with Maehane and Krishnamurthy. Ex-1003, ¶¶176-80.

A POSITA would have considered incorporating Krishnamurthy's disclosure of chamfered half-cells with Boretz as simply applying a known technique to a known device ready for improvement to yield predictable results. *See KSR*, 550 U.S. at 417. As explained above in Section VI.B.1, it is common industry practice to produce rectangular cells by splitting a pseudo-square cell (i.e., with chamfered corners) cut from a silicon wafer. Section VI.B.1. Such a process helps prevent waste of the silicon wafers while simultaneously maintaining a cell shape which can be patterned across the cell array, maximizing the utilization area of the module. Ex-1003, ¶¶176-77. Thus, applying Krishnamurthy's disclosure of chamfered half-cells to Boretz would yield the predictable outcome a POSITA would have expected to achieve through utilization of this common cell production process. *Id.*

A POSITA would have further found it obvious to arrange chamfered half-cells in Boretz using the orientation disclosed in Krishnamurthy, especially given the finite number of predictable choices, with a reasonable expectation of success. *See KSR*, 550 U.S. at 421. As discussed above, an important consideration in solar module design is

cell shape that can be easily patterned, or tessellated, across the array in order to maximize utilization of the module area. Ex-1003, ¶178. Once the cell shape is determined, the cells must then actually be arranged in a pattern which maximizes the utilization of this space, which is generally accomplished by using a simple grid structure. *Id.*

There are a limited number of ways to orient the chamfered half-cells in this arrangement. *Id.* Krishnamurthy discloses one such arrangement in aligning adjoining half-cells, from non-chamfered edge to non-chamfered edge, which also provides a uniform visual presentation of the cells. *Id.* Moreover, where as here the surface bus electrodes are symmetrical to a center line as required by claim 3—Section VI.A.4—selecting one of the finite other options for orienting the cells in this arrangement conveys no additional benefit over the presentation disclosed in Krishnamurthy, which the '214 patent itself expressly acknowledges. Ex-1003, ¶178.

A POSITA would have further been motivated to combine Boretz and Krishnamurthy with Maehane for the same reasons discussed above in Section VI.A.1.

A POSITA would have reasonably expected success in making this combination. Ex-1003, ¶180. Inclusion of Krishnamurthy's chamfered half-cells in an orientation wherein adjoining cells are aligned from non-chamfered edge to non-chamfered edge would constitute a routine, predictable improvement to Boretz's system, utilizing a commonly used cell shape well-suited to maximizing the utilization space of the

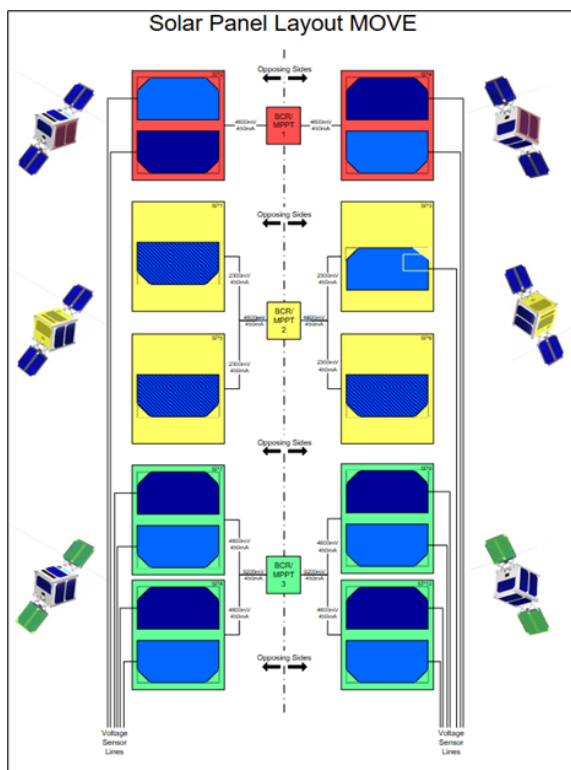
module area, in an arrangement and orientation that makes appropriate use of this cell shape's easy tessellation. *Id.*

2. **Claim 9: “The solar battery module according to claim 1, wherein long sides of the substantial rectangle include a first long side and a second long side, the substantial rectangle has chamfered corners on both ends of only the first long side such that the second long side is without chamfered corners, and wherein the first one of the solar battery cells and the second one of the solar battery cells are arranged in the cell array such that the first long side and the second long side of the first one and the second one of the solar battery cells do not face each other.”**

Boretz in view of Maehane and Krishnamurthy renders obvious claim 9. Ex-1003, ¶¶181-85.

As discussed above, Boretz in view of Maehane renders obvious claim 1. Ex-1003, ¶182. Neither Boretz nor Maehane expressly disclose solar cells with chamfered corners and the claimed cell arrangement. *Id.*

However, Krishnamurthy teaches a configuration wherein solar battery cells have chamfered corners only on the first long side and are arranged such that adjacent cells do not have chamfered edges facing one another. Ex-1012, Fig. 6-5; Ex-1003, ¶183. An excerpt of Figure 6-5 of Krishnamurthy is reproduced below:



Ex-1012, Fig. 6-5.

As Dr. Toliyat explains, a POSITA would have been motivated to incorporate Krishnamurthy's asymmetric chamfering and arrangement into Boretz's layout to improve module alignment, avoid mechanical stress at cell edges, and simplify automated assembly processes. Ex-1003, ¶184.

Accordingly, Boretz in view of Machane and Krishnamurthy renders obvious claim 9.

3. Claim 10

a) Limitation 10[pre]: "A solar battery module comprising:"

Boretz in view of Machane and Krishnamurthy renders claim 10 obvious.

To the extent, the preamble is limiting, Boretz teaches or suggests it. Section VI.A.2.a.

- b) **Limitation 10[a]: “plurality of solar battery cells, a plain shape of each being a substantial rectangle, and a ratio of a short side length and a long side length of the substantial rectangle being 1/n:1 (n is an integer equal to or larger than 2),”**

Boretz teaches or suggests this limitation. Section VI.A.2.b.

- c) **Limitation 10[b]: “includes a plurality of light-receiving-surface bus electrodes parallel to the short side of the substantial rectangle on a light receiving surface, and includes rear-surface bus electrodes each at a position on a non-light-receiving surface corresponding to each of the light-receiving-surface bus electrodes; and”**

Boretz in view of Maehane teaches or suggests this limitation. Section VI.A.2.c.

- d) **Limitation 10[c]: “an interconnector that electrically connects the light-receiving-surface bus electrodes of a first one of the solar battery cells to the rear-surface bus electrodes of an adjacent second one of the solar battery cells,”**

Boretz teaches or suggests this limitation. Section VI.A.2.d.

- e) **Limitation 10[d]: “wherein long sides of the substantial rectangle include a first long side and a second long side, the substantial rectangle has chamfered corners on both ends of only the first long side such that the second long side is without chamfered corners, and”**

Boretz in view of Maehane and Krishnamurthy teaches or suggests this limitation. Section VI.D.2.

- f) **Limitation 10[e]: “the first one of the solar battery cells and the second one of the solar battery cells are arranged in the module such that the first long side and the second long side of the first one and the second one of the solar battery cells do not face each other.”**

Boretz in view of Maehane and Krishnamurthy teaches or suggests this limitation. Section VI.D.2.

E. Ground 5: Claims 1-4, 6, 8, and 11 Are Obvious over Zhang and Ravi328

1. Motivation to Combine Zhang and Ravi328

It would have been obvious to combine Zhang with Ravi328. Ex-1003, ¶¶199-204.

A POSITA would have considered incorporating Ravi328’s disclosed electrode configuration with Zhang as simply applying a known technique to a known device ready for improvement to yield predictable results. *KSR*, 550 U.S. at 417. As with Boretz discussed above in Section VI.A.1, Zhang discloses a solar module comprising solar cells but does not explicitly describe the structure or orientation of the electrodes on the front and rear surfaces of each cell. Ex-1003, ¶202. Ravi328 also similarly discloses an electrode configuration common in the industry, wherein grid electrodes across the cell surface collect current, and bus electrodes direct the current to adjacent cells. Ex-1003, ¶201. Incorporating Ravi328’s design into Zhang’s module would improve current collection and connection efficiency. *Id.* Applying Ravi328 to Zhang would yield the predictable outcome a POSITA would have expected to achieve with

Ravi328's common electrode configuration.

A POSITA would have further recognized that incorporating Ravi328's disclosure of using of half-cells with Zhang would constitute a simple combination of prior art elements according to known methods, yielding predictable results. *See KSR*, 550 U.S. at 416. Zhang discloses a solar module which uses 125 mm x 125 mm square cells. Ex-1007, Abstract. Ravi328 discloses using half-cut (split) rectangular solar cells derived from 125-mm square wafers. Ex-1009, 3. A POSITA would recognize these half-cut cells, arranged in series-parallel layouts, minimize current through each string, thereby reducing resistive losses and boosting overall module efficiency. Ex-1003, ¶202. A POSITA would have found that these improvements in module efficiency would be the predictable result of combining Zhang and Ravi328 to incorporate half-cut cells. Ex-1003, ¶202.

A POSITA would have reasonably expected success in making this combination. Ex-1003, ¶204. Ravi328's electrode configuration was well-known and would constitute a routine, predictable improvement to Zhang's system, enhancing electrical performance without introducing uncertainty. *Id.* Similarly, a POSITA would have reasonably expected success in incorporating Ravi328's half-cells in Zhang, as the use of half-cut cells to minimize resistive losses and improve overall module performance was well-known at the time of the '214 patent. *Id.*

2. Claim 1

Zhang in view of Ravi328 renders claim 1 obvious.

a) Limitation 1[pre]: “A solar battery module comprising:”

To the extent the preamble is limiting, Zhang teaches or suggests it. Ex-1007, Abstract; Ex-1003, ¶¶206-8.

Specifically, Zhang discloses a PV module comprising “photovoltaic glass, unit cells connected by interconnection strips, and a package backsheet, which are packaged as a whole by a transparent laminated material.” Ex-1007, Abstract. The photovoltaic cells are “125x125 mm monocrystalline or polycrystalline solar cells.” Ex-1007, Abstract; Ex-1003, ¶207.

Accordingly, to the extent the preamble is limiting, Zhang teaches it.

b) Limitation 1[a]: “a plurality of solar battery cells, a plain shape of each being a substantial rectangle, and a ratio of a short side length and a long side length of the substantial rectangle being 1/n:1 (n is an integer equal to or larger than 2),”

Zhang in view of Ravi328 teaches or suggests this limitation. Ex-1003, ¶¶209-213.

While Zhang discloses a PV module with multiple 125×125 mm solar cells, it does not describe a rectangular shape or a 1/n:1 aspect ratio. Ex-1007, Abstract; Ex-1003, ¶210.

However, Ravi328 teaches a PV module incorporating 108 half-cut 125 mm

mono-crystalline cells, each with a substantial rectangular shape and a 1:2 short-to-long side ratio. Ex-1009, 3; Ex-1003, ¶211.

Figure 4 of Ravi328 further confirms that the half-cut cells have a substantial rectangular shape and a 1/2:1 aspect ratio, as depicted by the half-cell (right) relative to the full cell (left). Ex-1009, Fig. 4; Ex-1003, ¶212. An excerpt of Figure 4 is reproduced below:

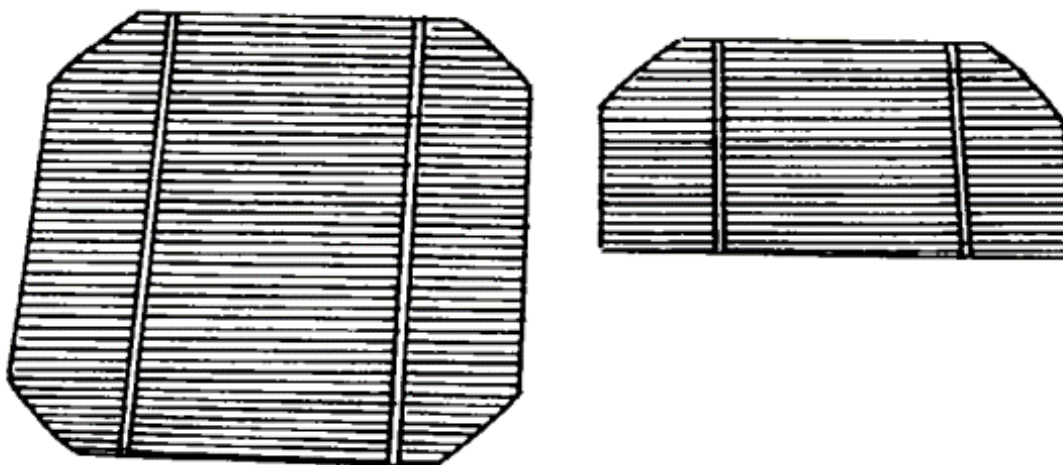


Fig. 4

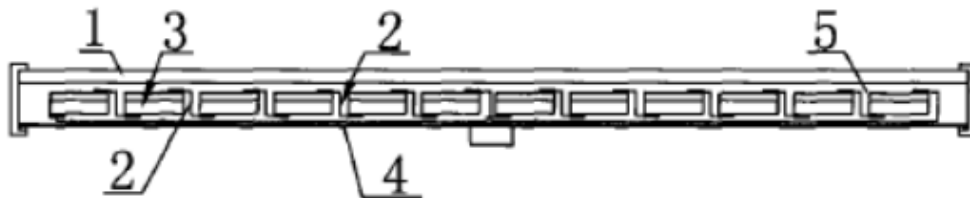
Ex-1009, Fig. 4.

Accordingly, Zhang in view of Ravi328 teaches or suggests limitation 1[a].

- c) **Limitation 1[b]: “includes a plurality of light-receiving-surface bus electrodes parallel to the short side of the substantial rectangle on a light-receiving surface, and includes rear-surface bus electrodes each at a position on a non-light-receiving surface corresponding to each of the light-receiving-surface bus electrodes; and”**

Zhang in view of Ravi328 teaches or suggests this limitation. Ex-1003, ¶¶214-223.

Zhang teaches that the front side of each solar cell is a light-receiving surface protected by photovoltaic glass, while the rear side is a non-light-receiving surface covered by a package backsheet. Ex-1007, Fig. 1; Ex-1003, ¶¶216-17.



Ex-1007, Fig. 1.

A POSITA would understand that both surfaces include bus electrodes aligned with the interconnection strips shown in Figure 1 of Zhang. Ex-1007, Fig. 1; Ex-1003, ¶¶218-220. Although Zhang does not specify the shape or orientation of the bus electrodes, Ravi328 discloses screen-printed front grid lines and rear busbars to enable front-to-back connections. Ex-1009, 4; Ex-1003, ¶221.

An annotated excerpt of Figure 4 of Ravi328 is reproduced below:

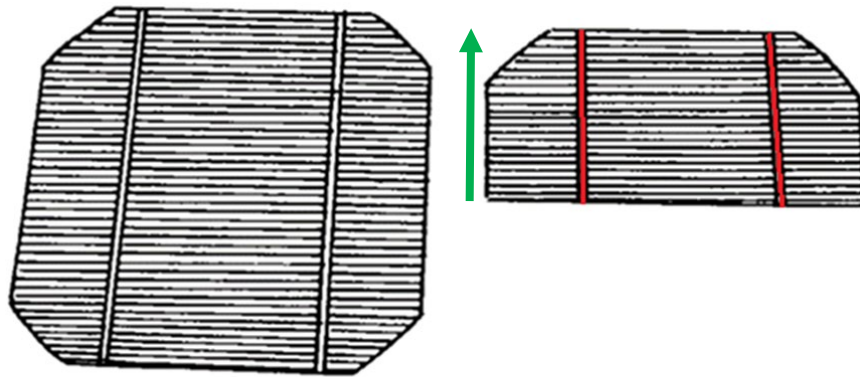


Fig. 4

Ex-1009, Fig. 4 (annotated).

As Dr. Toliyat explains, the rear contacts correspond directly to the front contacts, enabling front-to-back electrical connection between adjacent cells. Ravi328 teaches that “[t]inned copper interconnects are soldered on the front busbars of matched solar cells ... These are strung together (front contact of one cell connected to the back contact of the next cell through the interconnects).” Ex-1009, 5; Ex-1003, ¶222.

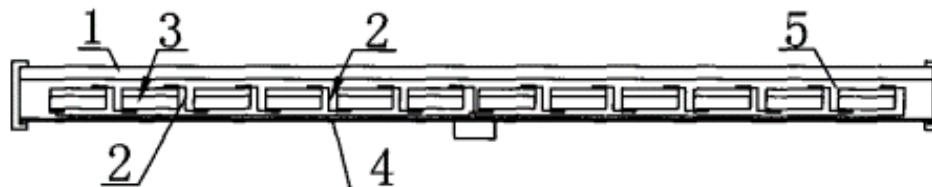
Accordingly, Zhang in view of Ravi328 teaches or suggests limitation 1[b].

- d) **Limitation 1[c]: “an interconnector that electrically connects the light-receiving-surface bus electrodes of a first one of the solar battery cells to the rear-surface bus electrodes of an adjacent second one of the solar battery cells,”**

Zhang teaches or at least suggests this limitation. Ex-1003, ¶¶224-28.

Zhang discloses that “unit cells 3 are connected in series to form a series group 6” using “interconnection strips 2.” Ex-1007, 4; Fig. 1; Ex-1003, ¶225. Figure 1 shows

strips 2 extending between adjacent unit cells 3 in a flat stack beneath photovoltaic glass 1.



Ex-1007, Fig. 1.

A POSITA would understand this as a standard configuration in which light enters from the top, making the upper cell surface the light-receiving surface and the bottom the rear surface. Ex-1003, ¶226.

In this arrangement, the interconnection strips connect the front-side bus electrode of one cell to the rear-side electrode of the next, enabling front-to-back series connection as claimed. Ex-1003, ¶227. As Dr. Toliyat notes, this reflects conventional, well-established interconnection practices in the solar cell art. *Id.*

Accordingly, Zhang teaches limitation 1[c].

- e) **Limitation 1[d]: “wherein a predetermined number of the solar battery cells are serially connected to each other, thereby configuring a cell string,”**

Zhang teaches or suggests this limitation. Ex-1003, ¶¶229-32.

Zhang discloses that 125×125 mm monocrystalline or polycrystalline cells are “connected in series to form a series group.” Specifically, nine cells are connected

in series to form one group, and six such groups are then connected in series to complete the module. Ex-1007, Abstract; Ex-1003, ¶230.

Figure 3 depicts a cell string comprised of a number of solar battery cells serially connected to each other. Ex-1007, Fig. 3; Ex-1003, ¶231. An excerpt of Figure 3 of Zhang is reproduced below:

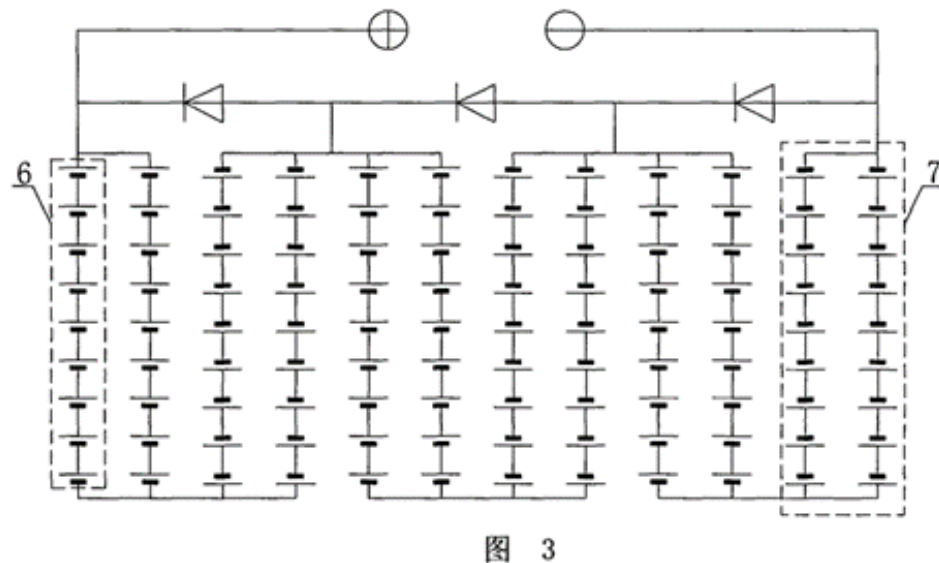


图 3

Ex-1007, Fig. 3.

Zhang further explains that pairs of series groups are connected in parallel, and six of these parallel-series combinations are connected in series to form the module output. Ex-1007, 4; Ex-1003, ¶231.

Accordingly, Zhang teaches limitation 1[d].

- f) **Limitation 1[e]: “n columns of the cell strings are connected in parallel by a first string connector at one end of the n columns, the n in the number of columns of the cell strings connected in parallel being equal to the n in the ratio of the long side length to the short side length, and”**

Zhang in view of Ravi328 teaches or suggests this limitation. Ex-1003, ¶¶233-37.

As shown in Zhang’s Figure 3, two vertically aligned strings (series groups 6) are connected in parallel at one end to form a parallel-series combination 7. Specifically, “endpoints of two series groups 6 are connected in parallel to form a parallel-series combination 7, and then six parallel-series combinations 7 are connected in series to form an output end of the module.” Ex-1007, 4; Ex-1003, ¶¶234-35. An annotated excerpt of Figure 3 of Zhang is reproduced below:

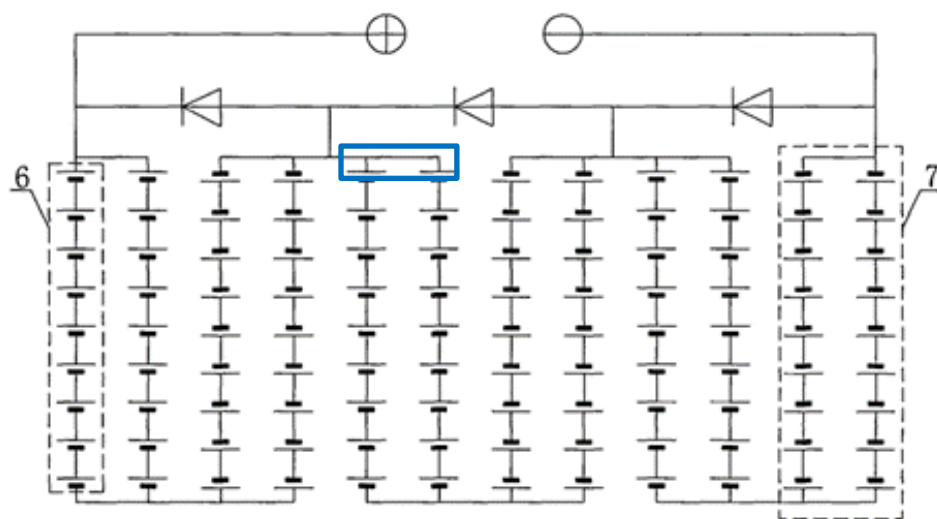


图 3

Ex-1007, Fig. 3 (annotated).

As shown in Figure 3, two series groups—i.e., n columns of cell strings—are connected in parallel by a first string connector (highlighted in blue), forming the claimed “ n -column parallel-connected cell strings,” where $n = 2$. Ex-1007, Fig. 3; Ex-1003, ¶235.

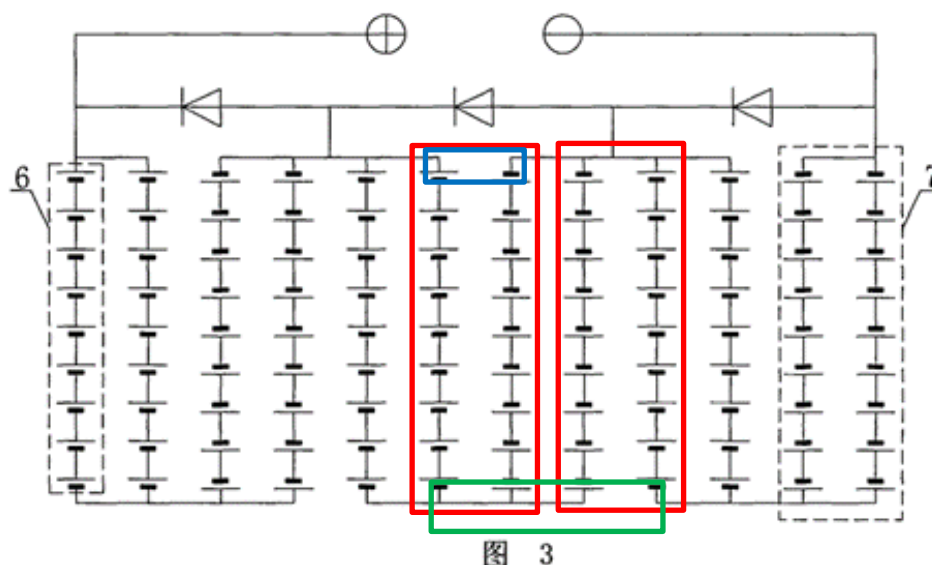
As explained above for limitation 1[a], Zhang in view of Ravi328 teaches or suggests solar cells having a $1/n:1$ aspect ratio, where $n = 2$. Ex-1009, 3; Ex-1003, ¶236.

Accordingly, Zhang in view of Ravi328 teaches or suggests limitation 1[e].

- g) Limitation 1[f]: “the n -column parallel-connected cell strings are further serially connected to another n -column parallel-connected cell strings by a second string connector at an opposite end of the n columns, thereby configuring an entire cell array.”**

Zhang in view of Ravi328 teaches or suggests this limitation. Ex-1003, ¶¶238-41.

As explained above for limitation 1[a], Zhang in view of Ravi328 teaches solar cells with a $1/n:1$ aspect ratio, where $n=2$. Ex-1009, 3; Ex-1003, ¶239. Figure 3 of Zhang shows two vertically aligned, parallel-connected columns (series groups 6) connected at both ends—first by a string connector forming a parallel pair (blue box), and then by a second string connector at the opposite end (green box), linking them to another pair of parallel-connected strings (red boxes). Ex-1007, Fig. 3; Ex-1003, ¶240.



Ex-1007, Fig. 3 (annotated).

Accordingly, Zhang in view of Ravi328 teaches or suggests limitation 1[f].

3. **Claim 2: “The solar battery module according to claim 1, wherein a predetermined number of the solar battery cells are serially connected, thereby configuring a cell string, two columns of the cell strings are connected in parallel, and the two-column parallel-connected cell strings are further serially connected, thereby configuring an entire cell array.”**

Zhang in view of Ravi328 renders claim 2 obvious. Ex-1003, ¶242-45.

As discussed above, Zhang in view of Ravi328 renders obvious claim 1. Zhang in view of Ravi328 teaches or suggests the further requirements of claim 2. As discussed above for limitation 1[e], Zhang in view of Ravi328 teaches or suggests two columns ($n=2$) of cell strings connected in parallel. As discussed above for limitation 1[f], Zhang in view of Ravi328 teaches or suggests that these parallel pairs are serially connected to form an array. Ex-1003, ¶¶243-45.

Accordingly, Zhang in view of Ravi328 renders claim 2 obvious.

4. **Claim 3: “The solar battery module according to claim 1, wherein the light-receiving-surface bus electrodes of each solar battery cell are formed at positions that are line-symmetrical with respect to a line passing through a middle point of a side perpendicular to an extended line of the light-receiving-surface bus electrodes and parallel to the light-receiving-surface bus electrodes.”**

Zhang in view of Ravi328 renders claim 3 obvious. Ex-1003, ¶¶246-50.

As discussed above, Zhang in view of Ravi328 renders obvious claim 1.

Ravi328 further teaches the additional limitation of claim 3. Ex-1003, ¶247.

Ravi328 states that “[t]inned copper interconnects are soldered on the front busbars of matched solar cells,” with the front busbars shown in Figure 4 as two thick vertical lines on the light-receiving surface of each cell. Ex-1009, 5; Ex-1003, ¶248. These busbars are parallel to the short side of the rectangular half-cut cell and symmetrically aligned along a vertical axis through the midpoint of the long side—i.e., line-symmetrical as claimed. Ex-1003, ¶249.

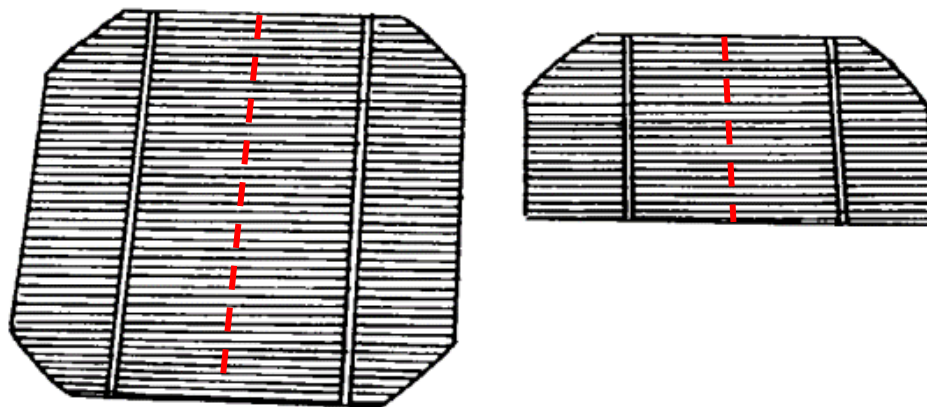


Fig. 4

Ex-1009, Fig. 4 (annotated).

Accordingly, Zhang in view of Ravi328 renders obvious claim 3.

5. **Claim 4: “The solar battery module according to claim 1, wherein the light-receiving-surface bus electrodes of each solar battery cell are formed at positions that are line-symmetrical with respect to a line passing through a middle point of a side parallel to the light-receiving-surface bus electrodes and perpendicular to the light-receiving-surface bus electrodes.”**

Zhang in view of Ravi328 renders obvious claim 4. Ex-1003, ¶¶251-55.

As discussed above, Zhang in view of Ravi328 renders obvious claim 1.

Ravi328 further teaches the additional limitation of claim 4. Ex-1009, 5; Ex-1003, ¶252.

As discussed above for claim 3, Ravi328 discloses front-side busbars arranged parallel to the short side of the rectangular cells and symmetrically aligned across the centerline. Figure 4 of Ravi328 shows these busbars as two thick vertical lines,

line-symmetrical with respect to a horizontal axis passing through the midpoint of the long side. Ex-1009, 5; Ex-1003, ¶¶253-54.

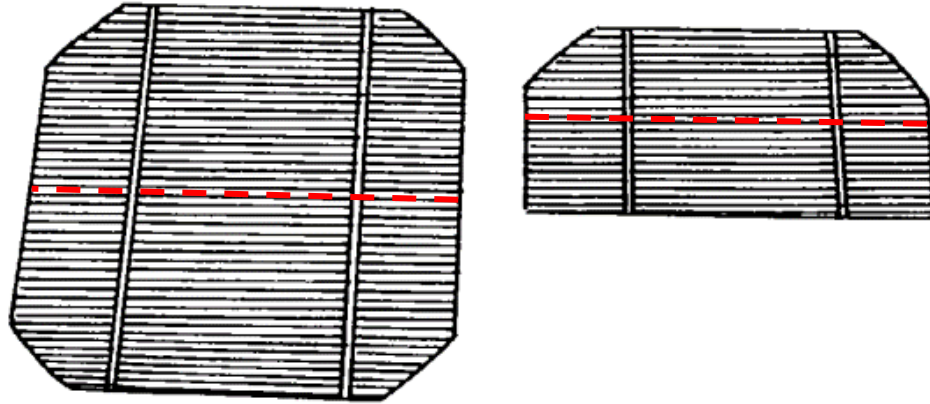


Fig. 4

Ex-1009, Fig. 4 (annotated).

Accordingly, Zhang in view of Ravi328 renders obvious claim 4.

6. Claim 6

- a) **Limitation 6[pre]: “The solar battery module according to claim 1,”**

Zhang in view of Ravi328 renders claim 6 obvious. Ex-1003, ¶¶256-269.

As discussed above, Zhang in view of Ravi328 renders obvious claim 1. Ex-1003, ¶257.

- b) **Limitation 6[a]: “which is obtained by dividing a basic solar battery cell with a plane shape thereof being a substantial square,”**

Ravi328 teaches or suggests the additional limitation of claim 6[a]. Ex-1003,

¶258.

Ravi328 discloses the use of half-cut solar cells derived from full-sized square cells, stating: “laser cutting of 125-mm full solar cells into two half solar cells.” Ex-1009, 3; Ex-1003, ¶259.

Accordingly, Ravi328 teaches limitation 6[a].

- c) **Limitation 6[b]: “which includes n light-receiving-surface electrode areas in each of which a plurality of light-receiving-surface bus electrodes parallel to a side of the substantial square and”**

Ravi328 teaches or suggests the additional limitation of claim 6[b]. Ex-1003, ¶¶261-64.

Figure 4 of Ravi328 shows that a full-sized square cell includes two light-receiving-surface electrode areas (n=2 in the illustrated half-cut case). Ex-1009, Fig. 4; Ex-1003, ¶262.

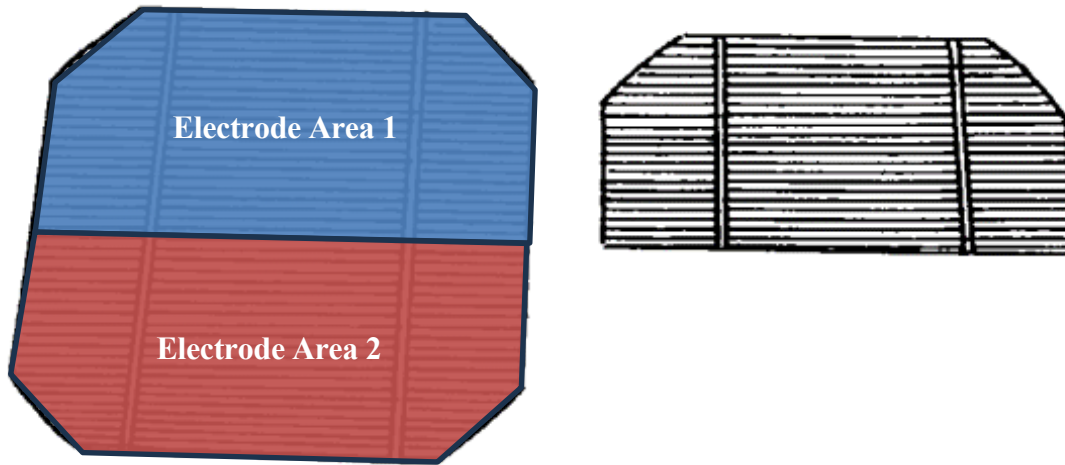


Fig. 4

Ex-1009, Fig. 4 (annotated).

As shown in annotated Fig. 4 below, each area contains multiple bus electrodes (annotated in red), all aligned parallel to a side of the square cell (annotated in green).

Ex-1009, Fig. 4; Ex-1003, ¶263. Ravi328 further confirms this structure, noting that “[t]inned copper interconnects are soldered on the front busbars of matched solar cells in terms of output current.” Ex-1009, 5; Ex-1003, ¶263.

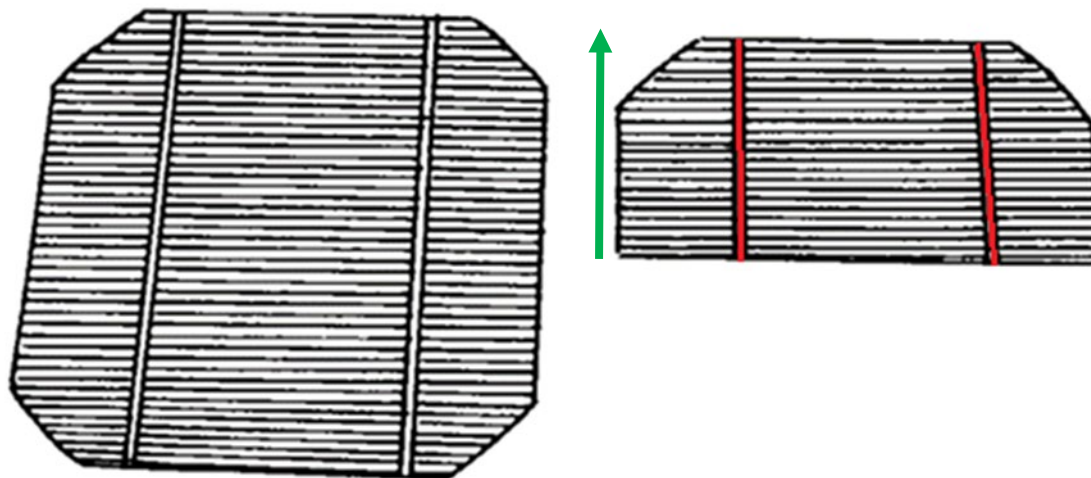


Fig. 4

Ex-1009, Fig. 4 (annotated).

Accordingly, Ravi328 teaches limitation 6[b].

- d) **Limitation 6[c]: “a plurality of grid electrodes perpendicular to the light-receiving-surface bus electrodes are provided on a light-receiving surface side and includes rear-surface bus electrodes each at a position on a non-light-receiving surface side corresponding to each of the light-receiving-surface bus electrodes into n respective boundaries of the n light-receiving-surface electrode areas.”**

Ravi328 teaches or suggests the additional limitations of claim 6[c]. Ex-1003, ¶¶265-69.

Figure 4 of Ravi328 shows a conventional front contact pattern: fine grid electrodes (in green) run perpendicular to vertical light-receiving-surface busbars (in red), forming a typical crystalline silicon layout. Ex-1009, Fig. 4; Ex-1003, ¶266.

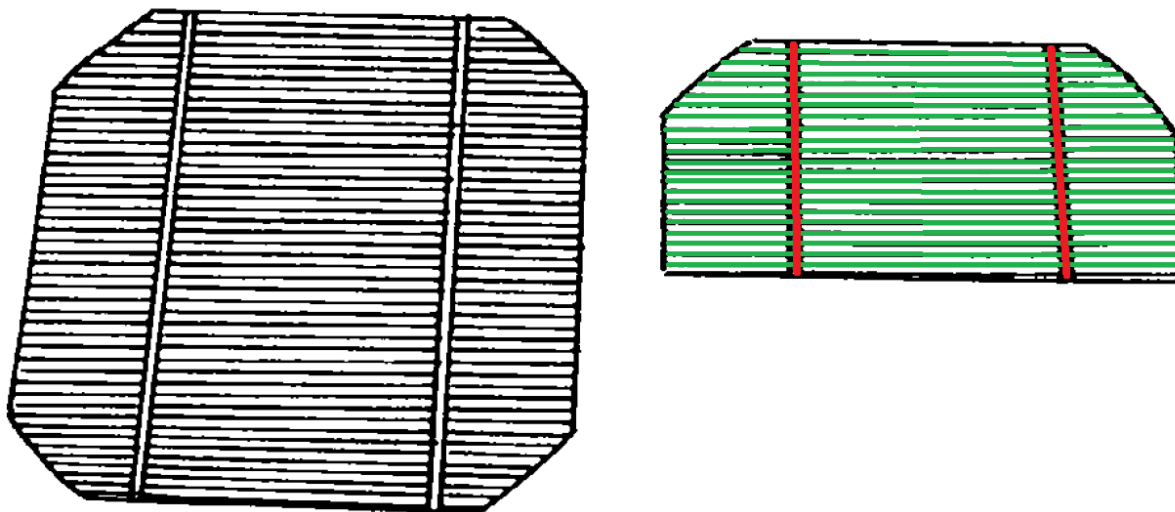


Fig. 4

Ex-1009, Fig. 4.

Ravi328 further discloses that “[b]usbars (Silver-aluminium) are printed on the back side for facilitating solder contacts,” and the rest of the rear is coated with aluminum paste to form a back surface field. Ex-1009, 5-6; Ex-1003, ¶267.

As Dr. Toliyat explains, a POSITA would understand that the rear-side busbars align with the front-side busbars, enabling front-to-back connections. This symmetrical placement is standard and allows each front busbar to correspond to a rear busbar at the same position. Ex-1003, ¶268; *see also supra*, limitation 1[c].

Accordingly, Ravi328 teaches limitation 6[c].

7. **Claim 8: “The solar battery module according to claim 1, wherein the interconnector is joined to the light-receiving-surface bus electrode of a solar battery cell nearest to the second string connector of the n-column parallel-connected cell strings, and is connected to the second string connector, and the second string connector is connected to a rear surface lead at the rear-surface bus electrode of a head solar battery cell nearest the second string connector of the another n-column parallel-connected cell strings.”**

Zhang in view of Ravi328 renders claim 8 obvious. Ex-1003, ¶¶270-74.

As discussed above, Zhang in view of Ravi328 teaches a solar battery module according to claim 1. Zhang further teaches the additional features of claim 8: (1) interconnectors join the front bus electrode of the end cell to the second string connector, and (2) the second string connector links to a rear surface lead at the rear bus electrode of a head cell from another string. Ex-1007, 4; Ex-1003, ¶271.

Figure 1 of Zhang shows “photovoltaic glass 1, unit cells 3 connected by interconnection strips 2, and a package backsheet 4, which are packaged as a whole by a transparent laminated material 5.” Ex-1007, 4; Ex-1003, ¶272. These interconnection strips span the cells in a staggered layout, facilitating front-to-back series connections:

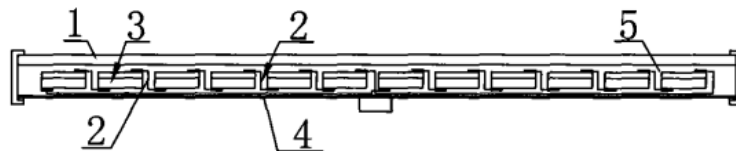


图 1

Ex-1007, Fig. 1.

As Dr. Toliyat explains, a POSITA would understand this layout to mean that the front busbar of the last cell in one group connects via an interconnector to the second string connector, while the second string connector also connects to the rear busbar of the head cell in the next group. Ex-1003, ¶273.

Accordingly, Zhang in view of Ravi328 renders obvious claim 8.

8. Claim 11: “The solar battery module according to claim 1, wherein the solar battery cells in the cell array are arranged so that the short side lengths are parallel to the extension of the n-column parallel-connected cell strings.”

Zhang in view of Ravi328 renders claim 11 obvious. Ex-1003, ¶¶275-78.

As discussed above, Zhang in view of Ravi328 teaches the solar battery module of claim 1. Ravi328 further teaches the additional limitation of claim 11 that the short sides of the solar cells are aligned parallel to the direction of the n-column parallel-connected cell strings. Ex-1009, Fig. 6; Ex-1003, ¶¶276-77.

Figure 6 of Ravi328 shows a 6×18 cell array composed of half-cut rectangular cells arranged in vertical columns. Ex-1003, ¶277. Each cell has a short vertical edge and a long horizontal edge, with the short sides aligned in the same direction as the vertical extension of the cell strings:

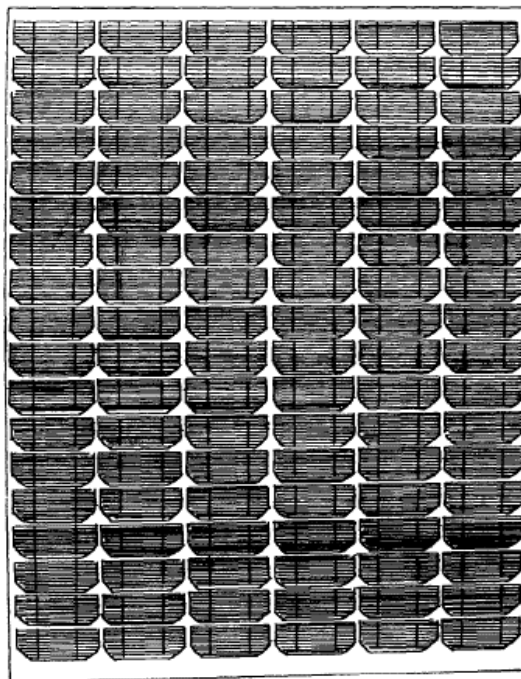


Fig. 6

Ex-1009, Fig. 6.

Accordingly, Zhang in view of Ravi328 renders obvious claim 11.

F. Ground 6: Claim 5 Is Obvious Based on Zhang, Ravi328, and Fujii

1. Motivation to Combine Zhang, Ravi328, and Fujii

It would have been obvious to combine Zhang with Ravi328 and Fujii. Ex-1003, ¶¶279-82.

A POSITA would have considered incorporating Fujii's teachings regarding margin spacing into the module architectures disclosed by Zhang and Ravi328 as simply applying a known technique to a known device ready for improvement to yield

predictable results. *KSR*, 550 U.S. at 417. Fujii teaches a solar module structure in which solar cells are arranged such that the dimensions and spacing of the cell surface electrodes can be configured to strike a good balance between the desires to help reduce the resistance from the busbar electrodes and simultaneously avoid reduction of the light receiving surface in order to preserve the conversion efficiency of the cell. Ex-1003, ¶¶281-282. It was also well-known at the time of the purported invention of the '214 patent that such configurations would be beneficial to help prevent short circuits in the connections between adjoining cells. *Id.* A POSITA would have recognized that applying Fujii's teaching of leaving intentional spacing between the edge of the surface bus electrodes and the perimeter of the cells to Zhang and Ravi328 would yield the predictable outcome of helping to prevent short circuits and maximizing conversion efficiency. Ex-1003, ¶¶280-82.

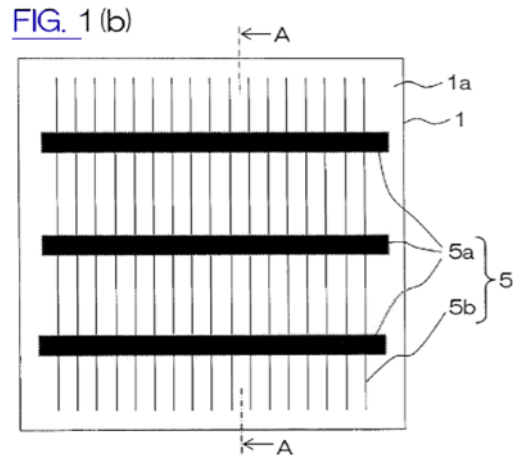
A POSITA would have reasonably expected success in making this combination. Ex-1003, ¶282. Implementing Fujii's teaching of leaving intermediary space between the edge of the surface bus electrodes and the perimeter of the cells would constitute a routine, predictable improvement to Zhang and Ravi328, and a POSITA would have understood such an improvement to pass along the same benefits taught by Fujii. *Id.*

2. **Claim 5: “The solar battery module according to claim 1, wherein each of the solar battery cells includes an area where the light-receiving-surface bus electrodes and the rear-surface bus electrodes are not formed within a predetermined dimension from an edge toward a central direction of the cell at an outer circumferential edge portion thereof.”**

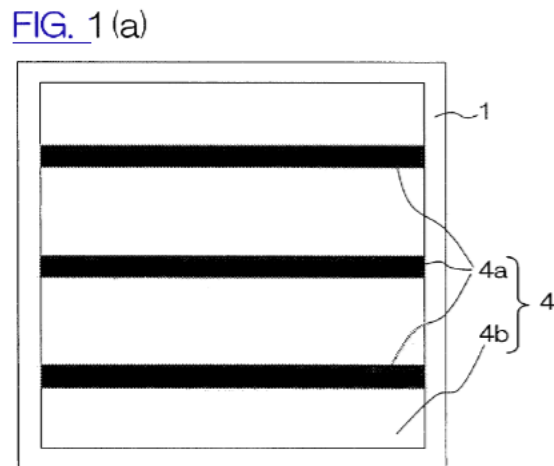
Zhang in view of Ravi328 and Fujii renders claim 5 obvious. Ex-1003, ¶¶283-88.

As discussed above, Zhang in view of Ravi328 renders obvious claim 1. Fujii further teaches that each solar cell includes a margin at its outer edge where neither front nor rear bus electrodes are formed. Ex-1003, ¶284.

Fujii discloses arranging solar cells such that minimal spacing is left between the busbar electrodes and other elements of the cells, leaving a small but deliberate gap between the outer edges of the busbar electrodes 5a and the perimeter of the cells. Ex-1003, ¶ 285. Figures 1(a) and 1(b) show that both front and rear busbar electrodes are formed inward from the edges, leaving a clear electrode-free boundary. Ex-1003, ¶¶285-86.



Ex-1011, Fig. 1(b).



Ex-1011, Fig. 1(a).

As Dr. Toliyat explains, a POSITA would have recognized the benefit of incorporating this margin design into Ravi328's layout to help enhance module performane and reduce potential short circuits. Ex-1003, ¶287.

Accordingly, Zhang in view of Ravi328 and Fujii renders obvious claim 5.

G. Ground 7: Claim 7 Is Obvious Based on Zhang, Ravi328, and Ravi260

1. Motivation to Combine Zhang, Ravi328, and Ravi260

It would have been obvious to combine Zhang with Ravi328 and Ravi260. Ex-1003, ¶¶289-95.

Ravi328 and Ravi260 share common inventors and both disclose inventions directed to photovoltaic modules using split solar cells arranged in series-parallel configurations. Ex-1009; Ex-1010. A POSITA would naturally consider them together and would recognize that each provides complementary teachings regarding cell array design and wiring configurations. Ex-1003, ¶290.

Furthermore, a POSITA would have considered incorporating Ravi260's disclosure of a second string connector which extends continuously across the entire cell array with Zhang and Ravi328 as simply applying a known technique to a known device ready for improvement to yield predictable results. *See KSR*, 550 U.S. at 417. Zhang teaches the use of the '214 patent's claimed "second string connector," Section VI.E.2.g, but does not teach that this connector extends continuously across the entire cell array. However, Ravi260 does disclose a second string connector that extends continuously across the entire cell array. Section VI.G.2. A POSITA would recognize that incorporating this disclosure from Ravi260 into the combination of Zhang and Ravi328 would enhance the structural integrity of the string connector and help prevent connection defects, which was well-known to be a concern at the time of the purported

invention of the '214 patent. Ex-1003, ¶¶292-93. Thus, applying Ravi260's disclosure of the second string connector extending continuously across the entire cell array to Zhang and Ravi328 would yield no more than the predictable outcome a POSITA would have expected to achieve. Ex-1003, ¶294.

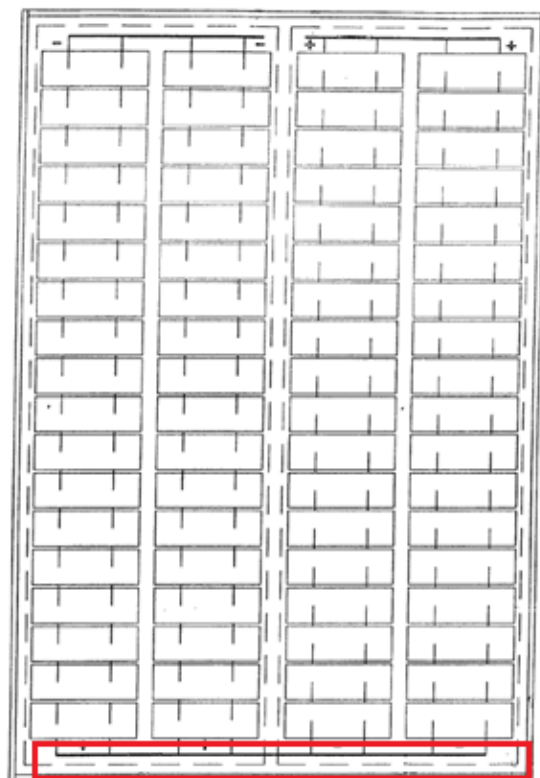
A POSITA would have reasonably expected success in making this combination. Ex-1003, ¶295. Ravi260's choice to extend the second string connector continuously across the entire cell array was well-known and would constitute a routine, predictable improvement to the combination of Zhang and Ravi328, utilizing a common and well-understood technique that would stand to improve the mechanical strength of the connector. *Id.*

2. Claim 7: “The solar battery module according to claim 1, wherein the second string connector extends continuously across the entire cell array.”

Zhang in view of Ravi328 and Ravi260 renders Claim 7 obvious. Ex-1003, ¶¶296-300.

Zhang in view of Ravi328 teaches the base solar module of claim 1. Ravi260 teaches or suggests the additional limitation of claim 7 that a second string connector that extends continuously across the entire cell array. Ex-1010, Fig. 6; Ex-1003, ¶297.

Ravi260 discloses a configuration in which the second string connector extends continuously across the entire cell array, as shown in the excerpt of Figure 6 below:



Ex-1010, Fig. 6 (annotated); *see also* Ex-1003, ¶298. The annotated red box depicts this second string connector.

As Dr. Toliyat explains, a POSITA would have been motivated to incorporate this feature into Zhang's architecture, as such string connector configurations were well-known and offered a predictable improvement. Ex-1003, ¶299.

Accordingly, Zhang in view of Ravi328 and Ravi260 renders obvious claim 7.

H. Ground 8: Claims 9 and 10 Are Obvious Based on Zhang, Ravi328, and Krishnamurthy

1. Motivation to Combine Zhang, Ravi328, and Krishnamurthy

It would have been obvious to combine Zhang with Ravi328 and Krishnamurthy

for largely the same reasons previously described above in Section VI.D.1. Ex-1003, ¶¶301-06. A POSITA would have considered incorporating Krishnamurthy and Ravi328's disclosure of chamfered half-cells with Zhang as simply applying a known technique to a known device ready for improvement to yield predictable results. *See KSR*, 550 U.S. at 417. As noted above in Section VI.D.1, it is a common industry practice to produce rectangular half-cells by splitting a pseudo-square chamfered cell, which helps to minimize silicon wafer waste and maximize utilization of the area of the module. Ex-1003, ¶¶302-03. Thus, incorporating chamfered half-cells into Zhang would yield no more than the predictable outcome a POSITA would have expected to achieve through utilization of this common cell production process. *Id.*

For the same reasons described above in Section VI.D.1, a POSITA would have further found it obvious to arrange chamfered half-cells in Zhang using the orientation disclosed in Krishnamurthy, especially given the finite number of predictable choices, with a reasonable expectation of success. *See KSR*, 550 U.S. at 421. Krishnamurthy's disclosed arrangement wherein adjoining half-cells are aligned from non-chamfered edge to non-chamfered edge provides a uniform visual presentation of the cells, and when applied to Zhang would help facilitate the maximization of the module area for the grid pattern of half-cells. Ex-1003, ¶304. Because here too in the combination of Zhang and Ravi328 the surface bus electrodes are symmetrical to a center line as required by claim 3—Section VI.E.4—selecting one of the finite other options for

orienting the cells in this arrangement conveys no additional benefit over the presentation disclosed in Krishnamurthy, which the '214 patent itself expressly acknowledges. Ex-1003, ¶304.

A POSITA would have further been motivated to combine Zhang and Krishnamurthy with Ravi328 for the same reasons discussed above in Section VI.D.1.

A POSITA would have reasonably expected success in making this combination. Ex-1003, ¶306. Inclusion of Krishnamurthy's chamfered half-cells in an orientation wherein adjoining cells are aligned from non-chamfered edge to non-chamfered edge would constitute a routine, predictable improvement to Zhang's system as modified by Ravi328, utilizing a commonly used cell shape well-suited to maximizing the utilization space of the module area, in an arrangement and orientation that makes appropriate use of this cell shape's easy tessellation. *Id.*

2. **Claim 9: “The solar battery module according to claim 1, wherein long sides of the substantial rectangle include a first long side and a second long side, the substantial rectangle has chamfered corners on both ends of only the first long side such that the second long side is without chamfered corners, and wherein the first one of the solar battery cells and the second one of the solar battery cells are arranged in the cell array such that the first long side and the second long side of the first one and the second one of the solar battery cells do not face each other.”**

Zhang in view of Ravi328 and Krishnamurthy renders obvious claim 9. Ex-1003, ¶¶307-311.

Zhang in view of Ravi328 teaches a solar module with rectangular half-cut cells.

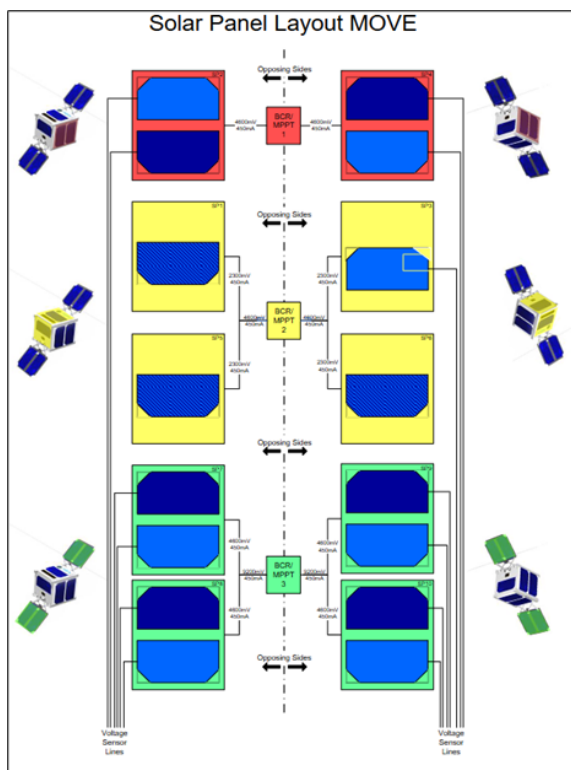
As shown in Figure 6 of Ravi328, these cells have chamfered corners on only one of the two long sides, creating an asymmetrical geometry.



Fig. 6

Ex-1009, Fig. 6; Ex-1003, ¶308.

Krishnamurthy further discloses a layout where cells are oriented such that the chamfered and non-chamfered long sides of adjacent cells do not face each other. Ex-1012, Fig. 6-5; Ex-1003, ¶309.



Ex-1012, Fig. 6-5.

As Dr. Toliyat explains, a POSITA would have been motivated to adopt this configuration into the Zhang-Ravi328 design to facilitate alignment and assembly, with a reasonable expectation of success. Ex-1003, ¶310.

Accordingly, Zhang in view of Ravi328 and Krishnamurthy renders obvious claim 9.

3. Claim 10

a) Limitation 10[pre]: “A solar battery module comprising:”

To the extent, the preamble is limiting, Zhang teaches or suggests it. Section VI.E.2.a.

- b) **Limitation 10[a]: “plurality of solar battery cells, a plain shape of each being a substantial rectangle, and a ratio of a short side length and a long side length of the substantial rectangle being 1/n:1 (n is an integer equal to or larger than 2),”**

Zhang in view of Ravi328 teaches or suggests this limitation. Section VI.E.2.b.

- c) **Limitation 10[b]: “includes a plurality of light-receiving-surface bus electrodes parallel to the short side of the substantial rectangle on a light receiving surface, and includes rear-surface bus electrodes each at a position on a non-light-receiving surface corresponding to each of the light-receiving-surface bus electrodes; and”**

Zhang in view of Ravi328 teaches or suggests this limitation. Section VI.E.2.c.

- d) **Limitation 10[c]: “an interconnector that electrically connects the light-receiving-surface bus electrodes of a first one of the solar battery cells to the rear-surface bus electrodes of an adjacent second one of the solar battery cells,”**

Zhang teaches or suggests this limitation. Section VI.E.2.d.

- e) **Limitation 10[d]: “wherein long sides of the substantial rectangle include a first long side and a second long side, the substantial rectangle has chamfered corners on both ends of only the first long side such that the second long side is without chamfered corners, and”**

Zhang in view of Ravi328 and Krishnamurthy teaches or suggests this limitation. Section VI.H.2.

- f) **Limitation 10[e]: “the first one of the solar battery cells and the second one of the solar battery cells are arranged in the module such that the first long side and the second long side of the first one and the second one of the solar battery cells do not face each other.”**

Zhang in view of Ravi328 and Krishnamurthy teaches or suggests this limitation.

Section VI.H.2.

VII. CONCLUSION

Petitioner respectfully requests institution of *inter partes* review and cancellation of the challenged claims of the '214 Patent.

Date: April 18, 2025

Respectfully submitted,

By: /Scott C. Weidenfeller/

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CERTIFICATION UNDER 37 C.F.R. § 42.24(D)

I certify that the foregoing complies with the type-volume limitation of 37 C.F.R. § 42.24 and contains 13,761 words based on the word count indicated by the word-processing system used to prepare the paper, and excluding those portions exempted by § 42.24(a).

Date: April 18, 2025

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CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§ 42.6 and 42.105, I hereby certify that the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 9,515,214, supporting exhibits, and Power of Attorney was served by Federal Express for Saturday delivery, a means at least as fast and reliable as Priority Mail Express®, on the following correspondence address of record for patent owner:

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