

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

3D Systems Corporation and 3D Systems, Inc.,

Petitioner

v.

Intrepid Automation, Inc.,
Patent Owner.

Case No. IPR 2025-01242
U.S. Patent No. 11,338,511

**PETITION FOR INTER PARTES REVIEW
UNDER 35 U.S.C. §§ 311–319 AND 37 C.F.R. § 42.100 ET. SEQ.**

TABLE OF CONTENTS

I.	INTRODUCTION	10
II.	REQUIREMENTS FOR STANDING.....	12
	A. Grounds for Standing—37 C.F.R. §42.104(a)	12
	B. Challenge and Relief Requested—37 C.F.R. §42.104(b)	13
III.	OVERVIEW OF TECHNOLOGY	13
	A. Background	13
	B. State of the Art	15
IV.	THE '511 PATENT	17
	A. Earliest Possible Effective Filing Date	17
	B. Overview of the '511 Patent	17
	C. Summary of the Prosecution History	19
V.	LEVEL OF ORDINARY SKILL	20
VI.	CLAIM CONSTRUCTION	20
VII.	RELEVANT PRIOR ART	21
	A. Shkolnik - U.S. Patent No. 8,666,142	21
	B. Sekine - WO2017/154564 A1	21
	C. Greene – U.S. Patent Pub. No. 2017/0102679	23
	D. Jørgensen - EP 3,053,729 A1	24
	E. Yi <i>et al.</i>, “Delta DLP 3-D Printing of Large Models,” <i>IEEE Transactions on Automation Science and Engineering</i> (DOI: 10.1109/TASE.2017.2751664) (“Yi”)....	25
VIII.	GROUND 1: CLAIMS 1-8, 14-15 ARE ANTICIPATED BY SHKLONIK	
	27	
	A. Shkolnik Discloses All Claimed Limitations	27
IX.	GROUND 2: CLAIMS 1-8, 14, AND 15 ARE UNPATENTABLE AS	
	OBVIOUS OVER SEKINE AND GREENE.....	45
	A. Sekine and Greene Disclose All Claimed Limitations	45
	B. Motivation to Combine Sekine with Greene.	69
X.	GROUND 3: CLAIMS 1-8, 14, AND 15 ARE OBVIOUS OVER	
	SHKOLNIK AND SEKINE.....	71
	A. Shkolnik and Sekine Disclose All Claimed Limitations	71
	B. Motivation to Combine Shkolnik with Sekine.	75

XI.	GROUND 4: CLAIMS 9-12 ARE OBVIOUS IN LIGHT OF SEKINE-GREENE-JØRGENSEN.....	76
A.	Sekine and Greene and Jørgensen Disclosed All Claimed Limitations	76
B.	Motivation to Combine Sekine and Greene with Jørgensen, and Reasonable Expectation of Success.....	81
XII.	GROUND 5: CLAIM 13 IS OBVIOUS IN LIGHT OF SEKINE-GREENE-JØRGENSEN IN FURTHER VIEW OF YI.....	82
A.	Sekine, Greene, Jørgensen and Yi Disclosed All Claimed Limitations.....	82
B.	Motivation to Combine Sekine, Greene, and Jørgensen with Yi and Reasonable Expectation of Success	84
XIII.	OBJECTIVE INDICIA OF NON-OBVIOUSNESS	86
XIV.	PAYMENT OF FEES – 37 C.F.R. § 42.103	86
XV.	MANDATORY NOTICES UNDER 37 C.F.R §42.8(a)(1)	86
A.	Real Party-In-Interest Under 37 C.F.R. §42.8(b)(1).....	86
B.	Related Matters Under 37 C.F.R. §42.8(b)(2)	86
C.	Lead And Back-Up Counsel Under 37 C.F.R. § 42.8(b)(3)	87
D.	Service Information	87
E.	Discretionary Denial is Not Warranted	87
XVI.	CONCLUSION	88

EXHIBIT LIST

Exhibit No.	Reference
1001	U.S. Patent No. 11,338,511 (“’511 Patent”)
1002	<p>Excerpts from the Prosecution History of the ’511 Patent (the “Prosecution History”)</p> <ul style="list-style-type: none"> • PPH Request (dated May 24, 2021) • PPH Request Decision (dated July 9, 2021) • Subsequent PPH Request and IDS (dated July 14, 2021) • Subsequent PPH Request Decision (dated July 16, 2021) • Non-Final Office Action (dated September 2, 2021) • Applicant-Initiated Interview Summary (from interview held on December 6, 2021) • Terminal Disclaimer and Approval of Terminal Disclaimer (dated December 20, 2021) • Response (dated December 20, 2021) • Notice of Allowance (dated January 28, 2022) • Rule 312 Amendment (dated February 28, 2022) • Additional IDS (dated March 8, 2022) • Issue Fee Payment (dated April 19, 2022) • Issue Notification (dated May 4, 2022)
1003	Yong Chen, Ph.D. Declaration
1004	U.S. Patent No. 8,666,142, “System and Method for Manufacturing” (“Shkolnik”)
1005	International Patent Application Publication WO 2017/154564 A1, “Three-Dimensional Shaping Device” (“Sekine”) – translated to English and including declaration of Eric Vance (translator)
1006	U.S. Patent Application Publication No. 2017/0102679, “Sub-Pixel Grayscale Three-Dimensional Printing” (“Greene”)
1007	Paul F. Jacobs, “Fundamentals of Stereolithography,” <i>Proceedings of the 1992 International Solid Freeform Fabrication Symposium</i> , pages 196-211 (“Jacobs”)
1008	C. Groth <i>et al.</i> , Three-Dimensional Printing Technology, VOLUME XLVIII NUMBER 8 © 2014 JCO, Inc. (“Groth”)
1009	U.S. Patent 8,102,332 (“Intensity Scaling for Multi-Projector Displays”)

1010	Song <i>et al.</i> , “A new edge blending paradigm for multi-projector tiled display wall,” <i>2010 International Conference on Computer Application and System Modeling (ICCASM 2010)</i> , Taiyuan, 2010, pp. V5-349-V5-352, doi: 10.1109/ICCASM.2010.5620133
1011	Brown and Lowe, “Automatic panoramic image stitching using invariant features,” <i>International Journal of Computer Vision</i> , 74 (2007): 59-73
1012	U.S. Patent 6,456,339 B1 (“Super Resolution Display”)
1013	U.S. Patent 7,079,157 B2 (“Matching the Edges of Multiple Overlapping Screen Images”)
1014	Garcia-Dorado and Cooperstock, “Fully automatic multi-projector calibration with an uncalibrated camera,” <i>CVPR 2011 WORKSHOPS</i> , Colorado Springs, CO, USA, 2011, pp. 29-36, doi: 10.1109/CVPRW.2011.5981726
1015	Harville <i>et al.</i> , “Practical Methods for Geometric and Photometric Correction of Tiled Projector,” <i>2006 Conference on Computer Vision and Pattern Recognition Workshop (CVPRW '06)</i> , New York, NY, USA, 2006, pp. 5-5, doi: 10.1109/CVPRW.2006.161
1016	U.S. Patent 7,443,364 B2 (“Projection of Overlapping Sub-Frames onto a Surface”)
1017	U.S. Patent 7,907,792 B2 (“Blend Maps for Rendering an Image Frame”)
1018	U.S. Patent 7,292,207 B1 (“Computing Blending Functions for the Tiling of Overlapping Video Projectors”)
1019	U.S. Patent 8,427,391 B2 (“Configurable Imaging System”)
1020	U.S. Patent 8,446,431 B2 (“DLP Edge Blending Artefact Reduction”)
1021	U.S. Patent Application Publication No. 2013/0269882 A1 (“Tiled Display Rotational Assembly”)
1022	U.S. Patent Application Publication No. 2013/0278840 A1 (“System and Method for Image Aspect Preservation in Multiple Projector Alignment”)
1023	U.S. Patent Application Publication No. 2013/0321475 A1 (“Zonal Illumination for High Dynamic Range Projection”)
1024	U.S. Patent Application Publication No. 2016/0046075 A1 (“Three-Dimensional Printing with Supported Build Plates”)
1025	Y. Chen <i>et al.</i> , “Digital Material Fabrication Using Mask-Image-Projection-Based Stereolithography,” <i>Rapid Prototyping Journal</i> , Vol. 19(3), 2013

1026	Y. Chen <i>et al.</i> , “Hopping Light Vat Photopolymerization for Multiscale Fabrication,” <i>Small</i> , Vol. 19(11), 2205784, 2023
1027	Y. Chen <i>et al.</i> , “Smooth Surface Fabrication Based on Controlled Meniscus and Cure Depth in Microstereolithography,” <i>Journal of Micro- and Nano-Manufacturing</i> , Vol. 3, September 2015
1028	European Patent Application Publication No. EP 3,053,729 A1, “Method for exposing a photo polymerizable material for solidification of material layer by layer to build a 3D object” (“Jørgensen”)
1029	Yi <i>et al.</i> , “Delta DLP 3-D Printing of Large Models,” <i>IEEE Transactions on Automation Science and Engineering</i> , Vol. 15, No. 3 (DOI: 10.1109/TASE.2017.2751664) (“Yi”)

'511 PATENT CLAIM LIMITATIONS

Claim	Limitation
1[a]	A method comprising:
1[b]	a. providing an additive manufacturing system, comprising:
1[c]	an image projection system comprising a plurality of image projectors; and
1[d]	an image display subsystem;
1[e]	b. projecting a composite image onto a build area within a resin pool using the image projection system, wherein:
1[f]	the image projection system is controlled by the image display subsystem;
1[g]	the composite image comprises a plurality of sub-images arranged in an array;
1[h]	two or more adjacent sub-images in the array overlap at two or more sub-image edges; and
1[i]	each sub-image is projected onto a portion of the build area using one of the plurality of image projectors; and
1[j]	c. adjusting properties and aligning a position of each sub-image in the array using a set of filters comprising:
1[k]	an irradiance mask that normalizes irradiance;
1[l]	a gamma adjustment mask that adjusts sub-image energy based on a reactivity of resin in the resin pool;
1[m]	a warp correction filter that provides geometric correction; and
1[n]	an edge blending bar at one or more sub-image edges.
2	The method of claim 1, wherein the image display subsystem controls the image projection system and each of the image projectors using digital light processing.
3	The method of claim 1, wherein the irradiance mask additionally adjusts the energy across the build area to compensate for non-uniformities in optics of the plurality of image projectors.
4	The method of claim 1, wherein the gamma adjustment mask comprises a logarithmic relationship between a cure depth of the resin and energy per unit area in the build area.
5	The method of claim 1, wherein the resin is selected from the group consisting of acrylates, epoxies, methacrylates, urethanes, silicone, vinyls, and combinations thereof.

6	The method of claim 1, wherein the edge blending bar comprises a blending distance and a function selected from the group consisting of: linear, sigmoid and geometric.
7	The method of claim 1, wherein the edge blending bar adjusts the one or more sub-image edges based on at least one layer boundary location within an object being manufactured.
8	The method of claim 1, further comprising a system controller that synchronizes exposure control of the plurality of image projectors with each other.
9	The method of claim 1, wherein the projecting the composite image further comprises moving the plurality of sub-images during an exposure of a layer of an object being manufactured.
10	The method of claim 1, wherein the movement of the sub-images is either a step-expose-step type movement or a continuous movement.
11	The method of claim 9, wherein the plurality of sub-images comprises a 1D array of sub-images oriented in a first direction; and the movement of the sub-images is in a second direction perpendicular to the first direction.
12	The method of claim 9, wherein the plurality of sub-images comprises a 2D array of sub-images with rows oriented along a first direction and columns oriented along a second direction; and the movement of the sub-images is in either one of the first or second directions, or both the first and second directions.
13	The method of claim 9, wherein the plurality of sub-images arranged in the array comprises one or more rows oriented along a first direction and one or more columns oriented along a second direction; and the movement of the sub-images is in a third direction that is different from both the first and second directions.
14	The method of claim 1, wherein the adjusting properties and aligning the position of each sub-image in the array further comprises applying the irradiance mask to each sub-image such that the composite image has a uniform irradiance range across the composite image.
15	The method of claim 1, wherein the adjusting properties and aligning the position of each sub-image in the array further comprises applying the irradiance mask to each sub-image to normalize irradiance non-uniformities within the image

	projection system arising from a projector-based spatial energy non-uniformity.
--	---

I. INTRODUCTION

In accordance with 35 U.S.C. §§ 311–319 and 37 C.F.R. § 42.100 et seq., 3D Systems Corporation and 3D Systems, Inc., (together “Petitioner”) respectfully requests that the Board institute *inter partes* review and cancel claims 1–15 of U.S. Patent No. 11,338,511, titled, Multiple Image Projection Method for Additive Manufacturing (“**’511 Patent**”)—issued on May 24, 2022. Five grounds support the Petition based on 35 U.S.C. §§ 102-103.

The ’511 Patent is directed towards well-known techniques in 3D printing used to improve printing resolution in additive manufacturing systems that use light projection to cure photoactive resins. EX1001. The ’511 Patent in particular focuses on digital light processing (“DLP”) systems, which utilize light projection to cure photoactive resins. *Id.* at 4:9-11.

As the ’511 Patent makes clear, the more precisely and accurately a DLP system projects an image onto a resin surface, the more precisely and accurately the final three-dimensional article will be printed. Achieving such precise light projection is attained through a finite number of techniques known in the art.

Within independent claim 1 of the ’511 Patent exist four techniques to improve printing resolution—(1) “normalizing irradiance/irradiance mask,” (2) “gamma adjustment,” (3) “warp correction,” and (4) “edge blending.” Although techniques (1)-(4) have been well-known for addressing common problems in the

industry, Intrepid Automation, Inc. (“Patent Owner”) recently repackaged those techniques in claims 1-15 of the ’511 Patent—with the use of idiosyncratic words or phrases to describe existing technology. Indeed, the four techniques described in the ’511 Patent are expressly taught in Shkolnik (EX1004), Sekine (EX1005), and Greene (EX1006), demonstrating that the claimed techniques were publicly available well before the earliest priority date of the ’511 Patent.

During prosecution of the ’511 Patent, the Patent Owner was able to convince the examiner that normalizing irradiance was novel over the prior art of record. However, the examiner did not have before them the prior art references of Shkolnik and Sekine. Likely because the Patent Owner elected to coin new terms for known existing techniques, the Patent Owner may have avoided key pieces of prior art. The Notice of Allowance for the ’511 Patent cited “.... the prior art **does not teach an irradiance mask** that normalizes irradiance in combination with the other features instantly claimed.” EX1002, p.74. While Petitioner will clearly show that an irradiance mask, or normalizing irradiance, was common practice at the filing date accorded to the ’511 Patent, Petitioner will also show the other limitations were also of common practice, and within the five grounds presented herein.

Ground 1. This ground is based on Shkolnik, which teaches all four techniques and anticipates claims 1-8, 14, and 15 of the ’511 Patent.

Ground 2. This ground is based on Sekine together with Greene. Sekine teaches three of the four claimed techniques, while Greene supplies the fourth technique of gamma adjustment, which renders obvious claims 1-8, 14, and 15 of the '511 Patent.

Ground 3. This ground is based on Shkolnik together with Sekine. As will be shown in Ground 1, Shkolnik anticipates claims 1-8, 14, and 15 of the '511 Patent, and Sekine further covers the irradiance mask or normalizing irradiance in greater detail.

Ground 4. This ground is based on Sekine and Greene together with Jørgensen. Sekine and Greene discuss all elements of the independent claim, and Jørgensen further delves into various movements and arrangements of DLP systems, which renders obvious claims 9-12 of the '511 Patent.

Ground 5. This ground is based on Sekine, Greene, and Jørgensen together with Yi. Sekine, Greene, and Jørgensen discuss all elements of the independent claim and dependent claim 9, and Yi further illustrates movement of the sub-images in a third direction, which renders obvious claim 13 of the '511 Patent.

Shkolnik, Sekine, Jørgensen, and Yi were not considered by the USPTO during the prosecution of the '511 Patent.

II. REQUIREMENTS FOR STANDING

A. Grounds for Standing—37 C.F.R. §42.104(a)

Petitioner certifies that the '511 Patent is eligible for Inter Partes Review (“IPR”) and that Petitioner is not barred or estopped from requesting an IPR challenging the patent claims. 37 C.F.R. § 42.104(a).

B. Challenge and Relief Requested—37 C.F.R. §42.104(b)

Petitioner respectfully requests that claims 1-15 of the '511 Patent be canceled based on the following grounds:

Ground	Claims	Basis for Rejection
§ 102 – Ground 1	1-8, 14, 15	Anticipated by Shkolnik
§ 103 – Ground 2	1-8, 14, 15	Obvious in light of Sekine + Greene
§ 103 – Ground 3	1-8, 14, 15	Obvious in light of Shkolnik + Sekine
§ 103 – Ground 4	9-12	Obvious in light of Sekine + Greene + Jørgensen
§ 103 – Ground 5	13	Obvious in light of Sekine + Greene + Jørgensen + Yi

III. OVERVIEW OF TECHNOLOGY

A. Background

The Chen Declaration, ¶¶35-60, provides an overview of the technology and common problems associated with additive manufacturing (“AM”) systems that use light projection to cure photoactive resins. Digital Light Processing (“DLP”) is a photocuring AM method wherein a light projector is used to cure an entire layer of

an object at a time. See Figure 3 from EX1008 which illustrates a simplified diagram of a DLP system.

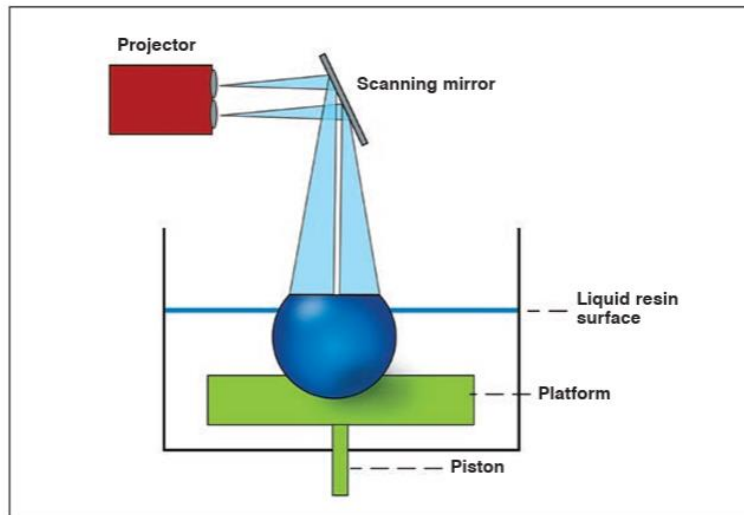


Fig. 3 Digital Light Processing (DLP) printer.

DLP utilizes a digital micromirror device (“DMD”) that contains hundreds of thousands or even millions of tiny mirrors that can be controlled individually. In a DLP projector, a single light source (e.g., a single “light bulb”) shines light onto all those thousands or millions of mirrors at the same time. Thus, the thousands or millions of mirrors in the DMD can *each* project light onto a separate pixel of a layer of resin, all at the same time. The result is that the curing time needed per layer is drastically reduced in DLP.

DLP still presents technical challenges, namely spatial resolution, which refers to how precisely an object is formed. DLP methods have an inherent resolution limit due to how light projectors work. Just like a light projector in a movie theater,

moving a DLP projector closer to or farther away from a surface (such as the surface of liquid resin) causes the image projected on the surface to be smaller or larger.

An early solution to this “scaling” problem was to use more than one DLP projector at the same time, to carry out the same “print job.” This allowed multiple projected images to be “stitched together” to form a single composite image. Using multiple projectors avoids the loss of resolution associated with “spreading out” the light from only a single projector, but new challenges are introduced. Each projector is also individually subject to the ordinary geometric distortions or warping such as “pincushioning,” “barrel distortions,” or “keystoning” familiar to anyone who has tried to use a portable light projector in an unfamiliar room.

The movie projector industry and related industries have dealt with these kinds of multi-projector challenges for many years, with many solutions put forth, such as irradiance normalization, gamma adjustment, warp correction, and edge blending. The AM community began using multiple projectors for DLP-based AM at least as early as 2008 and looked to the more general multi-projector prior art for ideas. EX1004.

B. State of the Art

Referring to the Chen Declaration, ¶¶35-60, DLP is known to undergo challenges related to irradiance normalization, edge blending (also known as “pixel

blending,” “image blending,” or “stitching”), gamma adjustment or gamma correction, grayscaling, anti-aliasing, and warp correction.

“Irradiance” in the context of AM refers to the amount of light that strikes a surface over a given area of resin. The “amount” of light is essentially how strong the light is. “Irradiance normalization” relates to “level setting” the amount of light that strikes a resin surface. DMDs used in DLP include thousands or millions of tiny mirrors, each of which reflects light onto a tiny area. The tiny area illuminated by a single micromirror is often associated as a single pixel. Like any opto-mechanical system, DMDs and DLP projectors are subject to various mechanical and engineering flaws related to precision. Irradiance normalization has been addressed for many years by “taking the lowest common denominator.” If some pixels are brighter than others when set to “full power”, then normalization can be carried out by “turning down” the brightness of the brightest pixels so that they are only as bright as the dimmest pixel.

“Edge blending” refers to managing areas of a composite projected image that include light received from multiple different light sources. Most commonly, these “overlap” areas or regions occur when multiple projectors project multiple sub-images onto the same surface. Edge blending has been known and addressed for a very long time in both the movie projector field and the AM field.

“Gamma adjustment” or “gamma correction” is best understood as both a physical process and a chemical process for photocuring a resin. The physical process is the penetration of the incident curing light into the resin. The chemical process is the curing or polymerization reaction of the photocurable resin. These two processes depend on the nature of the specific resin being cured.

“Grayscale” and “anti-aliasing” both relate to smoothness of surfaces. Pixels are generally square- or rectangle-shaped. As a result, forming an image from such “building blocks” can result in a “pixelated” appearance. “Anti-aliasing” refers specifically to reducing this effect. “Grayscale” is one technique that has long been recognized as a way of improving anti-aliasing.

“Warp correction” refers to making various adjustments to ensure that the actual geometric appearance of the printed article matches the digital model. That is, such geometric correction avoids “keystoning” or other types of distortions.

IV. THE ’511 PATENT

A. Earliest Possible Effective Filing Date

The earliest possible effective filing date is **July 30, 2018**. EX1001.

B. Overview of the ’511 Patent

The ’511 Patent is a continuation of U.S. Patent 11,014,301 (“the ’301 Patent”). The ’511 Patent and ’301 Patent share a common specification and drawings. The ’511 Patent describes an AM system using image projection that

comprises one or more image projectors that project a composite image onto a build area within a resin pool. EX1001, 1:40-46; FIGS. 1E, 1G; Chen ¶¶61-63. The composite image is formed from a “plurality of sub-images arranged in an array.” *Id.*, 1:45-46. The system also includes a subsystem that “controls each of the image projectors to **adjust the properties** of each sub-image and the alignment of the position of each sub-image within the composite image.” *Id.*, 4:16-20.

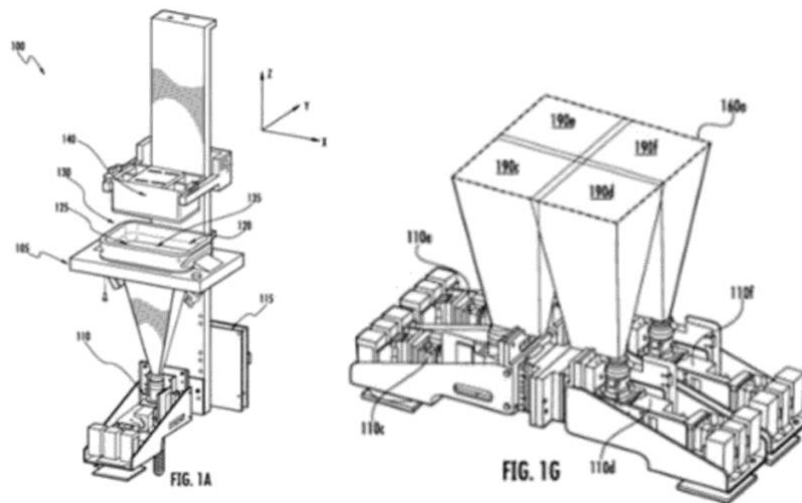
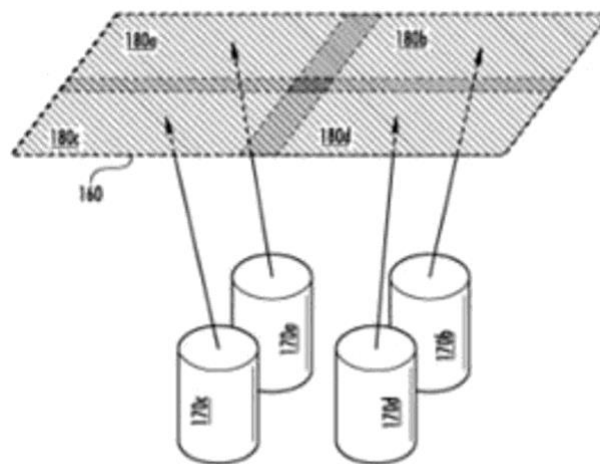


FIG. 1E

The '511 Patent purports to address inaccuracies related to 3D printing systems including (1) “normaliz[ing] irradiance,” (2) “gamma adjustment,” (3) “warp correction,” and (4) “edge blending.” To account for the various inaccuracies, and without limiting these concepts, the '511 Patent provides examples of what the four filters account for (i.e., their general purpose). Chen ¶63.

C. Summary of the Prosecution History

On September 2, 2021, the examiner rejected claims 1-8 based on nonstatutory double patenting grounds as being unpatentable over claims 14-21 of U.S. Patent No. 10,780,640, and further rejected independent claim 1, among others, based on obviousness. EX1002, p.42-43. Several references were cited supporting the obviousness rejection. *Id.*, p.44-47.

The Patent Owner traversed the rejection during an examiner interview, arguing that the cited references do not teach “**an irradiance mask that normalizes irradiance.**” EX1002, p.67-68. Applicant then filed a response arguing the same, specifically that the primary reference cited (“Kobayashi”) “is fundamentally different from that recited in present claim 1,” specifically citing to the Patent Owner’s specification that “applies a normalizing irradiance mask to an image (or each sub-image in a composite image) such that the image (or composite image) has a uniform irradiance range (i.e., from zero exposure to a maximum exposure limit) across the area.” EX1002, p.59-61.

On January 28, 2022, the examiner noted in the Notice of Allowance that the prior art of record “does not teach an irradiance mask that normalizes irradiance.” EX1002, p.74.

On March 8, 2022, Patent Owner filed an information disclosure statement (“IDS”) that included Greene and the Extended European Search Report dated March 3, 2022, which originally cited Greene. No additional information with respect to Greene was included in the submission. EX1002, p.77-79.

Shkolnik and Sekine both teach how to normalize irradiance, and both were not before the USPTO during prosecution of the ’511 Patent.

V. LEVEL OF ORDINARY SKILL

A Person of Ordinary Skill in the Art (POSITA) in the relevant time-period would have had a “master’s degree in mechanical engineering, industrial engineering, optics, or similar field, with industry experience in AM; or a bachelor’s degree with a subset of course work and 2-3 years of AM experience.” Chen ¶32. Professor Chen meets this definition. *Id.* ¶¶8-17.

VI. CLAIM CONSTRUCTION

Claim terms in an IPR are construed according to their “ordinary and customary meaning” to those of skill in the art. 37 C.R.F. § 42.100(b). For purposes of this Petition, Petitioner applies plain-and-ordinary meaning to all terms. At this time, Petitioner does not believe construction of any term is necessary to resolve the

invalidity challenges set forth herein. Petitioner does not concede the indefiniteness of claim terms or that the claims otherwise comply with the requirements of 35 U.S.C. § 112. Petitioner further reserves the right to proffer a rebuttal to any construction the Patent Owner submits in response to this Petition.

VII. RELEVANT PRIOR ART

A. Shkolnik - U.S. Patent No. 8,666,142

U.S. Patent No. 8,666,142 (“**Shkolnik**”) (EX1004) entitled, “System and Method for Manufacturing,” was published on March 4, 2014, with a filing date of November 18, 2008. EX1004. This date precedes the earliest priority date of the ’511 Patent (July 30, 2018). Compare EX1004; EX1001. Shkolnik is in the “same field of endeavor as the ’511 Patent and is reasonably pertinent to the problems encountered in 3D printing (AM) using light projection and photocurable resins.” Chen ¶¶95.

Shkolnik is directed towards a system used for increasing accuracy in making 3D components using either (1) a single pattern generator; or (2) multiple pattern generators. EX1004, abstract; Chen ¶¶96-99. The multiple pattern generator system is identical to the ’511 Patent disclosing all four filter limitations.

B. Sekine - WO2017/154564 A1

International Patent Application Publication No. WO2017/154564 A1 (“**Sekine**”) (EX1005)—translated—is entitled “Three-Dimensional Shaping

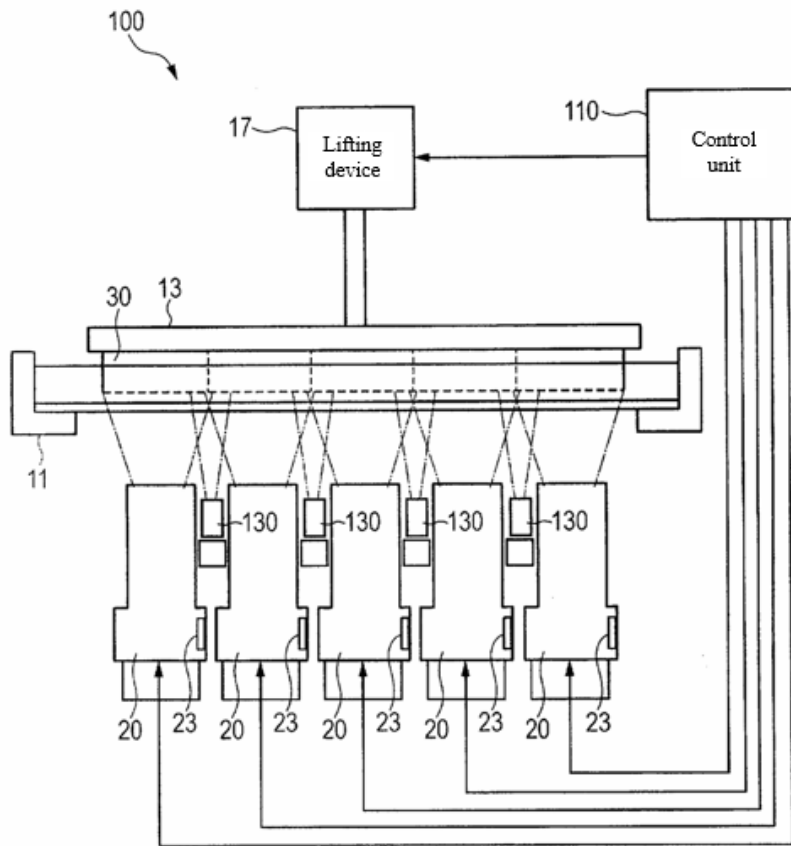
Device” and was published on September 14, 2017, with an international filing date of February 22, 2017, and an earliest priority date of March 9, 2016. These dates precede the earliest priority date of the ’511 Patent. Compare EX1005; EX1001. Sekine is in the “same field of endeavor as the ’511 Patent and is reasonably pertinent to the problems encountered in 3D printing using light projection and photocurable resins and is, therefore, relevant prior art.” Chen ¶112.

Sekine is a PCT application originally filed and published in Japanese. The original Japanese-language application has been translated by Eric Vance of Sun IP. EX1005 (Japanese version (Exhibit A) and English version (Exhibit B) to the declaration of Eric Vance).

Sekine is directed towards a system that is used for increasing accuracy in making 3D components using a multiple projector system. EX1005, [0005], [0009]; Chen ¶114-118. Sekine discloses three of the four filter techniques (irradiance, warp correction, edge blending).

FIG. 1 depicts a diagram of the configuration of the projector system. EX1005, FIG. 1.

[FIG. 1]



C. Greene – U.S. Patent Pub. No. 2017/0102679

U.S. Patent Application Publication No. 2017/0102679 (“**Greene**”) (EX1006), entitled “Sub-Pixel Grayscale Three-Dimensional Printing,” was published on April 14, 2017, with a filing date of October 6, 2016, and a priority date of October 7, 2015. These dates precede the earliest priority date of the ’511 Patent. Compare EX1006; EX1001.

Greene is in the same field of endeavor as the '511 Patent and is reasonably pertinent to the problems encountered in AM using light projection and photocurable resins and is, therefore, relevant prior art. Chen ¶129.

Greene is directed towards grayscaling in 3D printing. The purpose of the technology includes “to smooth out edges” while accommodating for the fact that different resins require varying exposure time. EX1006, [0008], [0037]; Chen ¶130. Greene teaches a process that assigns grayscale intensity levels to various voxels or pixels of the digital model, including “based on a nonlinear characteristic of the photoactive resin,” which Greene refers to as “gamma correction.” EX1006, [0040]; Chen ¶130. Gamma correction in Greene permits an intensity value between 0 and 255 to be assigned to pixels based on the unique nonlinear characteristics of whatever resin is used. EX1006, [0040]; Chen ¶130.

D. Jørgensen - EP 3,053,729 A1

European Patent Application Publication No. EP 3,053,729 A1 (“Jørgensen”) (EX1028) is entitled “Method for exposing a photo polymerizable material for solidification of material layer by layer to build a 3D object” and was published on August 10, 2016, with a filing date of February 4, 2015. These dates precede the earliest priority date of the '511 Patent. Compare EX1028; EX1001. Jørgensen is in the same field of endeavor as the '511 Patent and is pertinent to the problems

encountered in 3D printing using light projection and photocurable resins and is, therefore, relevant prior art. Chen ¶138.

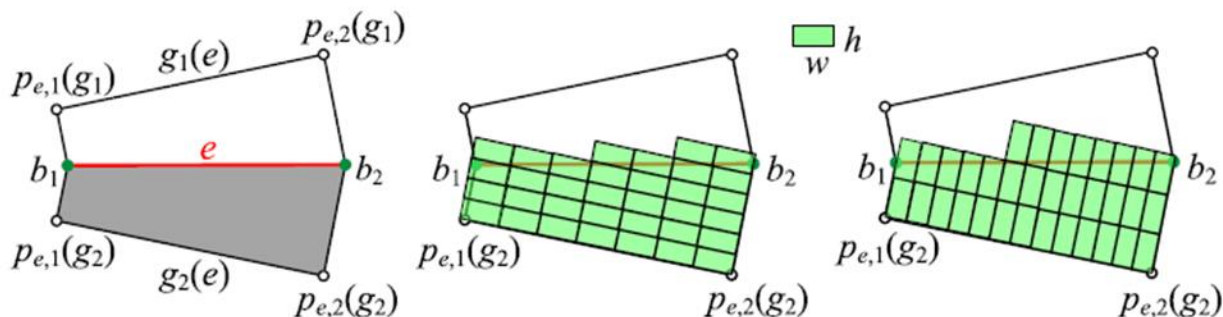
Jørgensen is directed towards DLP-based AM, including for purposes of meeting “the demand for larger building areas” while “obtaining...high resolution.” EX1028, [0002], [0004]; Chen ¶138. Jørgensen teaches DLP systems and methods that are “capable of increasing the resolution of the solidification material compared to the static image of projected light ... by using **image scrolling** while the light projector is in motion relative to the exposed [photopolymerizable] material.” EX1028, [0002], [0006]. Additionally, Jørgensen teaches that to print a “large exposed pattern image,” the image may be divided into sub-images and exposed sequentially using a “**step and flash**” procedure. EX1028, [0013]; Chen ¶139. Additionally, Jørgensen teaches that a composite image may be printed “**in a continuous way**,” in which the “light projector is moving relative to the exposed [photopolymerizable] material” continuously, pixel-by-pixel. EX1028, [0015]. Jørgensen further teaches that multiple images may be “**stitched together** forming a continu[ous] image strip.” EX1028, [0008], FIG. 3; Chen ¶139.

E. Yi et al., “Delta DLP 3-D Printing of Large Models,” *IEEE Transactions on Automation Science and Engineering* (DOI: 10.1109/TASE.2017.2751664) (“Yi”)

Yi (EX1029) is a non-patent literature paper by Ran Yi *et al.* and titled “Delta DLP 3-D Printing of Large Models,” published and widely circulated to a POSITA

exercising reasonable diligence on October 2, 2017 by the Institute of Electrical and Electronic Engineers (IEEE) and republished on July 2, 2018 as part of Volume 15, Number 3, of *IEEE Transactions on Automation Science and Engineering* (DOI: 10.1109/TASE.2017.2751664). Both of these publication dates precede the earliest priority date of the '511 Patent. Compare 1029; EX1001. Yi is in the same field of endeavor as the '511 Patent and is pertinent to the problems encountered in 3D printing using light projection and photocurable resins and is, therefore, relevant prior art. Chen ¶142.

Yi is directed towards DLP-based AM, including “**DLP-based 3-D printing with a large size.**” EX1029, p.1194. Yi discloses a system with a moveable platform and a light projector. EX1029, p.1194, FIG. 1. More specifically, “a new DLP system that allows the platform to move not only vertically (in *z*-axis) but also horizontally (in *x-y* plane).” EX1029, p.1194; Chen ¶143. In the Yi system, “[i]n addition to moving vertically (along *z*-axis), the working platform holding cured models can move **and rotate horizontally** (i.e., in the *x-y* plane).” EX1029, p.1194. This functionality allows the platform to be “moved to **any position** in a cylindrical working envelope.” EX1029, p.1195, 1198, FIG. 7; Chen ¶143.



VIII. GROUND 1: CLAIMS 1-8, AND 14-15 ARE ANTICIPATED BY SHKLONIK

Claims 1-8, 14, and 15 of the '511 Patent are anticipated by Shkolnik. EX1004; Chen ¶¶148-216.

A. Shkolnik Discloses All Claimed Limitations

1. Claim 1

1[a]: A method comprising:

To the extent the preamble is limiting, Shkolnik discloses systems and methods for additive manufacturing. EX1004, 4:22-23; Chen ¶151.

1[b] a. providing an additive manufacturing system, comprising;

Shkolnik teaches that “systems and methods disclosed therein are generally applicable to additive manufacturing.” EX1004, 4:22-23; Chen ¶152.

1[c] an image projection system comprising a plurality of image projectors; and

Shkolnik teaches an **image projection system** comprising **one or more image projectors**, referred to as pattern generators or digital light processing

devices. EX1004, 4:41-42, 8:63-8:65; Chen ¶154. Figure 1A of Shkolnik illustrates such a system wherein multiple image projectors (denoted as 102 and 104 in Figure 1A) each **project** an **image** or “pattern” or “sub-image” (denoted as 152 and 154 in Figure 1A) onto a portion of a **reactive material** or resin pool (denoted as 118 in Figure 1A) disposed within a container (denoted as 110 in Figure 1A), below. EX1004, Fig. 1A; Chen ¶155.

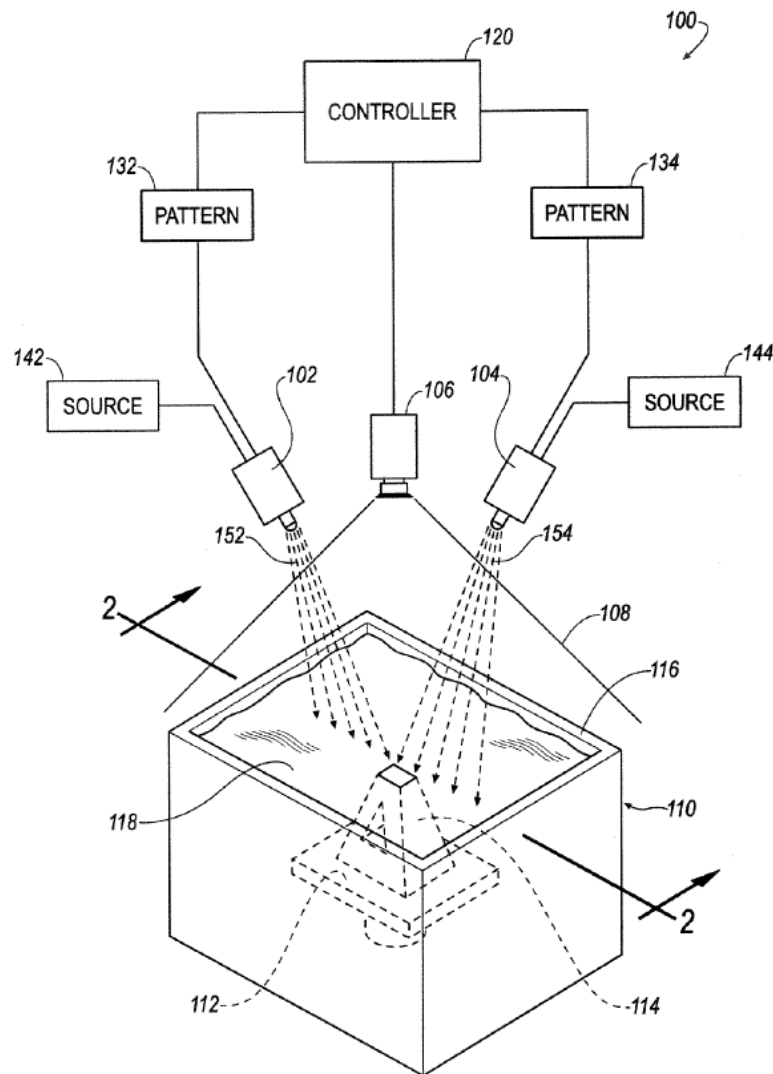


FIG. 1A

1[d] an image display subsystem;

The '511 Patent fails to define the image display subsystem, merely referring to it as item 115 on Fig. 1A. EX1001, Fig 1A. Fig. 1A of the '511 Patent does nothing more than depict a shroud or cover. Turning to Fig. 1B of the '511 Patent, one can potentially infer the shroud or cover as depicted is a chipset or **controller**. EX1001, Fig 1B. Shkolnik teaches a **controller**, also known as a display subsystem, that **interfaces with multiple pattern generators** or image projectors, and an **imager** “for self-calibration at any time before, during, or after manufacture” such as “image correction mapping...to modify an image or bitmap for positional inaccuracies.” EX1004, 7:10-22; 8:6-32; Chen ¶155. The “controller” in Shkolnik is denoted as element 120 in Figure 1A, and the “imager” is denoted as element 106 in Figure 1A (see reproduction of Figure 1A above). EX1004, Fig. 1A.

1[e] b. projecting a composite image onto a build area within a resin pool using the image projection system, wherein:

Shkolnik teaches an **image projection system** that includes one or more **image projectors**, such as one or more DLP devices. EX1004, 4:40-44 (“pattern generators”), 7:56-57. Figure 1A of Shkolnik illustrates a system in which multiple image projectors or “pattern generators” (denoted as 102 and 104 in Figure 1A) each **project an image** or “pattern” or “sub-image” (denoted as 152 and 154 in Figure

1A) onto a portion of a **reactive material** or resin pool (denoted as 118 in Figure 1A) disposed within a container—also known as a build area (denoted as 110 in Figure 1A). EX1004, Fig. 1A; Chen ¶157.

1[f] the image projection system is controlled by the image display subsystem;

As stated in 1[d] above, the image display subsystem is not explicitly defined, and one can potentially infer it is a controller for the image projection system. Shkolnik teaches that its system can include various components and subsystems for *controlling* the image projection system, and each of the image projectors may be adjusted by a **controller** to modify properties and alignment of a position of each sub-image in the array of sub-images. EX1004, 11:23-35.

Shkolnik specifically teaches a **controller that interfaces with multiple pattern generators** and an imager “for self-calibration at any time before, during, or after manufacture” such as “image correction mapping...to modify an image or bitmap for positional inaccuracies.” EX1004, 7:10-22; 8:6-32; 7:18-22 (“Note that while the image correction mapping is generally shown and described herein as being external to the pattern generators, the systems and methods, in whole or in part, may also be integrated with the pattern generators.”). Such a “controller” is denoted as element 120 in Figure 1A, and such an “imager” is denoted as element 106 in Figure 1A. Additionally, Shkolnik teaches that the imager 106 “may be used

for initial alignment and adjustment of pattern generators 102, 104 or for real-time, or near real-time, adjustment.” EX1004, 11:23-35; Chen ¶159.

1[g] the composite image comprises a plurality of sub-images arranged in an array;

Shkolnik teaches that composite images may comprise a plurality of sub-images arranged in bitmaps, and bitmaps (digital information) may form data arrays—foundational knowledge of data storage and representation. EX1004, 11:4-8. Shkolnik further discloses an image projection system that can include an array of image projectors that each project an image onto a reactive material. EX1004, 4:40-44; 5:9-14; Chen ¶161. In Figure 7A, Shkolnik teaches that the individual patterns or “sub-images” provided by the individual image projectors or pattern generators can together form an overall or composite image. EX1004, Fig. 7A; Chen ¶161.

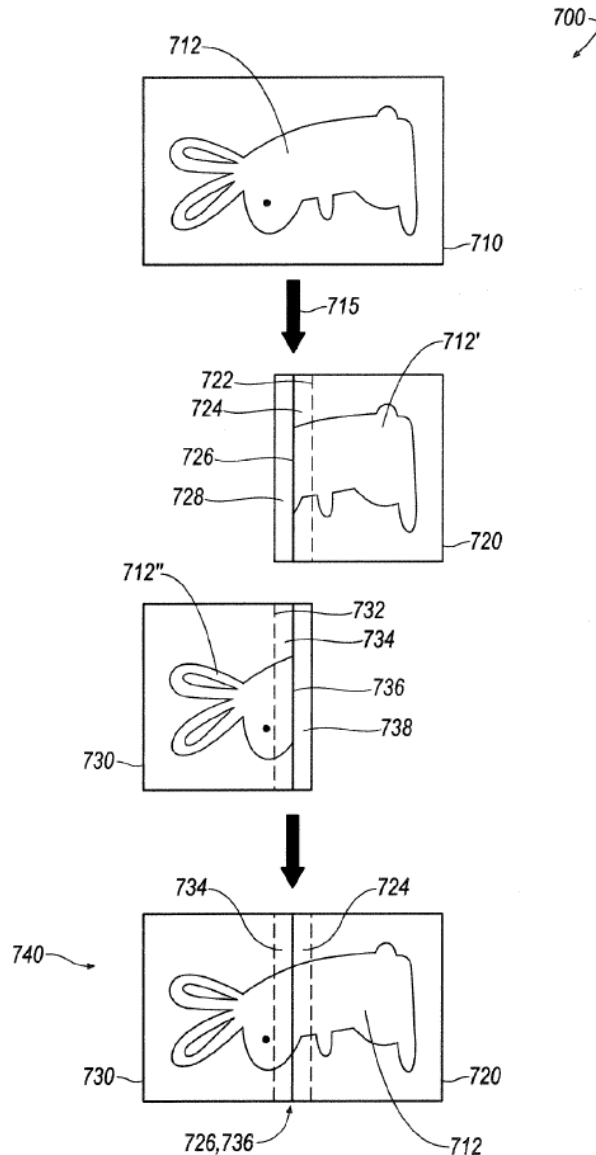


FIG. 7A

1[h] two or more adjacent sub-images in the array overlap at two or more sub-image edges; and

Shkolnik discloses **images** or patterns of an array of image projectors or pattern generators **can overlap**, including at their edges. EX1004, 33:45-34:14. Such overlap is illustrated in Figures 4C and 7A (above). EX1004, Fig. 4C; Chen ¶163.

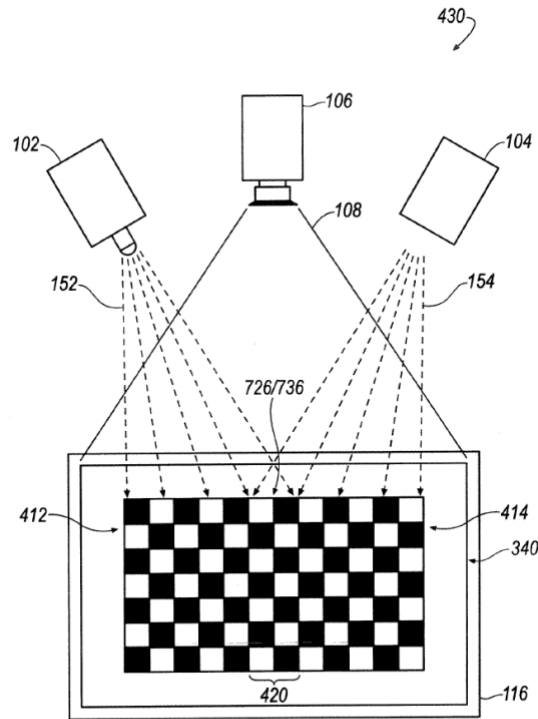


FIG. 4C

1[i] each sub-image is projected onto a portion of the build area using one of the plurality of image projectors; and

Shkolnik teaches that each sub-image is projected onto a portion of the build area using one of the plurality of image projectors. The image projectors of Shkolnik each project an image onto a reactive material, such as a container of photopolymerizable resin. EX1004, 5:9-14; Chen ¶165.

1[j] c. adjusting properties and aligning a position of each sub-image in the array using a set of filters comprising:

Shkolnik teaches that the patterns or sub-images produced by an array of pattern generators can be **bitmaps** (digital information), that can be **corrected**,

adjusted, or **fixed** in various ways, such as to provide positional compensation and intensity compensation, thereby adjusting properties of each sub-image. EX1004, 10:44-46 (multiple pattern generators), 11:4-8 (digital information), 14:51-53 (correction mapping/adjusting properties), 17:24-27 (correction mapping/adjusting properties); Chen ¶167. Further sub-image adjustments in Shkolnik comprise using a combination or stack of filters, masks, or maps. EX1004, 2:9-11; 2:22-26; Figures 1K, 1ME; Chen ¶167.

As another example, Shkolnik teaches that adjustments can be made to correct for both linear and non-linear distortions. The corrections or adjustments may also be iterative, undertaken in sequence, or carried out simultaneously. Shkolnik describes such adjustments of sub-images using a combination or “set” of filters, masks, or “maps.” EX1004, 2:9-11; Chen ¶168.

1[k] an irradiance mask that normalizes irradiance;

The '511 Patent discloses an irradiance masking filter (digital filter) that **normalizes radiance or intensity**: “...the irradiance mask filters enable control over the energy across the build area to compensate for non-uniformities in the projector optics and/or optical path.” EX1001, 11:30-35. Shkolnik teaches adjusting irradiance or intensity through a “correction map” (digital filter) that includes positional compensation and **intensity compensation**. EX1004, 5:38-53. The digital filters within Shkolnik are provided to calibrate/correct, which includes the

intensity for each pixel of the data files. EX1004, 58-64. A POSITA would recognize “intensity” as “brightness” of light striking a given pixel (which is the same as irradiance), either alone or in combination with the exposure time of the pixel. *Id.*, 9:35-46; Chen ¶170.

Even further, Shkolnik repeatedly discloses techniques of **adjusting** sub-image **intensity/irradiance** to an “**ideal**,” “**standard**,” “**compensation**” level, which a POSITA would recognize as normalizing the intensity/irradiance. EX1004, 5:38-53; 34:15-22. Shkolnik teaches that in the case of DLP pattern generators, “micro-mirrors may change shape or position to cause both linear and nonlinear distortions, which may be compensated for.” EX1004, 7:33-37. This compensation is described as “intensity compensation”, which a POSITA would understand as irradiance compensation, or normalizing irradiance. EX1004; 5:38-49; Chen ¶¶170-171.

Shkolnik further teaches that the brightness (or irradiance) and exposure time “may be parameters for the bitmap, together or separately.” *Id.*, 10:7-8. Shkolnik assigns an “intensity value” to each pixel, such as an integer between 0 and 255—and states that “the intensity value may be compensated or adjusted before being sent to the pattern generator, or may be compensated or adjusted at the pattern generator, or both.” *Id.*, 9:47-51. Thus, Shkolnik teaches that pattern generators must necessarily be adjusted for distortion, that the “irradiance mask filter” is a common

problem inherent to all DLP systems that rely on micro-mirrors or other optical elements, and that one of the ways to correct for distortion is to ensure that “intensity” (*i.e.*, irradiance) matches a “standard” (*i.e.*, normalized) value. Chen ¶172.

1[l] a gamma adjustment mask that adjusts sub-image energy based on a reactivity of resin in the resin pool;

Shkolnik teaches a set of filters comprising techniques defined in the '511 Patent as a gamma adjustment mask. As mentioned in the background, gamma adjustment is related to a combination of **light intensity** and **curing rate** of a particular resin. The techniques disclosed in Shkolnik work in an identical fashion to adjust sub-image energy (light intensity) based on a reactivity of resin in the resin pool. First, Shkolnik teaches the assignment of an “**intensity value**” or level to each pixel of a sub-image. EX1004, 9:47-51. For example, for an 8-bit system “intensity ranges of 0 to 255 are convenient.” EX1004, 9:59-62. Coincidentally, the Patent Owner also uses the “0 to 255” scale when discussing gamma adjustment. EX1001, 24:30-31. Moreover, Shkolnik teaches that “the **time and intensity** to achieve a particular depth of cure is material dependent,” with the result being a given **intensity value** that provides a particular **curing depth** for a specific resin. EX1004, 10:22-26; 18:32-37; Chen ¶175.

In addition, Shkolnik teaches that when a resin “has a minimum intensity threshold for polymerization or partial-polymerization, the ‘off’ or zero (0) value

intensity (e.g., brightness and/or ‘on’ time) may be determined based on the reactive material threshold.” EX1004, 9:51-55. Shkolnik teaches that “correction” of a pattern for forming an object can be achieved by mapping the intensity values to the resin reactivity, resulting in more accurate additive manufacturing. EX1004, 18:37-42; Chen ¶176-177.

1[m] a warp correction filter that provides geometric correction; and

Shkolnik specifically discloses that geometric distortion is “commonly associated with optical systems” that include multiple pattern generators (e.g., DLP devices). EX1004, 32:64-33:10, FIGS. 5A-5C; Chen. ¶179. Shkolnik Figures 5A and 5B are illustrative of such uncompensated distortion (barrel and pincushion distortion, respectively).

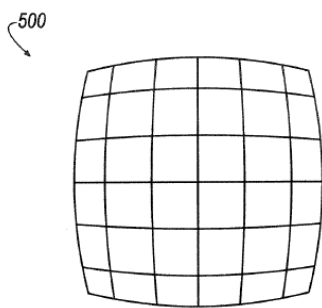


FIG. 5A

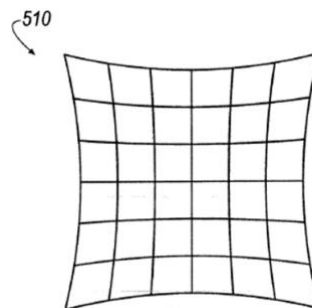


FIG. 5B

Shkolnik anticipates the warp correction filter limitations and provides a detailed description and illustration of how to correct a pincushion distortion—namely, how “to transform the pincushioned output of pattern generators to a more usable output” by using “**pattern correction methods**” and “**calibration patterns.**”

EX1004, 33:18-45, Fig. 6; Chen ¶180. As noted above, this ‘pattern correction’ can occur at each pattern generator, which means that the correction is occurring at least at the sub-image level. EX1004, 31:51-53, 7:18-22; Chen ¶180.

1[n] an edge blending bar at one or more sub-image edges.

The ’511 Patent fails to define what an edge blending bar is, rather it points to a frame in Fig. 2A that has intersecting lines near the edges. EX1001, Fig. 2A. Shkolnik teaches a set of filters comprising intersections or a “blending bar” at one or more sub-image edges. A POSITA would likely determine an “edge blending bar” as a name for using one or more edge blending techniques (edge blending, pixel blending, image blending, or stitching) in an area of overlap in two or more sub-images. Chen ¶182. Shkolnik teaches several of these edge blending techniques, and discloses that the images or patterns can overlap, including at their edges, and as such require such blending techniques. EX1004, 33:45-34:14. In particular, Shkolnik informs us that there is a “potential for overexposure of reactive material” due to the overlap of the sub-images EX1004, 34:2-14. To solve this problem, Shkolnik teaches an adjustment to the pixels at the edges of the sub-images can be made. Further, Shkolnik teaches that such adjustment (edge blending) can be performed in a dynamic manner: “Potential overlap regions 728, 738 allow for on-the-fly adjustment to image patterns 712’, 712” during use that may be desirable to

adjust for heat and other changes to the system that may introduce distortion.” Id., Fig. 7; 34:35-38; Chen ¶183-186.

2. **Claim 2 - The method of claim 1, wherein the image display subsystem controls the image projection system and each of the image projectors using digital light processing.**

See discussion in Ground I, 1[f]. Chen ¶189-190. With respect to “digital light processing,” Shkolnik specifically teaches that the pattern generators may be configured as digital light processing devices. EX1004, 8:63-65 (“Examples of pattern generators may *include Digital Light Processing technology (DLP) from Texas Instruments®*...”); Id., 7:56-67.

3. **Claim 3 – The method of claim 1, wherein the irradiance mask additionally adjusts the energy across the build area to compensate for non-uniformities in optics of the plurality of image projectors.**

Shkolnik discusses that “[t]ypical sources of error in the...pattern generator may include mechanical misalignment of the components or supporting structure, misaligned lenses or mirrors, and malformed lenses or mirrors,” as well as heating and/or cooling during operation, which “may cause components to move or expand, changing their position” or “[i]n the case of optical components, the position, shape, and size may change with heating and/or cooling.” EX1004, 7:23-30. Shkolnik further teaches that in the case of DLP pattern generators, “micro-mirrors may change shape or position to cause **both linear and nonlinear distortions**, which may be compensated for.” Id., 7:33-37. Chen ¶¶192-194.

4. **Claim 4 – The method of claim 1, wherein the gamma adjustment mask comprises a logarithmic relationship between a cure depth of the resin and energy per unit area in the build area.**

As shown above in 1[g], Shkolnik teaches a gamma adjustment mask. Shkolnik teaches “the time and intensity to achieve a particular depth of cure is material dependent.” EX1004, 10:22-26; Chen ¶196. A POSITA would understand it is inherent in the working principles of time and intensity of curing a specific resin (gamma adjustment) that a logarithmic relationship would exist. Chen ¶196-197. Indeed, for “**any** photocurable resin, the relationship between a cure depth of the resin and energy per unit area is **always** logarithmic.” Id. The “logarithmic relationship between cure depth and energy per unit area is literally a textbook principle that has been well known in the field for decades, as evidenced by Jacobs (EX1007), e.g. at page 204, inherent to all photocurable resins of the type described by Shkolnik.” Chen ¶164. Prior art can, as here, anticipate a claim even if it does not expressly spell out the limitation, if such limitation is inherent. *See Sigray, Inc. v. Carl Zeiss X-Ray Microscopy, Inc.*, 137 F.4th 1372, 1376 (Fed. Cir. 2025) (“[a] limitation is inherently disclosed ‘when the reference discloses prior art that must necessarily include the unstated limitation.’”).

5. **Claim 5 - The method of claim 1, wherein the resin is selected from the group consisting of acrylates, epoxies, methacrylates, urethanes, silicone, vinyls, and combinations thereof.**

Shkolnik teaches the use of “a material comprising a resin containing at least one ethylenically unsaturated compound (including but not limited to (meth)acrylate monomers and polymers) and/or at least one epoxy group.” EX1004, 5:17-24. Additionally, Shkolnik teaches that “a curable silicone composition” may be used as a reactive material. Id., 4:65-5:8. Chen ¶199. Furthermore, the list of photocurable resins is well-known and of general knowledge. Chen ¶199.

6. Claim 6 – The method of claim 1, wherein the edge blending bar comprises a blending distance and a function selected from the group consisting of: linear, sigmoid and geometric.

As discussed in Ground I, Claim 1[n] the '511 Patent fails to define what an edge blending bar is, rather it points to a frame in Fig. 2A that has intersecting lines near the edges. EX1001, Fig. 2A. Shkolnik also points at the edges of the patterns and teaches that the “overlap regions” or “overlap portions” which are the “blending distance”—can have any desired width, such as “from one pixel to any number of pixels to generate any width of overlap portions.” EX1004, 34:4-7. Shkolnik teaches that the “fading effect” created by the edge blending can “use a linear interpolation algorithm to reduce intensity such that when overlapped, the combined intensity is the same as the original image.” Id., 34:53-64. Chen ¶201.

7. Claim 7 – The method of claim 1, wherein the edge blending bar adjusts the one or more sub-image edges based on at least one layer boundary location within an object being manufactured.

Similar to Claim 1[n] and Claim 6 above, the “blending bar” is not defined and merely points to an image of a intersecting region. EX1001, Fig. 2A. A POSITA would readily understand that locations adjusted by the *edge blending bar* are “within an object being manufactured.” Chen ¶203. As previously discussed in Claim 1, Shkolnik teaches sub-images, and that those sub-images may form bitmaps that adjustments/corrections may be applied to. EX1004, 33:50-67, 34:2-4; See generally Chen ¶¶204-206.

8. **Claim 8 – The method of claim 1, further comprising a system controller that synchronizes exposure control of the plurality of image projectors with each other.**

Shkolnik discloses the use of a controller to synchronize a plurality of pattern generators to simultaneously project multiple sub-images. For example, Shkolnik discusses that “In general, an application of the system and method described herein may *use a pattern generator* to build a three-dimensional object by exposing a reactive material...” EX1004, 4:48-52. Shkolnik further comprises a “controller” that “receives and sends patterns to pattern generators that selectively produce patterns to produce a work piece” where components work “with controller 120 and pattern generators to produce a solid uninterrupted component.” Id., 8:10-17. Chen ¶208.

9. **Claim 14 – The method of claim 1, wherein the adjusting properties and aligning the position of each sub-image in the array further comprises applying the irradiance mask to**

each sub-image such that the composite image has a uniform irradiance range across the composite image.

Shkolnik teaches intensity compensation (or “correction”) when applying an irradiance mask/pattern correction map. EX1004, 5:47-49. Shkolnik further discloses the use of a grayscale value to “control a pattern generator’s output,” for example “to **provide full *intensity*, no output, or variations in between.**” Id., 6:23-31. Additionally, Shkolnik teaches that each pattern generator “... may reduce the ***amount of electromagnetic radiation that the reactive material is exposed to for each pixel according to the exposure time.***” Id. A POSITA would appreciate that by simultaneously “calibrating multiple pattern generators,” specifically to have “an intensity range scaled from zero (the minimum) to 255 (maximum),” the sub-images would be “scaled” to the same range (*i.e.*, representing “a uniform irradiance range”). Chen ¶210.

10. **Claim 15 – The method of claim 1, wherein the adjusting properties and aligning the position of each sub-image in the array further comprises applying the irradiance mask to each sub-image to normalize irradiance non-uniformities within the image projection system arising from a projector-based spatial energy non-uniformity.**

By “projector-based spatial energy non-uniformity,” a POSITA would understand the ’511 Patent to mean non-uniformities of irradiance energy caused by a projector, for example, “non-uniformities in the projector optics and/or optical path.” EX1001, 11:50-52; Chen ¶212.

These non-uniformities are exactly the same as those accounted for in Shkolnik. Shkolnik teaches that “[t]ypical sources of error in the ... pattern generator may include mechanical misalignment of the components or supporting structure, misaligned lenses or mirrors, and malformed lenses or mirrors,” as well as heating and/or cooling during operation, which “may cause components to move or expand, changing their position” or “[i]n the case of optical components, the position, shape, and size may change with heating and/or cooling.” EX1004, 7:23-30. What Shkolnik is teaching here is that a micromirror “may change shape” and create “distortions”—and a POSITA would understand that this is caused by degradation or temporary thermal cycling of the micromirror itself. Whether a micromirror has physically changed its position, shape, or size will have a direct impact on intensity—and in the scenario where such a change has occurred, Shkolnik is teaching that there is a need for compensation (*i.e.*, to “normalize”) arising from the sources of error (*i.e.*, a “projector-based spatial energy non-uniformity”).

A POSITA would also understand the individual projector-based standardizing to be normalizing irradiance non-uniformities within the image projection system arising from a projector-based spatial energy non-uniformity, for example, the projector-based spatial energy non-uniformity arising being any non-uniformity of a specific pattern generator that produces a particular sub-image. Chen ¶213-215.

IX. GROUND 2: CLAIMS 1-8, 14, AND 15 ARE UNPATENTABLE AS OBVIOUS OVER SEKINE AND GREENE

Sekine explicitly teaches all but one of the limitations of claims 1-8, 14, and 15 of the '511 Patent. The remaining limitation (gamma adjustment) is explicitly taught by Greene. For the reasons further described below, it was obvious to combine the teachings of Sekine and Greene, thereby arriving at claims 1-8, 14, and 15 of the '511 Patent. Chen ¶217.

A. Sekine and Greene Disclose All Claimed Limitations

1. Claim 1

1[a]: A method comprising:

Sekine is directed to systems and methods for additive manufacturing. EX1005, [0001], [0005], [0013]-[0014]; Chen ¶219.

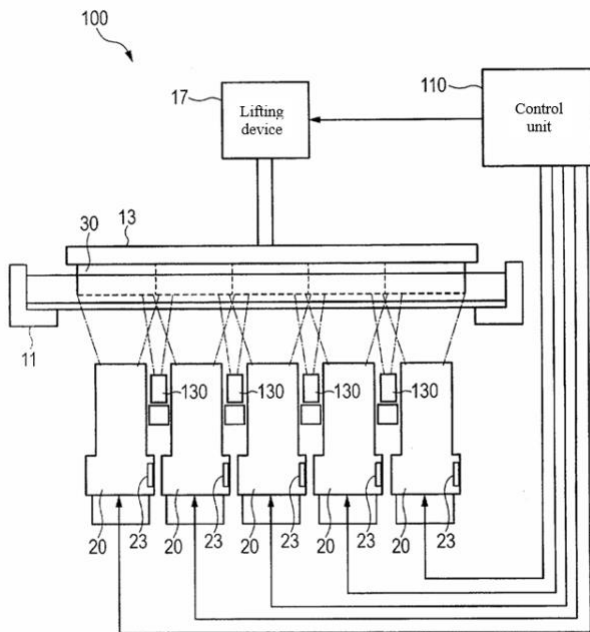
1[b] a. providing an additive manufacturing system, comprising;

Sekine teaches providing an AM system. EX1005, [0001], [0005], [0013]-[0014]. It should be noted that Sekine (as translated from the original Japanese) sometimes uses the term “three-dimensional shaping device” to refer to an additive manufacturing apparatus or system (DLP). Chen ¶220.

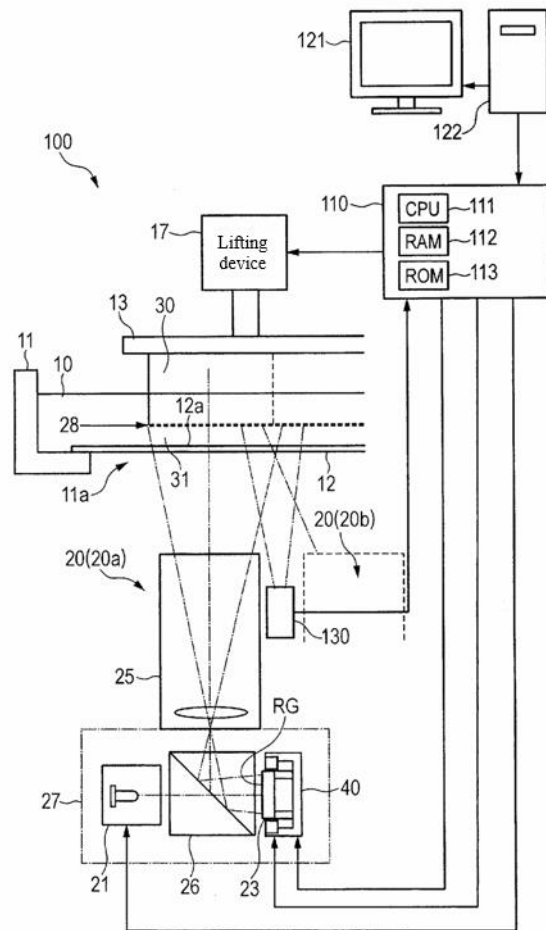
1[c] an image projection system comprising a plurality of image projectors; and

Figures 1-2 of Sekine illustrate an AM system and the configuration of the system's image projection system. EX1005, [0011], [0013]-[0014]; Chen ¶221-222. The AM system 100 projects an image into a liquid resin material 10 in a container 11 using projectors 20 arranged in a 5x5 grid of 25 projectors total. EX1005, [0014]-[0019], [0033]; Chen ¶221-222.

[FIG. 1]



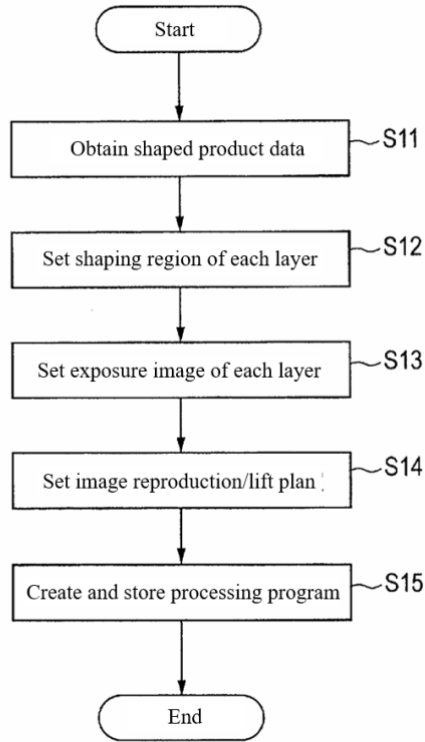
[FIG. 2]



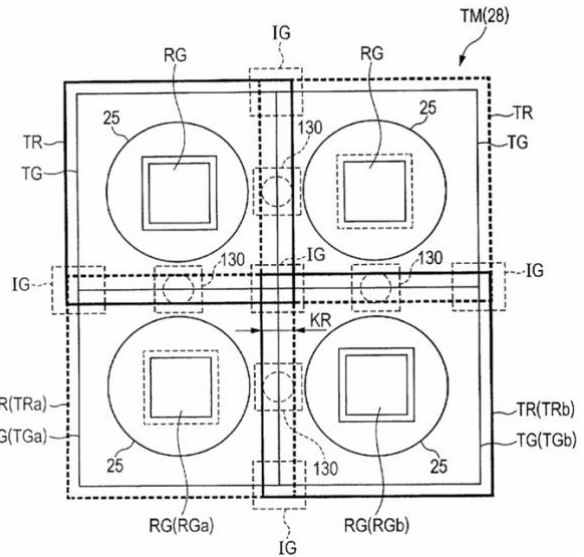
1[d] an image display subsystem;

As described in the '511 Patent, an image display subsystem can control the image projection system. EX1001, Claim 1. Sekine teaches a subsystem that controls the image projection system and each of the image projectors, with reference to Figures 2 and 3, Sekine teaches that an external computer 121 inputs design data of the desired product 30 into a control unit 110 and further inputs commands to the control unit 110, such as to start or interrupt the print job. EX1005, [0027]. Sekine further teaches that a CPU (denoted as 111) acquires the design data (e.g., CAD data) of the product 30 from the external computer 121 (denoted as step S11 in Figure 3). *Id.*, [0028]. The CPU 111 or external computer 121 then divides the product 30 into sub-regions and assigns the sub-regions to the various projectors 20 for actual printing, based on parameters provided by the subsystem. *Id.*, [0028]-[0030], [0042], FIGS. 2-3, 5-6; Chen ¶224-226.

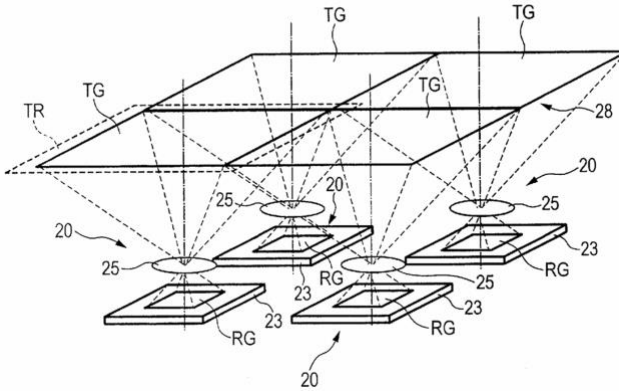
[FIG. 3]



[FIG. 6]



[FIG. 5]



1[e] b. projecting a composite image onto a build area within a resin pool using the image projection system, wherein:

Figure 1 of Sekine illustrates an AM system, and Figure 2 more specifically illustrates the configuration of the system's image projection system. EX1005, [0011], [0013]-[0014]; Chen ¶228. With reference to these figures, Sekine teaches that the AM system 100 projects an image into a liquid resin material 10 in a container 11 using projectors 20 arranged in a 5x5 grid of 25 projectors. EX1005, [0013]-[0019], [0033]; Chen ¶228. Each projector 20 projects an image onto the surface of the liquid resin material 10. EX1005, [0017].

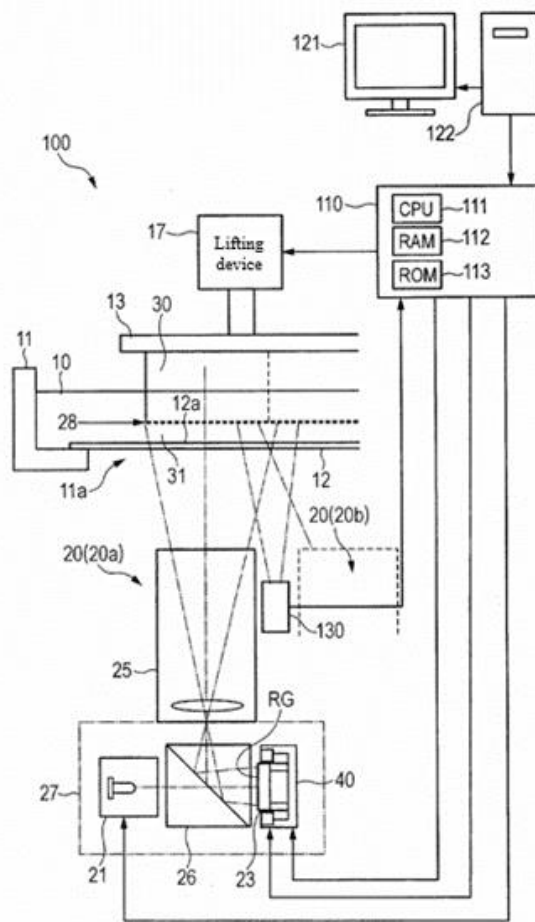
1[f] the image projection system is controlled by the image display subsystem;

Sekine teaches a subsystem that controls the image projection system and each of the image projectors to adjust properties and alignment of the positions; with reference to the system of Figure 2 and the flowchart of Figure 3, Sekine teaches that an external computer 121 inputs design data of the desired product 30 into a **control unit 110** and further inputs commands to the control unit 110, such as to start or interrupt the print job. EX1005, [0027]. Further, Sekine teaches that a CPU 111 acquires the design data (e.g., CAD data) of the product 30 from the external computer 121 (step S11 in Figure 3). Ex.1005, [0028]. The CPU 111 or external computer 121 then divides the product 30 into **sub-regions and assigns the sub-regions to the various projectors 20 for actual printing, based on parameters**

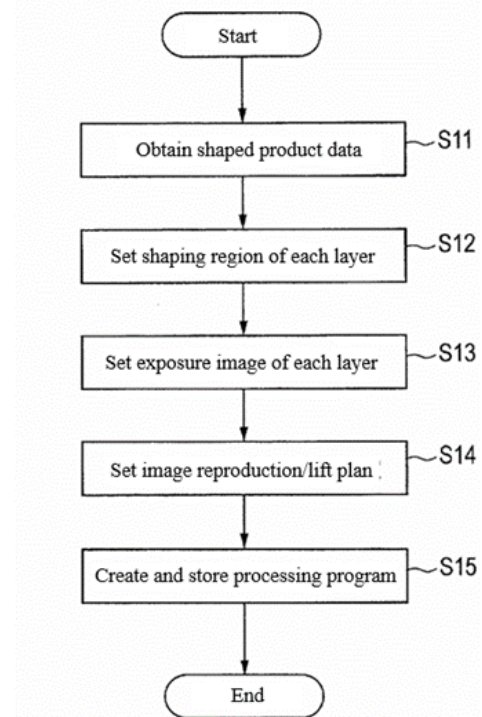
provided by the subsystem. EX1005, [0028]-[0030], [0042], FIGS. 2-3, 5; Chen ¶230.

Lastly, Sekine illustrates that the control unit 110 can adjust positions of adjacent sub-images by providing appropriate instructions to actuators. EX1005, [0038]-[0041]; Chen ¶231-232.

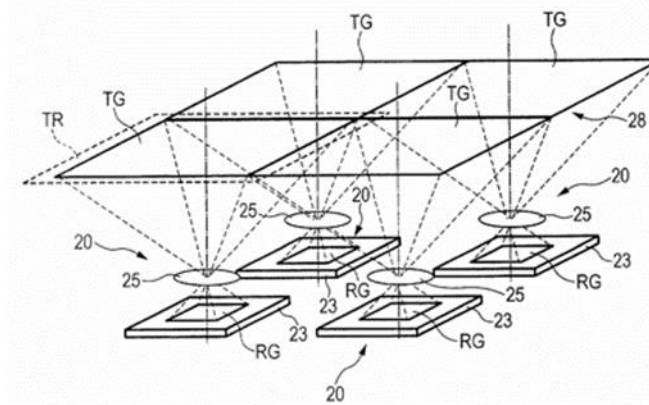
[FIG. 2]



[FIG. 3]



[FIG. 5]



1[g] the composite image comprises a plurality of sub-images arranged in an array;

Sekine teaches that AM system 100 projects an image onto a liquid resin material 10 in a container 11 using projectors 20 arranged in a 5x5 grid of 25 projectors total. EX1005, [0013]-[0019], [0033], Figures 1-2. Figure 5 illustrates a 2x2 portion of the projector array, with four projectors arranged in a row-column array. Each of these projectors projects a sub-image consistent with the same orientation. EX1005, Figure 5; Chen ¶234-235.

1[h] two or more adjacent sub-images in the array overlap at two or more sub-image edges; and

As stated above for 1[g], Sekine teaches it is possible to divide a composite image into smaller sub-images, where each sub-image is provided by a separate projector in the array. EX1005, [0017], [0035]. These sub-images can be “stitched” together, such as shown in Figures 5-6, where the individual sub-images are denoted as “TG.” *Id.*, [0035]. The edges of “stitched” sub-images TG overlap in the boundary region denoted as “KR.” *Id.*, [0044]; Chen ¶237.

1[i] each sub-image is projected onto a portion of the build area using one of the plurality of image projectors; and

As noted above, Sekine teaches that to form a large, single product (denoted as element 30) with high resolution, it is possible to divide the overall or composite image 30 into smaller pieces or sub-images, where each sub-image is provided by a separate projector in the array. EX1005, [0035], Figures 1, 5, 6. Chen ¶239.

1[j] c. adjusting properties and aligning a position of each sub-image in the array using a set of filters comprising:

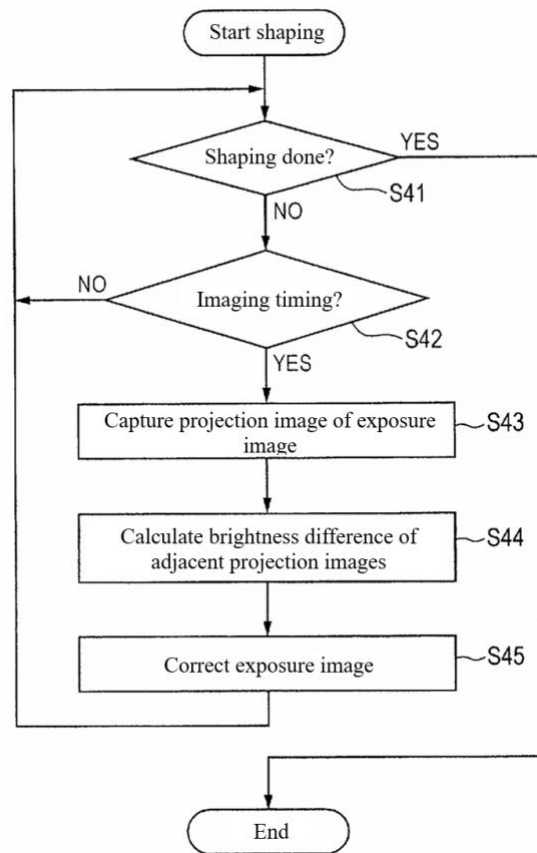
Sekine teaches multiple types of adjustments of sub-images, and multiple adjustment types can be used in the same print job to correct multiple types of errors. EX1005, [0042], [0073]. The '511 Patent refers to these correction mechanisms as “filters” or “masks.” Chen ¶241. Sekine describes these mechanisms using different terms, such as “illuminance correction control” or “alignment control.” EX1005, [0042], [0073]. However, “the concept is exactly the same.” Chen ¶241.

1[k] an irradiance mask that normalizes irradiance;

Sekine teaches that the “illumination” or “brightness” of a composite image can be non-uniform, and that such lack of uniformity is undesirable. For instance, Sekine teaches that when multiple sub-images are stitched together to form a composite image, “gaps” or “streaks” may occur due to “brightness differences between adjacent projection images” or misalignment. EX1005, [0070], [0099]; Chen ¶251. Sekine teaches that brightness differences may be due to “performance differences” within the projection system. EX1005, [0071]; Chen ¶243.

To address these variations, Sekine teaches a step of normalizing irradiance “to **eliminate** the brightness **difference between** adjacent projection images” and “make the illumination distribution **uniform.**” EX1005, [0070]-[0071]. Sekine further explains one way of doing so: “to ensure that the illuminance difference between adjacent projection images TG across the boundary is eliminated, the brightness gradation (duty ratio) of each pixel in the plane of the image forming element 23 is controlled to be the same.” *Id.*, [0071]; Chen ¶244. Sekine also provides a flowchart in Figure 11 for such “illuminance correction control,” describing adjusting the light source for **each projector** as “one example of adjustment means” for achieving uniform irradiance, wherein each projector projects a sub-image within the boundary allotted to that projector—meaning that adjustment occurs at the sub-image level. EX1005, [0042], Figure 5; Chen ¶244.

[FIG. 11]



1[l] a gamma adjustment mask that adjusts sub-image energy based on a reactivity of resin in the resin pool;

Greene teaches a “gamma correction” process that adjusts “grayscale intensity levels” of pixels based on “a nonlinear characteristic of the photoactive resin,” for the purpose of achieving improved printing accuracy (e.g., “smooth out edges”). EX1006, [0008], [0037]-[0040], [0031], [0047]; Chen ¶¶247-257.

Like the ’511 Patent, Greene teaches “**mapping** a digital model onto a three-dimensional grid” of voxels or pixels at certain “intensity levels.” EX1006, [0007], [0037]-[0040]. Greene discloses that a grayscale technique can be used with this

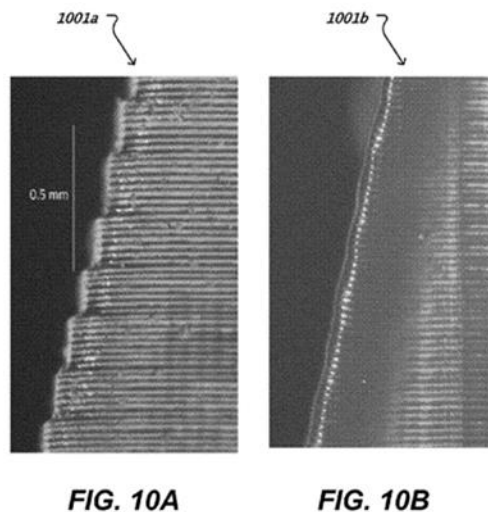
digital model “to provide sub-pixel resolution and smoothing capabilities.” EX1006, [0008], [0031].

Greene further discloses at paragraphs [0037]-[0040] that the gamma adjustment process “**can adjust** the one or more grayscale intensity levels based on a nonlinear characteristic of the **of the photoactive resin.**” Paragraph [0040] of Greene is reproduced below.

At 435, the process assigns one or more grayscale intensity levels to one or more grayscale voxels If the digital model, covers 60% of the volume of a voxel (e.g., 60% containment degree), then the process can assign an intensity level that is 60% of the white intensity level ... The one or more grayscale intensity levels are not sufficient to completely cure the photoactive resin during the predetermined curing time. **In some implementations, the process can adjust the one or more grayscale intensity levels based on a nonlinear characteristic of a light source within the 3D printer, a nonlinear characteristic of the photoactive resin, or both. For example, a photoactive resin may have a nonlinear relationship between intensity levels and a curing degree.** In cases where the nonlinearity is substantially a power function (e.g., $y=x^\gamma$), an adjustment can be performed by applying the inverse power ($1/\gamma$) to the grayscale intensity levels, **e.g., by performing gamma correction.** Alternatively, a lookup table can be applied to correct for arbitrary nonlinearities. In some implementations, the intensity levels are R-bit values, where R is a predetermined number of bits associated with a graphic file format that range from 0 (black) to 255 (white). For example, the intensity levels can be represented as 8-bit values that range from 0 (black) to 255 (white). Other values for R are possible.

EX1006, [0008], [0037]-[0039], [0031], [0047]. A POSITA would understand that the pixel (grayscale) intensity level of Greene (e.g., on a scale of 0 to 255) can be **adjusted “based on** a nonlinear characteristic of a light source within the 3D printer,

a nonlinear characteristic of the photoactive resin, or both.” EX1006, [0040], [0047]. A POSITA would appreciate that just like the gamma adjustment limitation in claim 1 of the ’511 Patent (“adjusts sub-image energy based on a reactivity of resin in the resin pool”), “gamma correction in Greene permits an intensity value...to be assigned to pixels based on the unique nonlinear characteristics of whatever resin is used in a given print job.” Chen ¶262. By applying varying intensity levels, Greene teaches the gamma adjustment process is used to “accurately represent[s] the digital model, e.g., a smoother edge is formed as shown in image 1001b rather than a jagged, stair-stepped edge as shown in image 1001a.” EX1006, [0053], [0008], Figures 10A-10B.

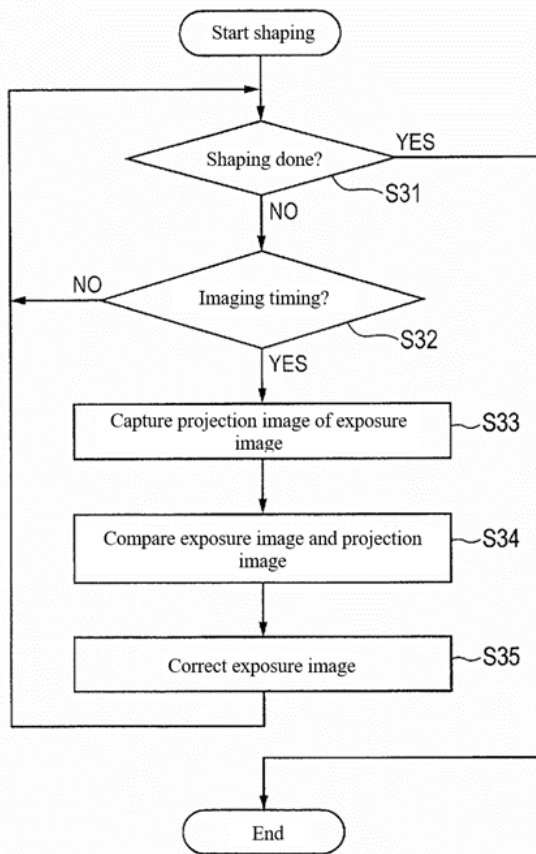


1[m] a warp correction filter that provides geometric correction; and

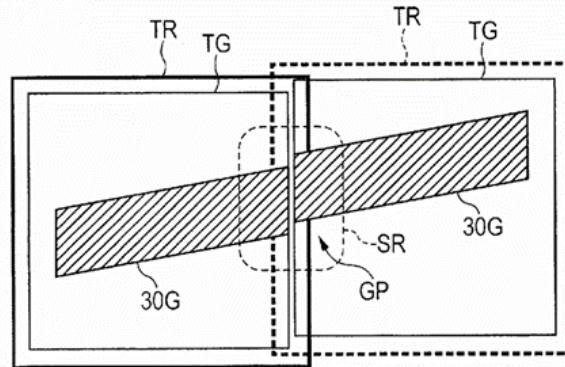
Sekine discloses “when using multiple projectors 20 to project individual exposure images RG formed by dividing the overall exposure image...**distortion** of the image itself” can occur, such as indicated by a “**displacement of the [overall] image pattern** at the boundary of the adjacent [sub-images].” EX1005, [00062]. To address such distortion, Sekine teaches correction of the sub-images so that the overall image matches the designed position. EX1005, [0063]. Moreover, each projector projects a sub-image within the boundary allotted to that projector—which occurs at the sub-image level. EX1005, [0042]; Chen ¶259.

Figures 9 and 10 describe one example of geometric correction. EX1005, [0064]-[0068]; Chen ¶260. Figure 9 discloses “displacement correction control.” Figures 10A-10B disclose “**before**” and “**after**” depictions of a geometrically displaced image (Figure 10A) and corrected image (Figure 10B).

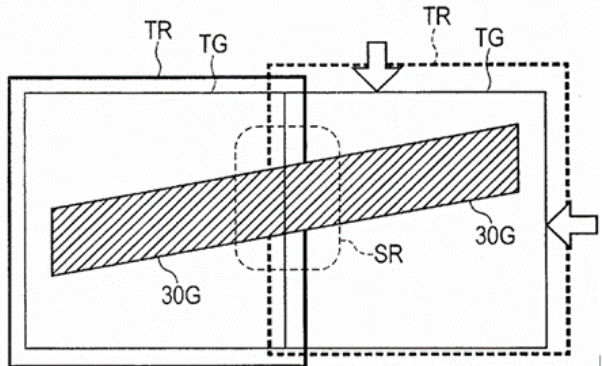
[FIG. 9]



[FIG. 10A]



[FIG. 10B]



A POSITA would understand from Sekine that “if a displacement error occurs between adjacent projection regions TR, a gap GP may form in the desired product image.” EX1005, [0067]; Chen ¶261. In Figure 10, the desired image is depicted as a hatched rectangle (element “30G”). EX1005, [0067]. Sekine teaches one way to correct this distortion is by adjusting position and tilt. *Id.* As illustrated in Figure 10B, the POSITA would understand that the individual projection regions TR are not moved. Instead, the projection image TG is moved within the projection region

TR as indicated by the **arrows** to eliminate the **gap** GP. EX1005, [0067], Figure 10B; Chen ¶261.

This correction can be achieved by (1) moving the contour position of the product 30 displayed in the exposure image RG on the image forming element 23 by a “positional correction amount” and also (2) tilting by a “tilt correction amount.” EX1005, [0067], Figure 2; Chen ¶261.

A POSITA would understand that these position and angle adjustments remove the distortion and correct the geometry of the printed article. *Id.*, ¶270. Further, a POSITA would understand that the geometric correction techniques of Sekine are just like the techniques used in the ’511 Patent where, “a warp correction filter can be used to correct warp or skew in projected images that are caused by variation in projector optics or alignment within the build area.” ’511 Patent, 8:45-48, 18:16-29, FIG. 3; Chen ¶90.

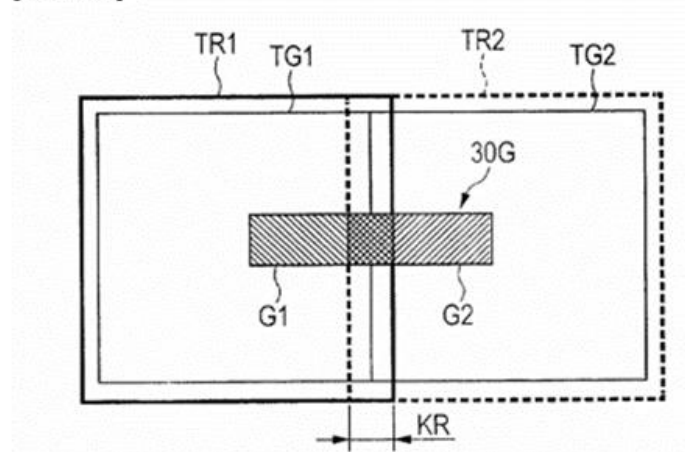
1[n] an edge blending bar at one or more sub-image edges.

“Edge blending,” “pixel blending,” “image blending,” and “stitching” can all refer to the management of overlapping regions in a composite image, such as described in the ’511 Patent using the term “edge blending bar.” Chen ¶63. For example, as taught by the ’511 Patent, a POSITA would understand that edge blending “enable[s] the data within the overlapping regions...to be faded out so that the transition between adjacent sub-images can be made less noticeable,” as depicted

in Figure 2B of the '511 Patent. *Id.* ¶93 (quoting '511 Patent, 9:3-5). Further, as taught by the '511 Patent and understood by a POSITA, because edge blending fades out the shaded regions, it therefore “improve[es] the quality of the printed object surface.” '511 Patent, 9:8-11; Chen ¶93-94.

A POSITA would understand that Sekine teaches a mechanism for improving printing resolution by blending the ends of adjacent sub-images. *Id.* ¶272. Specifically, Sekine teaches the use of “grayscaleing” or “stepping” of adjacent sub-images where their edges overlap, such that the two sub-images blend into one another gradually. EX1005, [0101]-[0105], Figure 17; Chen ¶264. This correction mechanism is described in detail with reference to Figure 17.

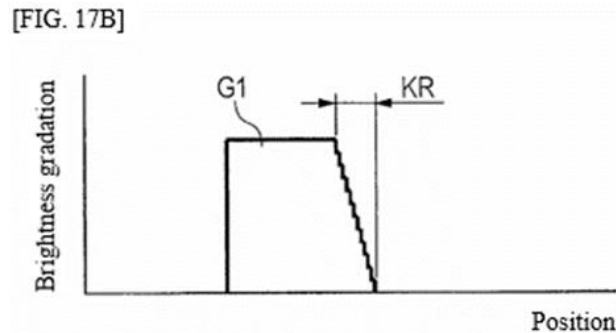
[FIG. 17A]



Here, the desired overall image 30G is rectangle shaped and includes two parts, denoted as G1 and G2. EX1005, [0101]-[0105], Figure 17; Chen ¶264. The first part G1 is included in a first sub-image (TG1) produced by a first projector. EX1005, [0101]-[0105], Figure 17; Chen ¶264. A POSITA would understand that

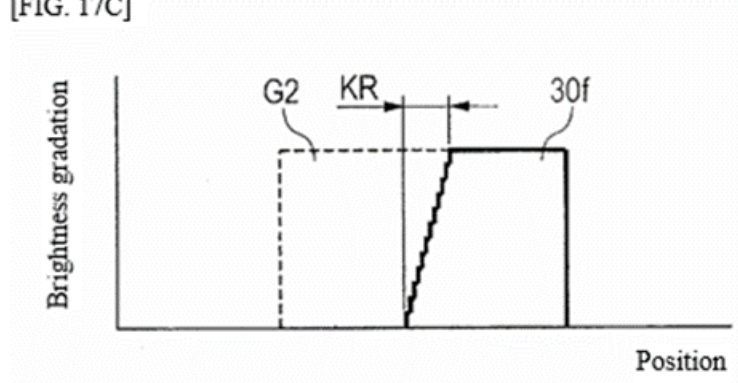
the second part G2 is included in a second sub-image (TG2) produced by a second projector. EX1005, [0101]-[0105], Figure 17; Chen ¶264. The element “KR” in Figure 17 shows the boundary region where the sub-images TG1 and TG2 overlap. EX1005, [0101]-[0105], Figure 17.

As shown in Figure 17B, the brightness or irradiation of G1 is graded or “grayscaled” within the overlap region KR—that is, G1 has a “stair step” brightness, with brightness decreasing as G1 gets closer to G2.



Similarly, as shown in Figure 17C, the brightness of G2 is also graded or grayscaled, with brightness decreasing as G2 gets closer to G1. EX1005, [0101]-[0105]; Chen ¶266. Thus, a POSITA would understand that the edges of sub-images TG1 and TG2 are blended together to improve the quality of the printed object. *Id.* Sekine teaches this approach **avoids** both ‘**gaps**’ (where there is not enough light, and thus the photocurable resin is under-exposed) and ‘**streaks**’ (where there is too much light, and the photocurable resin is over-exposed).” EX1005, [0070]-[0072], [0101]-[0105].

[FIG. 17C]



Claim 2 - The method of claim 1, wherein the image display subsystem controls the image projection system and each of the image projectors using digital light processing.

As discussed with respect to element 1[f], Sekine teaches the image display subsystem controls the image projection system. EX1005, [0028]-[0030], [0042], Figures 2-3, 5-6. Chen ¶¶269-272. Additionally, Sekine teaches that the control unit can adjust positions of adjacent sub-images by providing appropriate instructions to various actuators. EX1005, [0038]-[0041]; Chen ¶271.

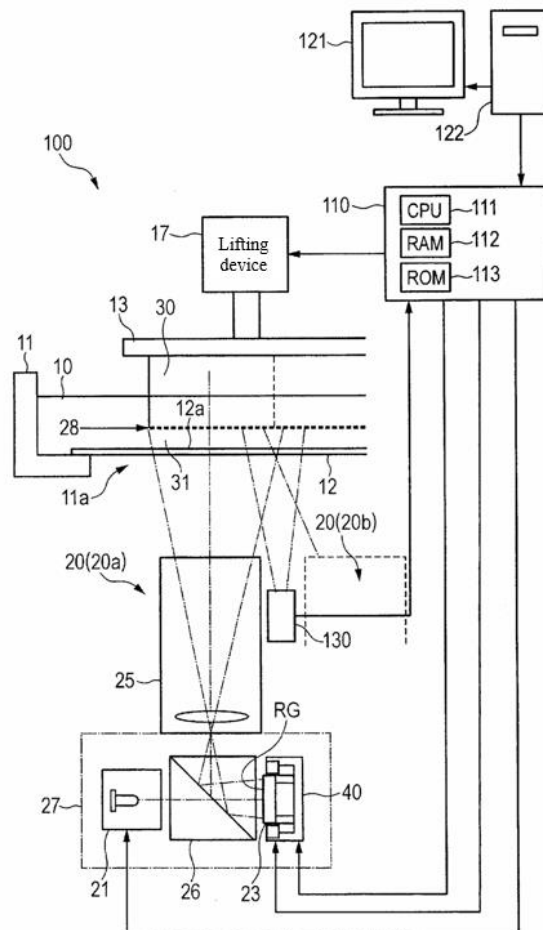
With respect to “digital light processing”, Sekine specifically teaches that DLP devices may be utilized. EX1005, [0019]. Chen ¶272.

Claim 3 – The method of claim 1, wherein the irradiance mask additionally adjusts the energy across the build area to compensate for non-uniformities in optics of the plurality of image projectors.

Sekine discloses multiple types of adjustments of sub-images, including, *e.g.*, “illuminance correction control” or “alignment control.” EX1005, [0042], [0073]. It is well understood that non-uniformities in the optics of projectors can cause

illuminance and/or alignment errors, and the correction of such errors is discussed at great length in Sekine, including in paragraphs [0108]-[0111]. Chen ¶274. For example, Sekine teaches that various actuators of Sekine (*e.g.*, actuators denoted as 41-48 and 51-53) can be used to adjust optical elements of individual projectors to correct for displacement and angle errors. EX1005, Figure 2, [0038]-[0041]; Chen ¶275.

[FIG. 2]



Claim 4 – The method of claim 1, wherein the gamma adjustment mask comprises a logarithmic relationship

between a cure depth of the resin and energy per unit area in the build area.

Greene teaches a gamma adjustment mask, which necessarily includes “accounting for the unique chemistry and physics of a specific photocurable resin (e.g., with reference to that resin’s working curve).” Ground II, 1[1]; Chen ¶277. Further, for “any photocurable resin, the relationship between a cure depth of the resin and energy per unit area is always logarithmic.” *Id.* Indeed, the “logarithmic relationship between cure depth and energy per unit area is literally a textbook principle that has been well known in the field for decades, as evidenced by Jacobs (EX1007), e.g. at page 204, inherent to all photocurable resins of the type described by Greene. Chen ¶278.

Claim 5 - The method of claim 1, wherein the resin is selected from the group consisting of acrylates, epoxies, methacrylates, urethanes, silicone, vinyls, and combinations thereof.

Sekine specifically contemplates different “resin materials,” including resins recited here. EX1005, [0024]. Chen ¶280.

Claim 6 – The method of claim 1, wherein the edge blending bar comprises a blending distance and a function selected from the group consisting of: linear, sigmoid and geometric.

As described in claim 1, Sekine teaches a mechanism for improving printing resolution by blending adjacent sub-images. This mechanism is described with reference to Figures 2 and 17A-C, which depict the blending distance as overlap or

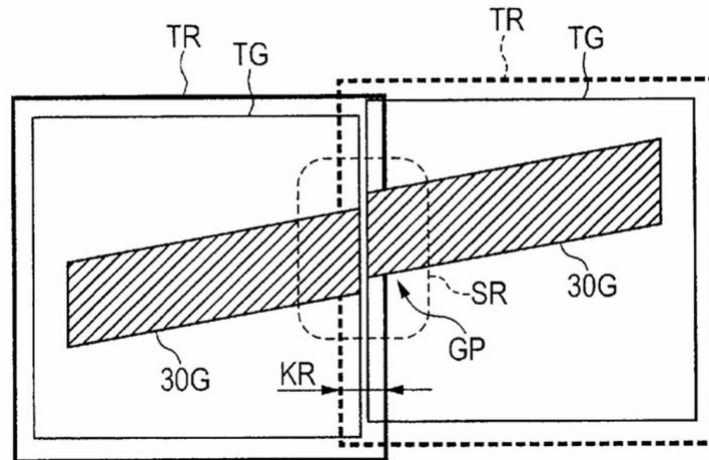
boundary region “KR.” EX1005, [0101]-[0105]. Here, “the illuminance of the exposure image in the boundary region is set to gradually decrease.” EX1005, [0105]. As well understood in the field, a “gradual decrease” as described by Sekine can be achieved by various standard choices for mathematical functions, including linear, sigmoid, and geometric functions, all of which can provide the “gradual decrease” taught by Sekine, with a linear function being the quintessential example of a “gradual decrease.” Chen ¶282-283.

Claim 7 – The method of claim 1, wherein the edge blending bar adjusts the one or more sub-image edges based on at least one layer boundary location within an object being manufactured.

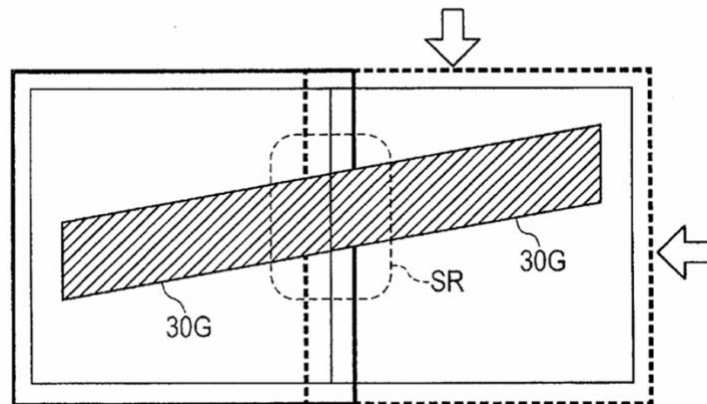
As discussed in the context of claims 1[k] and 1[h], Sekine teaches that when multiple sub-images are stitched together to form a composite image, “gaps” or “streaks” may occur due to “brightness differences between **adjacent** projection images” or misalignment. EX1005, [0070], [0099]. To address these variations, Sekine teaches a step of normalizing irradiance “to eliminate the brightness difference **between adjacent** projection images” and “make the illumination distribution **uniform.**” *Id.*, [0070]-[0071]. Sekine further explains “to ensure that the illuminance difference between adjacent projection images TG across the boundary is eliminated, the brightness gradation (duty ratio) of each pixel **in the plane of the image forming element 23** is controlled to be the same.” *Id.*, [0071]. Sekine specifically discusses that “it is necessary to **correct positional displacement**

between adjacent projection images and to make the light distribution uniform.” *Id.*, [0035]; Chen ¶285.

[FIG. 8A]



[FIG. 8B]



Claim 8 – The method of claim 1, further comprising a system controller that synchronizes exposure control of the plurality of image projectors with each other.

As discussed above for claim 1, Sekine discusses use of multiple pattern generators simultaneously, for example “four projectors 20 [that] project the exposure image RG **divided into four to form the projection image TG** at the

image formation position 28.” EX1005, [0043]. Sekine explicitly contemplates that a CPU may set a shaping region and “divide[] such into shaping regions of each projector 20,” where the CPU further “sets the exposure images of the photocuring resin material *for each shaping region* of the predetermined height increment of the projectors 20.” *Id.*, [0028]-[0029]. According to Sekine, the “present invention” of Sekine is provided with “first image projection means for projecting a first exposure image into the resin material from the incident surface [and] second image projection means for projecting a second exposure image **continuous with the first exposure image into the resin material from the incident surface.**” *Id.*, [0009]. It is clear to a POSITA that the invention of Sekine includes means such as a controller that controls the projection of the divided images and regions such that the corresponding areas are exposed “continuous[ly]” or simultaneously with one another. Chen ¶287.

Claim 14 – The method of claim 1, wherein the adjusting properties and aligning the position of each sub-image in the array further comprises applying the irradiance mask to each sub-image such that the composite image has a uniform irradiance range across the composite image.

As discussed above for claims 1[k], Sekine teaches splitting of an exposure image into multiple sub-images that “form the projection image.” EX1005, [0043]. Sekine further teaches that the “illumination” or “brightness” of a composite image can be non-uniform, and that such lack of uniformity is undesirable and can result in “gaps” or “streaks” due to “brightness differences between adjacent projection

images” or misalignment. *Id.*, [0070], [0099]. To address these variations, Sekine teaches normalizing irradiance “to eliminate the brightness difference between adjacent projection images” and “make the illumination distribution **uniform.**” *Id.*, [0070]-[0071]. Sekine further explains one way of doing so (at [0071]) and provides a flowchart in Figure 11 for such “illuminance correction control,” describing adjusting the light source for **each projector.** *Id.*, [0042]; Ground II, 1[1]. Sekine also teaches “it is necessary to correct positional displacement between adjacent projection images **and to make the light distribution uniform.**” EX1005, [0035]. A POSITA would understand that the adjustments being made—specifically to control irradiance to be the same at a sub-image level—would make uniform the irradiance across the composite image as a whole. Chen ¶289.

Claim 15 – The method of claim 1, wherein the adjusting properties and aligning the position of each sub-image in the array further comprises applying the irradiance mask to each sub-image to normalize irradiance non-uniformities within the image projection system arising from a projector-based spatial energy non-uniformity.

By “projector-based spatial energy non-uniformity,” a POSITA would understand the ’511 Patent to mean non-uniformities of irradiance energy caused by a projector, for example, “non-uniformities in the projector optics and/or optical path.” EX1001, 11:50-52; Chen ¶291. These non-uniformities are exactly the same as those accounted for in Sekine. As discussed above for claim 3, it is well understood that non-uniformities in the optics of projectors can cause illuminance

and/or alignment errors, and the correction of such errors is discussed at great length in Sekine, including in paragraphs [0108]-[0111]. Ground II, 3. Sekine also teaches that various actuators of the system of Sekine can be used to adjust optical elements of individual projectors to correct for displacement and angle errors at the sub-image level. EX1005, Figure 2, [0038]-[0042]; Chen ¶¶292-293.

Sekine provides a flowchart in Figure 11 for such “illuminance correction control” and specifically states that “it is necessary to correct positional displacement between adjacent projection images **and to make the light distribution uniform.**” *Id.*, [0035]. Indeed, Sekine explicitly states that the brightness gradation is controlled “to make the illumination distribution uniform,” in the same paragraph where Sekine discusses that there may be “illumination differences” from “(1) **performance differences** of the projection optical system 25 and (2) **performance differences of the light source.**” Thus, a POSITA would understand that the adjustments taught by Sekine correct irradiance non-uniformities within the image projection system arising from a projector-based spatial energy non-uniformity. Chen ¶¶291-293.

B. Motivation to Combine Sekine with Greene.

A POSITA would be motivated to combine Sekine and Greene. Chen ¶¶295-303. The '511 Patent states directly in the background the “problem” that exists in additive manufacturing with image projectors is that as layer size/pixel size

increases, the resolution decreases, and as such endeavors to *improve resolution and accuracy* in 3D printed products. EX1001, (Abstract, Background). Sekine and Greene are directed towards the same field of endeavor of “improving precision and accuracy in the formation of 3D printed products formed by light projection such as DLP.” *Id.* ¶296; EX1005, [0009], [0010]; EX1006, [0002], [0008]. Second, there are no teachings in the references that would “disparage or teach away” from the combination. Chen ¶298.

Importantly, the combination would lead to a reasonable expectation of success. Combining Sekine with Greene “would simply involve applying known techniques (i.e., gamma adjustment) to a known device ready for improvement (Sekine’s multi-projector 3D printing system) to yield predictable results (improved precision and accuracy in a 3D product, particularly with respect to the smoothness of the product itself).” Chen ¶302 (Sekine and Greene “would work together...operating as they are expected to function”). Lastly, Sekine and Greene are analogous art because they are in the same field as the ’511 Patent (“image projection based additive manufacturing”) EX1001, (Abstract) EX1005, 1:1-1; EX1006, [0003]. Furthermore, the ’511 Patent, Sekine, and Greene are all listed under International Classification B29C—shaping or joining of plastics.

X. GROUND 3: CLAIMS 1-8, 14, AND 15 ARE OBVIOUS OVER SHKOLNIK AND SEKINE.

A. Shkolnik and Sekine Disclose All Claimed Limitations

1. Claim 1

1[a]: A method comprising:

Shkolnik teaches this limitation in Ground I. Claim 1[a], EX1004, 4:22-23;

Chen ¶304.

1[b] a. providing an additive manufacturing system, comprising;

Shkolnik teaches this limitation in Ground I. Claim 1[b], EX1004, 4:22-23.

Chen ¶305.

1[c] an image projection system comprising a plurality of image projectors; and

Shkolnik teaches this limitation in Ground I. Claim 1[c], EX1004, 4:41-42;

7:56-57. Chen ¶306.

1[d] an image display subsystem;

Shkolnik teaches this limitation in Ground I. Claim 1[d], EX1001, claim 1;

EX1004, 7:10-22; 8:6-32; 11:23-35. Chen ¶308.

1[e] b. projecting a composite image onto a build area within a resin pool using the image projection system, wherein:

Shkolnik teaches this limitation in Ground I. Claim 1[e], EX1004, 5:9-14;

33:59-63. Chen ¶310.

1[f] the image projection system is controlled by the image display subsystem;

Shkolnik teaches this limitation in Ground I. Claim 1[f], EX1004, 7:10-22; 8:6-32; 7:18-22; 11:23-35. Chen ¶312.

1[g] the composite image comprises a plurality of sub-images arranged in an array;

Shkolnik teaches this limitation in Ground I. Claim 1[g], EX1004, 4:40-44; 5:9-14. Chen ¶314.

1[h] two or more adjacent sub-images in the array overlap at two or more sub-image edges; and

Shkolnik teaches this limitation in Ground I. Claim 1[h], EX1004, 33:45-34:14. Chen ¶316.

1[i] each sub-image is projected onto a portion of the build area using one of the plurality of image projectors; and

Shkolnik teaches this limitation in Ground I. Claim 1[i], EX1004, 5:9-14. Chen ¶318.

1[j] c. adjusting properties and aligning a position of each sub-image in the array using a set of filters comprising:

Shkolnik teaches this limitation in Ground I. Claim 1[j], EX1004, 2:9-11; 7:18-22; 10:44-46; 11:4-8; 14:51-53; 17:18-31; 2:22-26; 2:36-38; 5:38-53; 10:7-13; 14:26-31; 14:51-56; 15:36-57; 19:38-50; 20:2-11; 28:36-48; 32:40-63; Figures 1K, 1ME, 1MG, 1MFB, 1MGB, 1O, 1Q, 4A, 4B, 4C, 6. Chen ¶¶320-321.

1[k] an irradiance mask that normalizes irradiance;

Sekine teaches this limitation in Ground II. Claim 1[k], EX1005, [0042]; [0070], [0071], [0099]. Chen ¶¶323-325.

1[l] a gamma adjustment mask that adjusts sub-image energy based on a reactivity of resin in the resin pool;

Shkolnik teaches this limitation in Ground I. Claim 1[l], EX1001, 5:66-5:67; 12:9-12; EX1004, 7:18-22; 9:47-51; 9:51-55; 9:59-62; 10:22-26; 18:32-37; 18:37-42; 31:51-53. Chen ¶¶327-329.

1[m] a warp correction filter that provides geometric correction; and

Shkolnik teaches this limitation in Ground I. Claim 1[m], EX1004, 7:18-37; 31:51-53; 32:64-33:16; 33:18-45, Figure 6. Chen ¶¶331-332.

1[n] an edge blending bar at one or more sub-image edges.

Shkolnik teaches this limitation in Ground I. Claim 1[n], EX1001, 9:6-8; 10:30-35; EX1004, 4:40-44; 5:9-14; 7:18-22; 31:51-53; 33:45-34:14; 34:35-43. Chen ¶¶334-338.

2. **Claim 2 - The method of claim 1, wherein the image display subsystem controls the image projection system and each of the image projectors using digital light processing.**

Shkolnik teaches this limitation in Ground I. Claim 2, EX1004, 6:43-47; 7:10-22; 7:56-67; 8:6-32; 11:23-35. Chen ¶¶341-342.

3. **Claim 3 – The method of claim 1, wherein the irradiance mask additionally adjusts the energy across the build area to compensate for non-uniformities in optics of the plurality of image projectors.**

Sekine teaches this limitation in Ground II. Claim 3, EX1005, [0038]-[0042], [0073]. Chen ¶¶344-345.

4. **Claim 4 – The method of claim 1, wherein the gamma adjustment mask comprises a logarithmic relationship between a cure depth of the resin and energy per unit area in the build area.**

Shkolnik teaches this limitation in Ground I. Claim 4, EX1004, 10:22-26, Chen ¶¶347-348.

5. **Claim 5 - The method of claim 1, wherein the resin is selected from the group consisting of acrylates, epoxies, methacrylates, urethanes, silicone, vinyls, and combinations thereof.**

Shkolnik teaches this limitation in Ground I. Claim 5, EX1004, 5:17-24; 4:65-5:8. Chen ¶¶350.

6. **Claim 6 – The method of claim 1, wherein the edge blending bar comprises a blending distance and a function selected from the group consisting of: linear, sigmoid and geometric.**

Shkolnik teaches this limitation in Ground I. Claim 6, EX1004, 33:45-34:14, 34:53-64. Chen ¶352.

7. **Claim 7 – The method of claim 1, wherein the edge blending bar adjusts the one or more sub-image edges based on at least one layer boundary location within an object being manufactured.**

Shkolnik teaches this limitation in Ground I. Claim 7, EX1004, 4:22-4:34; 7:18-22; 26:15-33; 31:51-53; 34:2-4; 34:10-14; 34:35-38. Chen ¶¶354-357.

8. **Claim 8 – The method of claim 1, further comprising a system controller that synchronizes exposure control of the plurality of image projectors with each other.**

Shkolnik teaches this limitation in Ground I. Claim 8, EX1004, 4:48-52; 8:10-17; 35:33-35. Chen ¶359.

9. **Claim 14 – The method of claim 1, wherein the adjusting properties and aligning the position of each sub-image in the array further comprises applying the irradiance mask to each sub-image such that the composite image has a uniform irradiance range across the composite image.**

Sekine teaches this limitation in Ground II. Claim 14, EX1005, [0035]; [0042]; [0043]; [0070]-[0071]; [0099]. Chen ¶361.

10. **Claim 15 – The method of claim 1, wherein the adjusting properties and aligning the position of each sub-image in the array further comprises applying the irradiance mask to each sub-image to normalize irradiance non-uniformities within the image projection system arising from a projector-based spatial energy non-uniformity.**

Sekine teaches this limitation in Ground II. Claim 15, EX1001, 11:50-52, EX1005, [0035]; [0038]-[0042]; [0108]-[0111]; Figure 2. Chen ¶¶363-365.

B. Motivation to Combine Shkolnik with Sekine.

A POSITA would be motivated to combine Shkolnik and Sekine. Chen ¶¶367-377. The '511 Patent states directly in the background the “problem” that exists in additive manufacturing with image projectors is that as layer size/pixel size increases, the resolution decreases, and as such endeavors to *improve resolution and accuracy* in 3D printed products. EX1001, (Abstract, Background). Shkolnik and

Sekine are directed towards the same field of endeavor of “improving precision and accuracy in the formation of 3D printed products formed by light projection.” *Id.* ¶369. Second, there are no teachings in the references that would “disparage or teach away” from the combination. Chen ¶370. The combination of Shkolnik-Sekine would lead to a reasonable expectation of success as they are both focused on additive manufacturing, in particular photocuring a resin, along with methods and techniques of improving printed part accuracy. Combining Shkolnik with Sekine “would simply involve applying known techniques (i.e., normalizing irradiance in Sekine) to a known device ready for improvement (Shkolnik’s multi-projector 3D printing system) to yield predictable results (improved precision and accuracy).” Chen ¶¶376-377. Lastly, Shkolnik and Sekine are analogous art because they are in the same field as the ’511 Patent (“image projection based additive manufacturing”) EX1001, (Abstract) EX1004, 1:11-44; EX1005, [0005].

XI. GROUND 4: CLAIMS 9-12 ARE OBVIOUS IN LIGHT OF SEKINE-GREENE-JØRGENSEN.

As discussed above with respect to Ground 2, Sekine and Greene disclose all elements of independent claim 1. With respect to the remaining elements of claims 9-12 that depend therefrom, the combination of Sekine, Greene, and Jørgensen teach such elements, as discussed below.

A. Sekine and Greene and Jørgensen Disclosed All Claimed Limitations

1. **Claim 9 – The method of claim 1, wherein the projecting the composite image further comprises moving the plurality of sub-images during an exposure of a layer of an object being manufactured.**

Jørgensen teaches that an image may be “divided into” sub-images, such as the division of image 106 into sub-images 103, 104, and 105 in Figure 1. EX1028, [0013], FIG. 1; EX1028, [0015], FIG. 3.

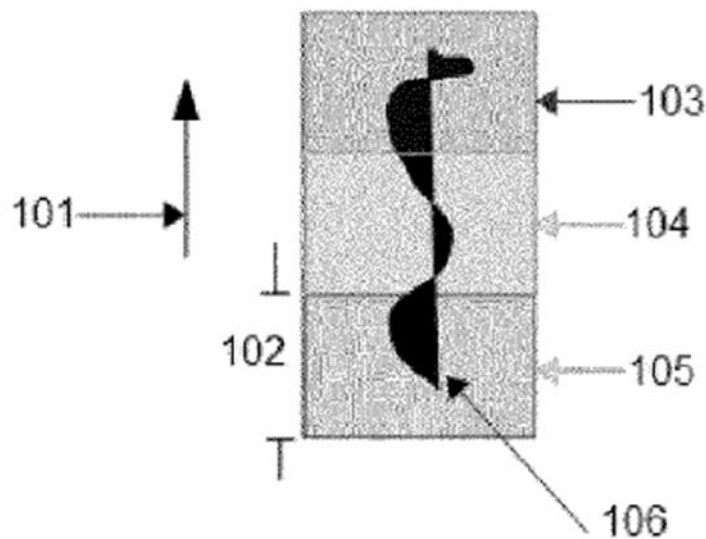


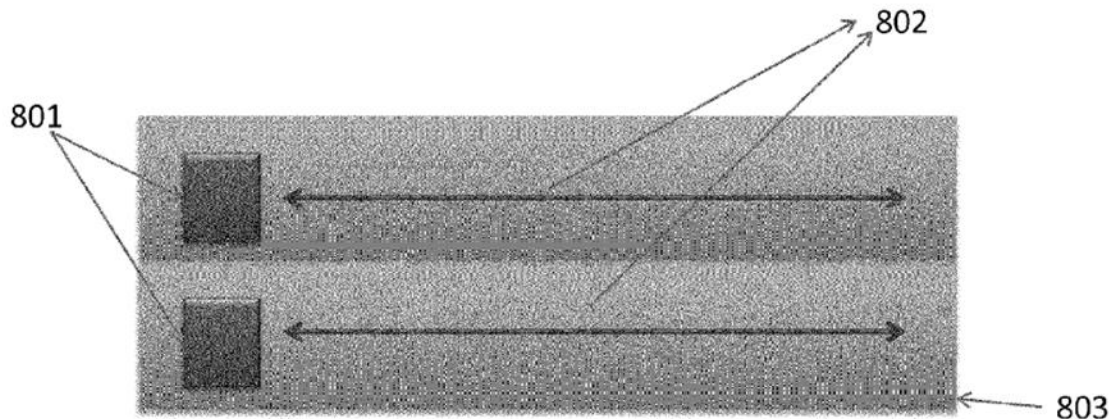
Fig. 1

Jørgensen further teaches that the sub-images can be moved during exposure of a layer. For instance, the projection system that produces the sub-images can “be moved relative to the material along the x axis back and forth over the material to be solidificated.” EX1028, [0009], FIG. 4. Jørgensen depicts the movement in several figures, for example in Figures 7, 8, and 9. In Figure 8 (below), each element “801” represents a “scrolling electronic light projector[.]” moving “relative to the light sensitive media 803” in the direction of an “x axis” denoted as “802.” Each “scrolling

light projector” in Figure 8 corresponds to a sub-image. EX1028, FIG. 8; Chen ¶379.

Thus, Jørgensen in view of Sekine and Greene render claim 9 obvious.

FIGURE#8

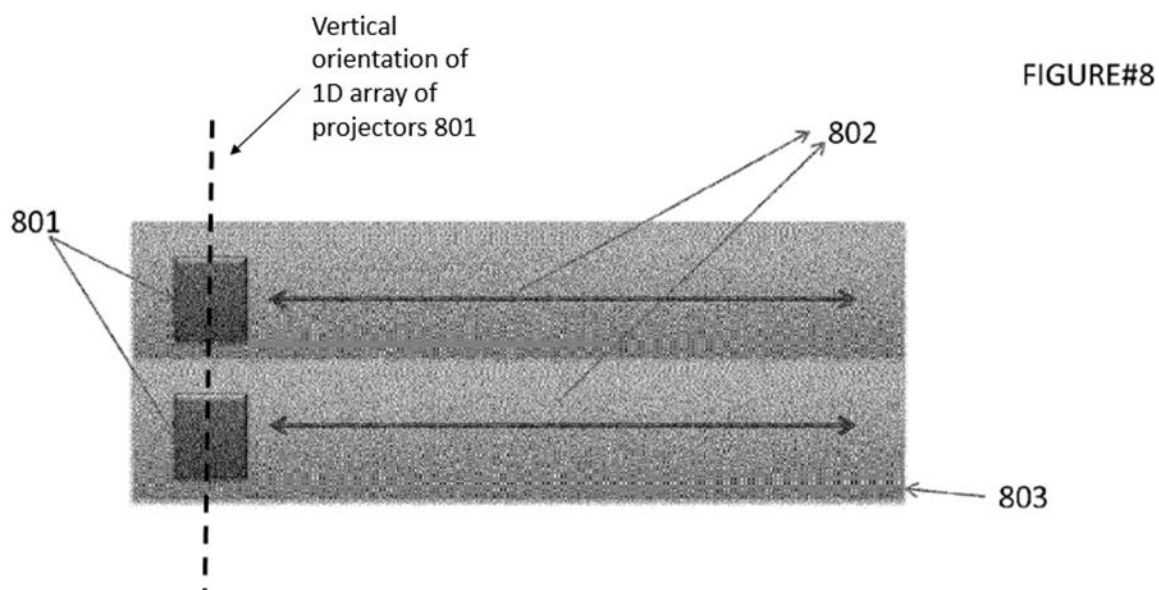


2. **Claim 10 – The method of claim 9, wherein the movement of the sub-images is either a step-expose-step type movement or a continuous movement.**

Jørgensen teaches that the movement of the sub-images is either a step-expose-step type movement or a continuous movement. Specifically, that to print a “large exposed pattern image,” the image may be divided into sub-images and exposed sequentially using a “**step and flash**” procedure, which is the same as a “step-expose-step” type of movement. EX1028, [0013]. Further, as an alternative to “step and flash,” a composite image may be printed “**in a continuous way**,” in which the “light projector is moving relative to the exposed [photopolymerizable] material” continuously, pixel-by-pixel. EX1028, [0015]; Chen ¶381. Thus, Jørgensen in view of Sekine and Greene render claim 10 obvious.

3. **Claim 11 -- The method of claim 9, wherein the plurality of sub-images comprises a 1D array of sub-images oriented in a first direction; and the movement of the sub-images is in a second direction perpendicular to the first direction.**

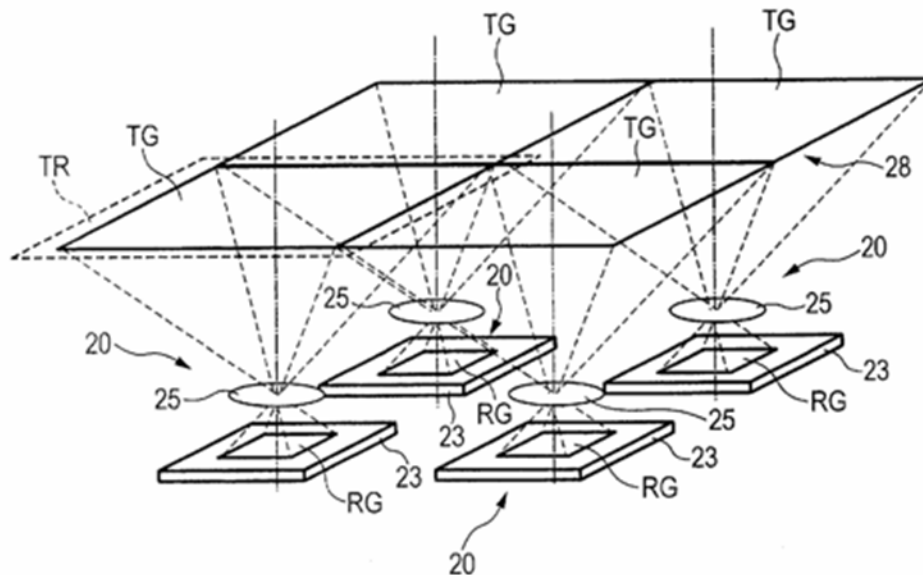
As taught above in claim 9, Jørgensen teaches a plurality of sub-images comprising a 1D array oriented in a first direction. Further, Jørgensen at Figure 8 depicts two vertically aligned “scrolling electronic light projectors 801.” EX1028, [0020], Figure 8. The projectors “move relative to the light sensitive media 803 back and forth along the x axis 802.” EX1028, [0020], FIG. 8. As depicted in Figure 8, the x-axis is perpendicular to the vertical orientation of the scrolling electronic projectors 801, where this vertical orientation can be represented by the dashed line superimposed below on Figure 8 of Jørgensen. Chen ¶383. Therefore, Jørgensen teaches the movement (arrows) of the sub-images is in a second direction perpendicular to the first (dashed line). EX1028, [0020], FIG. 8.



4. **Claim 12 – The method of claim 9, wherein the plurality of sub-images comprises a 2D array of sub-images with rows oriented along a first direction and columns oriented along a second direction; and the movement of the sub-images is in either one of the first or second directions, or both the first and second directions.**

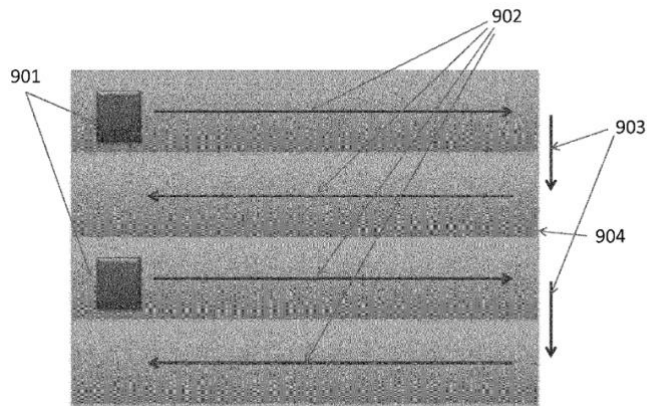
As discussed above with respect to claim 1, Sekine teaches that “multiple projectors” project multiple projection images, including “four projectors 20 [that] project the exposure image RG divided into four.” EX1005, [0043], and Figures 5, 6.

[FIG. 5]



Jørgensen teaches movement of multiple projectors, each producing a sub-image, for example, with reference to Jørgensen FIG. 9.

FIGURE#9



A POSITA would readily understand that moving the 2 x 2 array of Sekine in the manner taught by Jørgensen for projectors 901 (above) would necessarily result in the movement described in claim 12. Jørgensen specifically teaches that “to speed up the building process even further, one can add multiple light projectors ... assembled on the machine,” for example where “their motion is parallel along the x-axis.” EX1028, [0010]; Chen ¶388.

B. Motivation to Combine Sekine and Greene with Jørgensen, and Reasonable Expectation of Success

See Ground 2, there is appropriate motivation to combine Sekine and Greene with a reasonable expectation of success. A POSITA would also be motivated to combine Sekine-Greene with Jørgensen. Chen ¶¶391-398. The '511 Patent is concerned with improving resolution and part accuracy in AM systems utilizing image projection. EX1001, 1:25-36. Each of Sekine-Greene-Jørgensen are likewise directed towards improving resolution and accuracy of projection-based AM systems. EX1005, [0005]-[0008]; EX1006, [0008], [0031]; EX1028, [0001]-[0004].

Additionally, there are no teachings in the references that would “disparage” the combination. Chen ¶394.

Importantly, the combination would lead to a reasonable expectation of success. Combining Sekine-Greene with Jørgensen “would simply involve applying known techniques (*i.e.*, Jørgensen’s multi-projector movement) to a known device ready for improvement (*i.e.*, Sekine’s multi-projector 3D printing system modified with Greene’s gamma adjustment) to yield predictable results (*i.e.*, improved precision, accuracy, and efficiency in a 3D product, particularly with respect to accuracy over any size build area).” Chen ¶397. Sekine-Greene-Jørgensen “work together...operating as they are expected to function.” Chen ¶398. Lastly, Sekine-Greene-Jørgensen are analogous art because they are in the same field as the ’511 Patent (“image projection based additive manufacturing”) EX1001, (Abstract); EX1005, 1:1-1; EX1006, [0003]; EX1028, (Abstract). Furthermore, the ’511 Patent, Sekine-Greene-Jørgensen are all listed under International Classification B29C.

XII. GROUND 5: CLAIM 13 IS OBVIOUS IN LIGHT OF SEKINE-GREENE-JØRGENSEN IN FURTHER VIEW OF YI.

A. Sekine, Greene, Jørgensen and Yi Disclosed All Claimed Limitations

As discussed above with respect to Ground 4, Sekine and Greene and Jørgensen disclose all elements of independent claim 1 and dependent claim 9.

With respect to the remaining elements of claim 13 that depends therefrom, the combination of Sekine, Greene, Jørgensen, and Yi teach such elements, as discussed below.

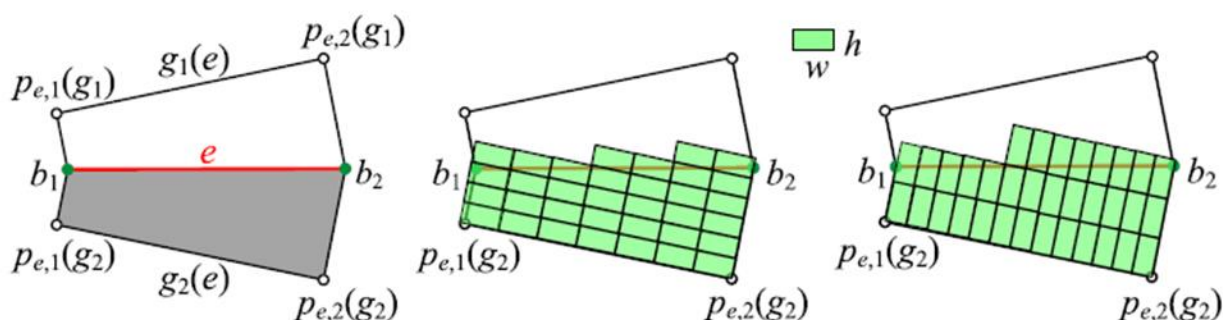
1. **Claim 13 – The method of claim 9, wherein the plurality of sub-images arranged in the array comprises one or more rows oriented along a first direction and one or more columns oriented along a second direction; and the movement of the sub-images is in a third direction that is different from both the first and second directions.**

As explained above, the combination of Sekine, Greene, and Jørgensen teaches the method of claim 9. Yi (EX1029) teaches the additional limitation of claim 13. Specifically, Yi teaches *movement in a third direction that is different from both the first and second directions*. Yi discloses a “new DLP system that allows the platform to move not only vertically (in *z*-axis) but also horizontally (in *x-y* plane).” EX1029, p.1194. In the Yi system, “[i]n addition to moving vertically (along *z*-axis), the working platform holding cured models can **move and rotate horizontally** (i.e., in the *x-y* plane).” EX1029, p.1194; Chen ¶401.

In the figures, Yi represents individual projected images as rectangles, where each such rectangle corresponds to “the maximal area that can be projected by a light source, which is a rectangular region in our delta DLP 3-D printer.” EX1029, p.1196, FIG. 4. Yi refers to each such rectangle as an “elementary rectangle.” *Id.* Yi further discloses “sets” or arrays of rectangles having multiple columns and rows. EX1029, p.1198, FIG. 7, FIG. 8 (green rectangles). Additionally, Yi teaches that “bigger

models are made by multiprojections for each layer.” EX1029, p.1202, FIGS. 13, 14; Chen ¶402.

Notably, the system of Yi is movable and rotatable in the x-y plane such that “the rectangles are allowed to be in **any orientation**,” when projected onto the curable material surface, and are not limited to having their “sides parallel to two orthogonal directions.” EX1029, p.1194. Yi depicts one example of such an off-axis orientation in FIG. 7 (reproduced below). EX1029, p.1198, FIG. 7; Chen ¶403.



Therefore, it is my opinion that Yi discloses the additional limitations of claim 13 of the '511 Patent.

B. Motivation to Combine Sekine, Greene, and Jørgensen with Yi and Reasonable Expectation of Success

See Ground 4, there is motivation to combine Sekine-Greene-Jørgensen with a reasonable expectation of success. There is further motivation to combine Yi. Each of Sekine, Greene, Jørgensen, and Yi are in a shared field of endeavor—DLP-based additive manufacturing systems that use light projection to cure photoactive materials. They are also directed towards the same purposes of improving efficiency

and accuracy in the formation of a 3D printed product formed by light projection on a resin. Given the nature of the problem and design needs in the industry to improve the accuracy and efficiency of printing—particularly across large building areas—it would be natural for a POSITA to look towards similar references with similar purposes, in the exact same field, to solve well-known problems. EX1005, [0006]; EX1006, [0031]; EX1028, [0006].

Yi seeks to address the very issue that the '511 Patent attempts to solve, “the resolution of projected masks is limited by the resolution of a projector,” such that a “project mask with a lower resolution will lead to a fabrication result with less geometric detail.” EX1029, p.1193; Chen ¶406. A POSITA would expect that the combination of Yi and the Sekine-Greene-Jørgensen references would allow a POSITA to address the very issues the '511 Patent attempts to solve.

A POSITA would have had a reasonable expectation that the techniques work together because the techniques disclosed are being used in their conventional ways. That is, a POSITA would have readily combined these references as these techniques were all known to improve precision and accuracy in 3D printing. Chen ¶413. Lastly, Sekine-Greene-Jørgensen and Yi are analogous art because they are in the same field as '511 Patent (“image projection based additive manufacturing”) EX1001, (Abstract); EX1005, [00005]; EX1006, [00007]; EX1028, [0002]-[0005]; EX1029, p. 1.

XIII. OBJECTIVE INDICIA OF NON-OBVIOUSNESS

There is no objective indicia that support the non-obviousness of the '511 Patent. Chen ¶415.

XIV. PAYMENT OF FEES – 37 C.F.R. § 42.103

The United States Patent Trademark Office is authorized to charge fees for this Petition to Deposit Account 08-0719.

XV. MANDATORY NOTICES UNDER 37 C.F.R §42.8(a)(1)

A. Real Party-In-Interest Under 37 C.F.R. §42.8(b)(1)

The real parties-in-interest are 3D System Corporation and 3D Systems, Inc. (Petitioner).

B. Related Matters Under 37 C.F.R. §42.8(b)(2)

Pursuant to 37 C.F.R. § 42.8(b)(2), to the best knowledge of Petitioner, the '511 Patent is or was involved, or affected by, the following cases:

Case	Number	Court	Filed	Status
<i>Intrepid Automation, Inc. v. 3D Systems Corporation et al.</i>	3-24-cv-02262	SDCA	Dec. 4, 2024	Active
<i>3D Systems Corporation and 3D Systems, Inc., v. Intrepid Automation, Inc.,</i>	Inter Partes Review (IPR) 2025-01241	USPTO	July 8, 2025	Active

--	--	--	--	--

C. Lead And Back-Up Counsel Under 37 C.F.R. § 42.8(b)(3)

Lead Counsel Bryan L. Baysinger Reg. No. 71,119 MAYNARD NEXSEN, PC 864-282-1117 bbaysinger@maynardnexsen.com	Backup Counsel John Zimmer Reg. No. 64,750 MAYNARD NEXSEN, PC 704-338-5372 jzimmer@maynardnexsen.com
Backup Counsel Ben Roxborough Reg. No. <i>Pro Hac Vice Forthcoming</i> MAYNARD NEXSEN, PC broxborough@maynardnexsen.com	

D. Service Information

Please address all correspondence to the lead counsel and backup counsel at the addresses shown above. Petitioner consents to electronic service by email.

E. Discretionary Denial is Not Warranted

The Board should not discretionarily deny the Petition, because the prior art was not of record, the grounds are compelling, the Petition was filed expeditiously, the parallel proceeding most recently added claims for patent infringement, and a case management conference has not set dates for a trial.

XVI. CONCLUSION

For the reasons set forth above, the Challenged Claims of the '511 Patent should be canceled.

CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24(d), Petitioner hereby certifies, in accordance with and reliance on the word count provided by the word-processing system used to prepare this Petition, that the number of words in this paper do not exceed 14,000. The word count excludes the table of contents, table of authorities, mandatory notices, certificate of service, certificate of word count, appendixes and any claim listings.

Dated: July 18, 2025

/Bryan L. Baysinger/
Bryan L. Baysinger
Lead Counsel for Petitioner
Reg. No. 71,119

CERTIFICATE OF SERVICE

The undersigned hereby certifies that the foregoing petition for *Inter Partes* Review, together with all exhibits and other documents filed herewith, was served by FEDEX on July 18, 2025, on the Patent Owner's counsel of record at the United States Patent & Trademark Office having the following address:

MLO Intellectual Property Law Firm

Attn: David Jackrel, PhD

9920 Pacific Heights Blvd Suite 150

San Diego, CA 92121

Dated: July 18, 2025

/Bryan L. Baysinger/
Bryan L. Baysinger
Lead Counsel for Petitioner
Reg. No. 71,119