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 2025-01241
U.S. Patent No. 11,014,301

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

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EXHIBIT LIST

Exhibit No.	Reference
1001	U.S. Patent No. 11,014,301 ("'301 Patent")
1002	Excerpts from the Prosecution History of the '301 Patent (the "Prosecution History"), including: • Non-Final Office Action dated October 6, 2020 • Examiner's Interview Summary dated December 1, 2020 • Response dated December 15, 2020 • Notice of Allowance dated January 15, 2021
1003	Yong Chen 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," *Proceedings of the 1992 International Solid Freeform Fabrication Symposium*, pages 196-211 ("Jacobs")
1008	C. Groth *et al.*, 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 *et al.*, "A new edge blending paradigm for multi-projector tiled display wall," *2010 International Conference on Computer Application and System Modeling* (ICCASM 2010), Taiyuan, 2010, pp. V5-349-V5-352, doi: 10.1109/ICCASM.2010.5620133
1011	Brown and Lowe, "Automatic panoramic image stitching using invariant features," *International Journal of Computer Vision*, 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," *CVPR 2011 WORKSHOPS*, Colorado Springs, CO, USA, 2011, pp. 29-36, doi: 10.1109/CVPRW.2011.5981726

1015	Harville *et al.*, "Practical Methods for Geometric and Photometric Correction of Tiled Projector," *2006 Conference on Computer Vision and Pattern Recognition Workshop (CVPRW '06)*, 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 *et al.*, "Digital Material Fabrication Using Mask-Image-Projection-Based Stereolithography," *Rapid Prototyping Journal*, Vol. 19(3), 2013
1026	Y. Chen *et al.*, "Hopping Light Vat Photopolymerization for Multiscale Fabrication," *Small*, Vol. 19(11), 2205784, 2023
1027	Y. Chen *et al.*, "Smooth Surface Fabrication Based on Controlled Meniscus and Cure Depth in Microstereolithography," *Journal of Micro- and Nano-Manufacturing*, Vol. 3, September 2015

’301 PATENT CLAIM LIMITATIONS

Claim	Limitation
1[a]	An additive manufacturing system, comprising:
1[b]	an image projection system comprising a plurality of image projectors that project a composite image onto a build area within a resin pool, wherein each of the image projectors projects a sub-image onto a portion of the build area, wherein the composite image comprises a plurality of sub-images arranged in an array, and wherein two or more adjacent sub-images in the array overlap at two or more sub-image edges;
1[c]	a display subsystem, wherein the display subsystem controls the image projection system and each of the image projectors to adjust properties and alignment of a position of each sub-image in the array; and
1[d]	a stack of filters configured to adjust the properties of each sub-image in the array, the stack of filters comprising:
1[e]	an irradiance mask configured to normalize irradiance;
1[f]	a gamma adjustment mask configured to adjust sub-image energy by mapping a plurality of pixel intensity levels to an addressable range of reactivity for curing resin of the resin pool, thereby reducing aliasing artifacts of curved or smooth surfaces;
1[g]	a warp correction filter configured to provide geometric correction; and
1[h]	an edge blending bar at one or more sub-image edges.
2	The additive manufacturing system of claim 1, wherein the plurality of pixel intensity levels comprises levels from 0 to 255.
3	The additive manufacturing system of claim 1, wherein the gamma adjustment mask further comprises a transfer function that maps an operating energy range of a printed layer to a control system operating range, wherein the control system operating range is a quantized set of values.
4	The additive manufacturing system 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 additive manufacturing system of claim 1, further comprising the resin pool, wherein the resin of the resin pool is selected from a group consisting of acrylates, epoxies,

	methacrylates, urethanes, silicone, vinyls, and combinations thereof.
6	The additive manufacturing system of claim 1, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 1% to 5%.
7	The additive manufacturing system of claim 1, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 50% to 100% to increase a local power within the composite image.
8	The additive manufacturing system of claim 1, wherein the warp correction filter corrects skew in projected images that are caused by variation in alignment within the build area.
9	The additive manufacturing system of claim 1, wherein the warp correction filter corrects skew in projected images that are caused by variation in projector optics.
10	The additive manufacturing system of claim 1, wherein the edge blending bar comprises a blending distance and a function selected from a group consisting of linear, sigmoid and geometric.
11[a]	A method comprising:
11[b]	a. providing an additive manufacturing system, comprising:
11[c]	an image projection system comprising a plurality of image projectors; and
11[d]	an image display subsystem;
11[e]	b. projecting a composite image onto a build area within a resin pool using the image projection system, wherein:
11[f]	the image projection system is controlled by the image display subsystem;
11[g]	the composite image comprises a plurality of sub-images arranged in an array;
11[h]	two or more adjacent sub-images in the array overlap at two or more sub-image edges; and
11[i]	each sub-image is projected onto a portion of the build area using one of the plurality of image projectors; and
11[j]	c. adjusting properties and aligning a position of each sub-image in the array using a set of filters comprising:
11[k]	an irradiance mask that normalizes irradiance;
11[l]	a gamma adjustment mask that adjusts sub-image energy by mapping a plurality of pixel intensity levels to an addressable

	range of reactivity for curing the resin of the resin pool, thereby reducing aliasing artifacts of curved or smooth surfaces;
11[m]	a warp correction filter that provides geometric correction; and
11[n]	an edge blending bar at one or more sub-image edges.
12	The method of claim 11, wherein the plurality of pixel intensity levels comprises levels from 0 to 255.
13	The method of claim 11, wherein the gamma adjustment mask further comprises a transfer function that maps an operating energy range of a printed layer to a control system operating range, wherein the control system operating range is a quantized set of values.
14	The method of claim 11, 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.
15	The method of claim 11, wherein the resin is selected from a group consisting of acrylates, epoxies, methacrylates, urethanes, silicone, vinyls, and combinations thereof.
16	The method of claim 11, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 1% to 5%.
17	The method of claim 11, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 50% to 100% to increase a local power within the composite image.
18	The method of claim 11, wherein the warp correction filter corrects skew in projected images that are caused by variation in alignment within the build area.
19	The method of claim 11, wherein the warp correction filter corrects skew in projected images that are caused by variation in projector optics.
20	The method of claim 11, wherein the edge blending bar comprises a blending distance and a function selected from a group consisting of linear, sigmoid and geometric.

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 1–20 of U.S. Patent No. 11,014,301, titled, *Multiple image projection system for additive manufacturing* ("**'301 Patent**")—issued on May 25, 2021. Three grounds support the Petition based on 35 U.S.C. §§ 102-103, all of which were not before the examiner.

The '301 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 '301 Patent in particular focuses on digital light processing ("DLP") systems, which utilize light projection to cure photoactive resins. Id. at 4:5-7.

As the '301 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 the independent claims of the '301 Patent exist four techniques to improve printing resolution— (1) "normalizing irradiance," (2) "gamma adjustment," (3) "warp correction," and (4) "edge blending." The independent

system and method claims are nearly identical. The remaining dependent claims also fail to add novelty and merely serve to claim scientific principles fundamental to the curing of photoactive resins.

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 1-20 of the '301 Patent—with the use of idiosyncratic words or phrases to describe existing technology. Indeed, the techniques described in the '301 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 '301 Patent. Critically, however, the Patent Owner relied on a **single technique** as the alleged **point of novelty** for obtaining allowance of the '301 Patent— "a gamma adjustment mask. . .to adjust sub-image energy by mapping. . .**pixel intensity** levels to an addressable **range of reactivity for curing resin of the resin pool** … reducing aliasing artifacts of curved or **smooth surfaces**." EX1001, Claim1.

Both Shkolnik and Greene teach this limitation. Greene—which is directed to additive manufacturing using photocurable resins—teaches a "**gamma correction**" process that adjusts pixel "**intensity levels**" based on "a **nonlinear characteristic of the photoactive resin**" to cure the resin for the purpose of improving printing precision and accuracy, including smoothness. EX1006, [0008],

[0037]-[0040], [0047]. Greene expressly teaches that this "**gamma correction**" process "can adjust" energy and pixel "intensity levels" (id. [0040]) when applied to "different photoactive resins" that "require" … different curing intensities," (id. [0037])—thereby "**smooth[ing] out edges** in three-dimensional printing." Id. [0008]; see also Id., [0047] ("[T]he process generates containment degrees for the finalized pixels … [where], the intensity levels are **gamma corrected** based on nonlinearities associated with the printer's projection system, **resin**, or both.").

Three grounds support invalidating the '301 Patent:

Ground 1. This ground is based on Shkolnik, which teaches all four techniques and anticipates claims 1-20 of the '301 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.

Ground 3. This ground is based on Shkolnik together with Sekine. As will be shown in Ground 1, Shkolnik anticipates the '301 Patent, and Sekine further covers the irradiance filter in greater detail.

Notably, none of these references were considered by the USPTO during the prosecution of the '301 Patent.

II. REQUIREMENTS FOR STANDING

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

Petitioner certifies that the '301 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 1-20 of the '301 Patent be canceled based on the following grounds:

Ground	Claims	Basis for Rejection
§ 102 – Ground 1	1-20	Anticipated by Shkolnik
§ 103 – Ground 2	1-20	Obvious over Sekine + Greene
§ 103 – Ground 3	1-20	Obvious over Shkolnik + Sekine

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.

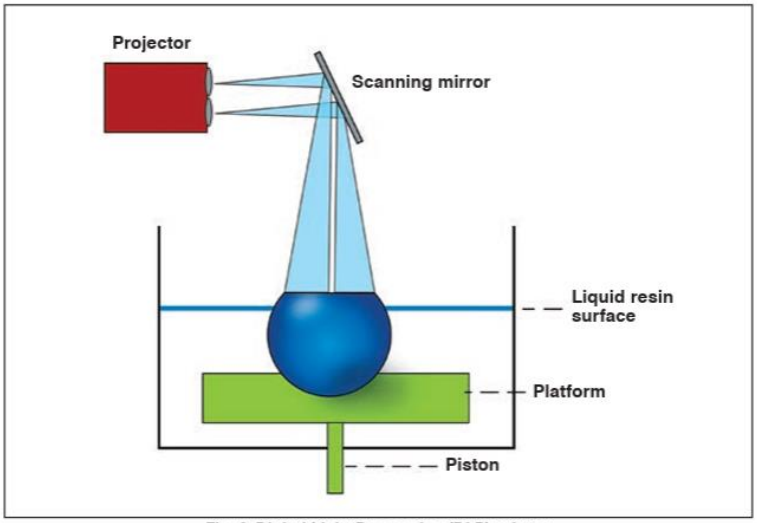


Fig. 3 Digital Light Processing (DLP) printer.

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 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 from 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" refers to the amount of light that strikes a surface over a given area, such as a square centimeter of liquid 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 "spot" 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.

Therefore, when multiple DLP projectors are used there is an almost infinite number of possible variations. This common problem has been addressed for many years by "normalizing" the irradiance. One way to conceptualize irradiance normalization is to "take 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.

"Grayscaling" and "anti-aliasing" both relate to smoothness of surfaces. Pixels are generally square-shaped 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. "Grayscaling" 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 '301 PATENT

A. Earliest Possible Effective Filing Date

The earliest possible effective filing date is **July 30, 2018.** '301 Patent.

B. Overview of the '301 Patent

The ’301 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, 1:38-41; FIGS 1A, 1E, 1G; Chen ¶¶61-63. The composite image is formed from a “plurality of sub-images arranged in an array.” ’301 Patent, 1:41-44. 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.*, 4:12-16.

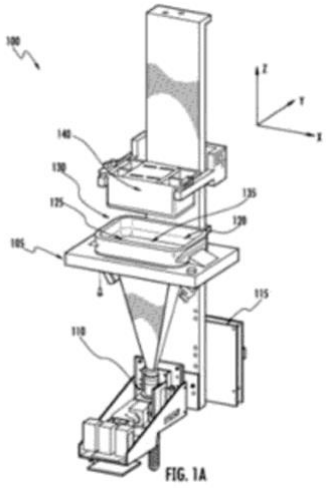


FIG. 1A

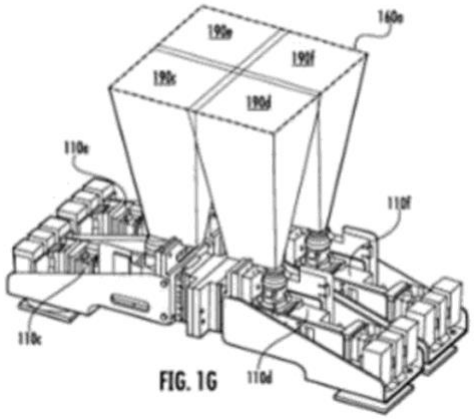


FIG. 1G

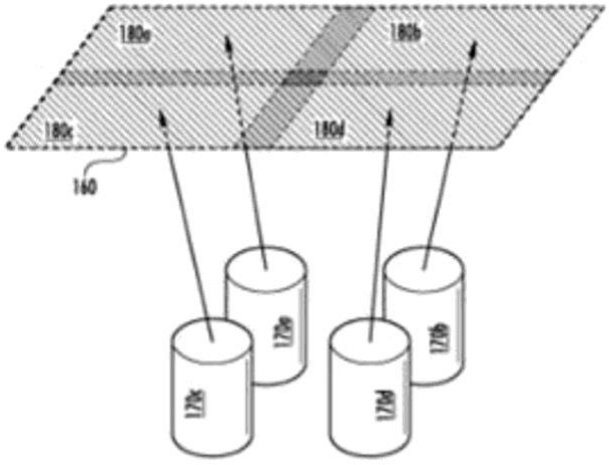


FIG. 1E

The ’301 Patent purports to address inaccuracies related to 3D printing systems including (1) “normalizing irradiance,” (2) “gamma adjustment,” (3) “warp correction,” and (4) “edge blending.” To account for the various inaccuracies, and without limiting these concepts, the ’301 Patent provides examples of what the four filters account for (i.e., their general purpose). Chen ¶63.

C. Summary of the Prosecution History

On October 6, 2020, the examiner rejected independent claims 1 and 11, among others, based on obviousness. Several references were cited to support the rejection. EX1002, Prosecution History (Non-Final Office Action dated October 6, 2020, p.2). The Patent Owner traversed the rejection during an examiner interview. Id. (Examiner’s Interview Summary dated December 7, 2020, p.2).

On January 15, 2021, the examiner noted in the Notice of Allowance and reasons for allowance that the prior art of record did not “**teach the gamma adjustment mask**.” EX1002, Prosecution History (Notice of Allowance dated January, 15, 2021, p.2). The ’301 Patent issued on May 25, 2021.

Notably, the prior art references at issue here—Shkolnik, Sekine and Greene—were not before the USPTO during prosecution of the ’301 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 ¶63. Professor Chen meets this definition regarding the level of ordinary skill in the art. 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 that the claims are no indefinite 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, cover. This date precedes the earliest priority date of the '301 Patent (July 30, 2018). EX1001, cover. Shkolnik is in the "same field of endeavor as the '301 Patent and is reasonably pertinent to the problems encountered

in 3D printing (additive manufacturing) using light projection and photocurable resins." Chen ¶90.

Shkolnik is directed towards a system used for increasing accuracy in making 3D components using either (1) a single pattern generator; or (2) a multiple pattern generator. EX1004, abstract; Chen ¶¶90-92. The multiple pattern generator system is identical to the '301 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 '301 Patent. Sekine is in the "same field of endeavor as the '301 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 ¶107.

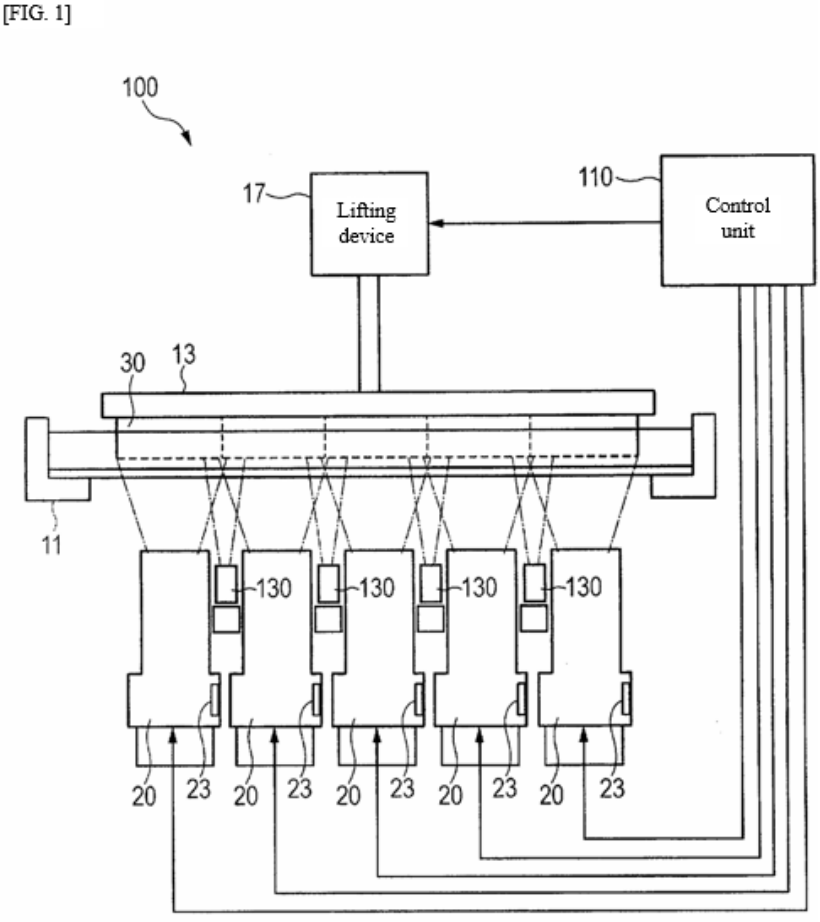
Sekine is a PCT application originally filed and published in Japanese. The original Japanese-language application has been translated by Eric Vance of Sun IP. Mr. Vance has over 9 years of professional translation experience, JLPT N1 Certification, OPI advanced high certification, and BS/BA degrees in Physiology

and Japanese. EX1005 (Japanese version (Exhibit A) and English version (Exhibit B) to the declaration of Eric Vance).

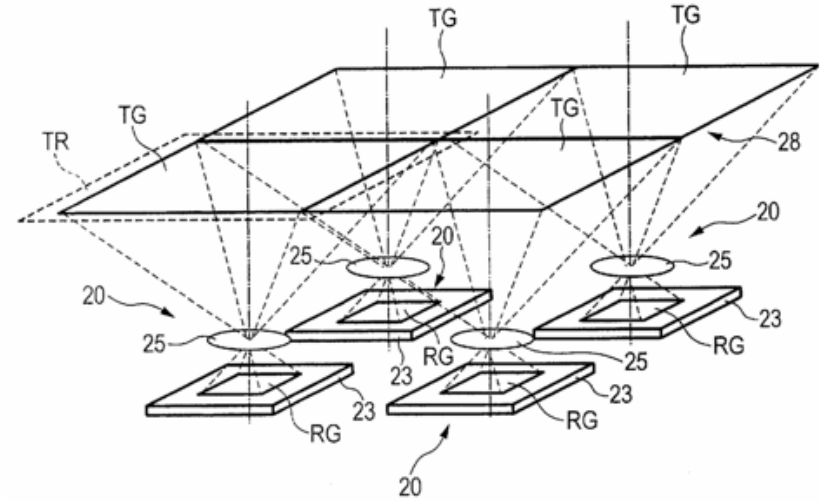
Sekine is directed towards a system that is used for increasing accuracy in making 3D components using a multiple projector system. EX1005, [0005]-[0009]; Chen ¶109. Sekine discloses three of the four filters:

FIG. 1 depicts a diagram of the configuration of the three-dimensional projector system—which is "arranged in a 5×5 configuration to create a shaped product 30." EX1005, [0014], [0017]; Chen ¶110. See also EX1005, Figure 5.

[FIG. 1]



[FIG. 5]



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 '301 Patent. Compare EX1006, cover; EX1001, cover.

Greene is in the same field of endeavor as the '301 Patent and is reasonably pertinent to the problems encountered in AM using light projection and photocurable resins and is, therefore, relevant prior art.

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 ¶125. 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 ¶126. 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.

VIII. GROUND 1: CLAIMS 1-20 ARE ANTICIPATED BY SHKLONIK

Claims 1-20 of the '301 Patent are anticipated by Shkolnik. EX1004; Chen ¶¶138-218.

A. Shkolnik Discloses All Claimed Limitations

1. Claim 1

1[a] An additive manufacturing system, comprising:

To the extent the preamble is limiting, Shkolnik discloses systems and methods for AM. EX1004, 4:22-23; Chen ¶138.

1[b] an image projection system comprising a plurality of image projectors that project a composite image onto a build area within a resin pool, wherein each of the image projectors projects a sub-image onto a portion of the build area, wherein the composite image comprises a plurality of sub-images arranged in an array, and wherein two or more adjacent sub-images in the array overlap at two or more sub-image edges;

Shkolnik teaches an **image projection system** that includes one or more **image projectors**, such as one or more digital light processing or "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 (denoted as 110 in Figure 1A), below. EX1004, Fig. 1A; Chen ¶139.

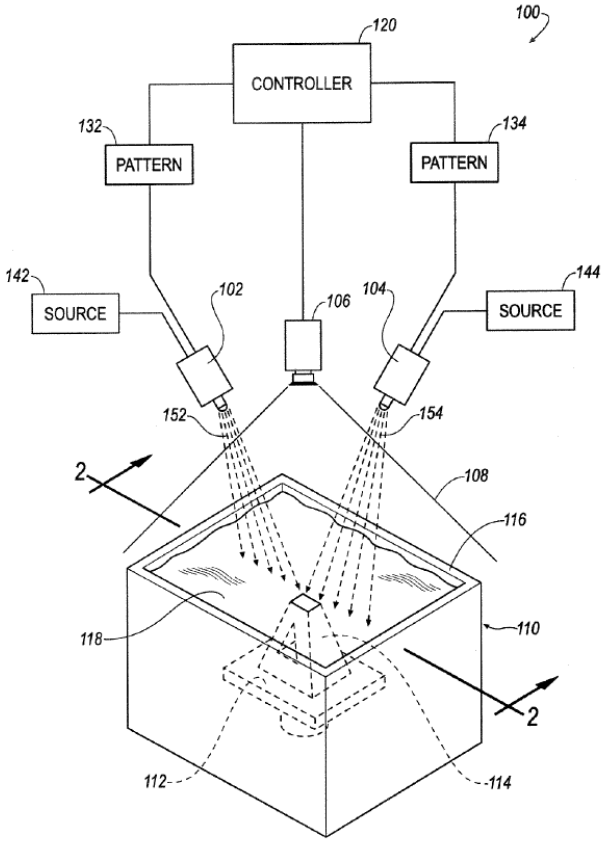


FIG. 1A

Shkolnik further teaches that the individual patterns or **sub-images** provided by the individual image projectors or pattern generators (denoted as 712' and 712" in Figure 7A) **can together form a composite image** (denoted as 712 in Figure 7A, referring to the complete image of the rabbit). The adjacent sub-images 712' and

712" in Figure 7A overlap at two edges of the sub-images (e.g., at edges 722/726 and 732/736 in Figure 7A, forming overlap portions 728 and 738). EX1004, Fig. 7A. Moreover, 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 Figure 4C and Figure 7A of Shkolnik. EX1004, Fig. 4C; Chen ¶139.

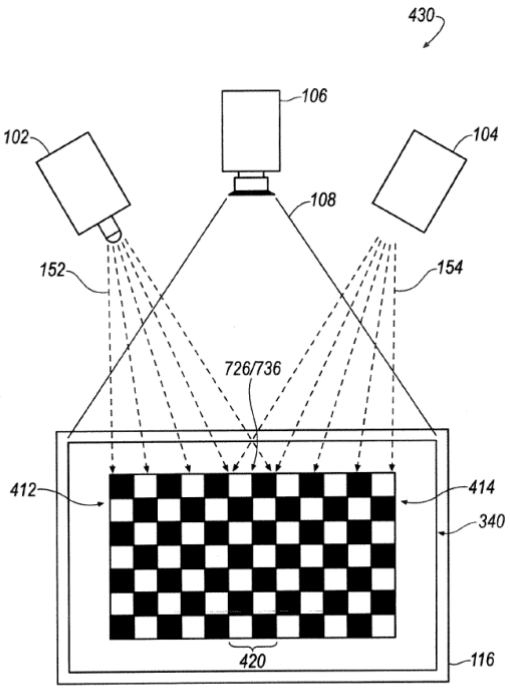


FIG. 4C

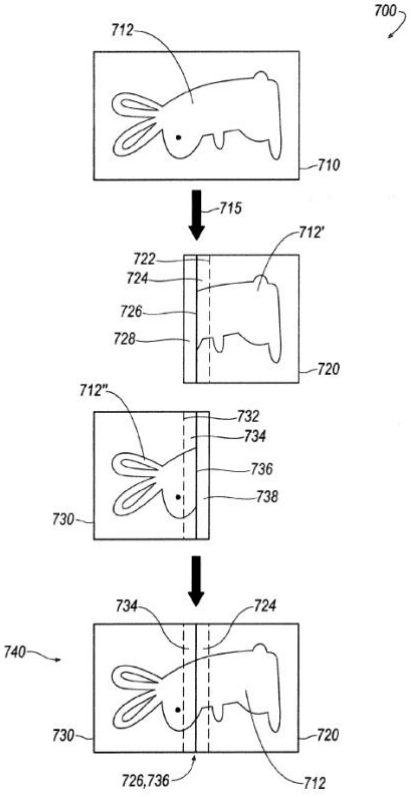


FIG. 7A

1[c] a display subsystem, wherein the display subsystem controls the image projection system and each of the image projectors to adjust properties and alignment of a position of each sub-image in the array; and

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 ¶140. 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. 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 ¶140.

1[d] a stack of filters configured to adjust the properties of each sub-image in the array, the stack 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 ¶142. 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 ¶142.

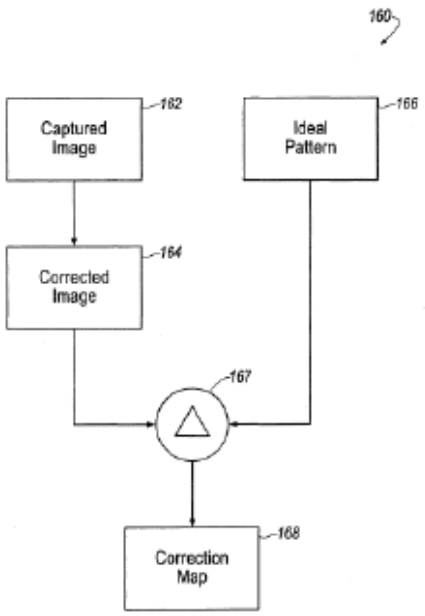


FIG. 1K

Furthermore, FIG. 1K in Shkolnik is illustrative of a generalized correction map generation system. EX1004, Fig. 1K; Chen ¶142.

1[e] an irradiance mask configured to normalize irradiance;

Shkolnik teaches **adjusting** sub-image **irradiance** to an "**ideal**," "**standard**," "**compensation**," level, of which a POSITA would recognize as normalizing irradiance or intensity. EX1004, 16:5-13. 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", of which a POSITA would understand as irradiance compensation, or normalizing irradiance. EX1004; 5:38-49; Chen ¶¶144-147.

Furthermore, this normalization technique is disclosed in Shkolnik as the brightness or irradiance and the exposure time which "may be parameters for the bitmap [digital information] … that may modified to produce the desire total exposure value." EX1004, 10:7-14; Chen ¶146. The irradiance parameter is then assigned 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." EX1004, 9:47-51; Chen ¶146.

1[f] a gamma adjustment mask configured to adjust sub-image energy by mapping a plurality of pixel intensity levels to an addressable range of reactivity for curing resin of the resin pool, thereby reducing aliasing artifacts of curved or smooth surfaces;

90. Shkolnik teaches a process that leads to reduced aliasing artifacts and a "**smooth surface**", which is known by a POSITA as gamma adjustment. EX1004, 26:15-33; Chen ¶¶148-153. In Shkolnik each pixel in a sub-image is assigned an "**intensity value**." EX1004; 9:47-51. For example, Shkolnik teaches that for an 8-bit system "intensity ranges of 0 to 255 are convenient." EX1004; 9:59-62. The '301 Patent itself provides that the purpose of the "gamma correction filter" is to "enable[] correct smoothing (and/or antialiasing) of pixels by mapping the pixel intensity range (e.g., 0-255) to the minimum and maximum reactivity characteristics of the pixel. EX1001, 12:6-10; Chen ¶152. 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; EX1004, 18:32-37. Further, Shkolnik teaches that when a resin (such as "reactive material 118") "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; Chen ¶ 149.

Lastly, 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**: A detailed example of pixel correction, including intensity modification is shown below with respect to FIGS. 1MA-1MG. EX1004, Figs. 1MA-1MG. The "gamma adjustment" process in Shkolnik is consistent with a POSITA's understanding of the ordinary and customary meaning of the term *gamma adjustment* as crafted in the '301 Patent—which similarly accounts for the "different resin formulations" and the "different curing times" of different resins as energy is applied. EX1001, 5:60-67; Compare Chen ¶151 with ¶¶79-81.

1[g] a warp correction filter configured to provide geometric correction; and

Shkolnik specifically discloses that geometric distortion is "commonly associated with optical systems" that include multiple pattern generators (e.g., DLP

devices), such as pattern generators. EX1004, 32:64-33:10, FIGS. 5A-5C; Chen. ¶155. Shkolnik Figures 5A and 5B are illustrative of such uncompensated distortion (barrel and pincushion distortion, respectively).

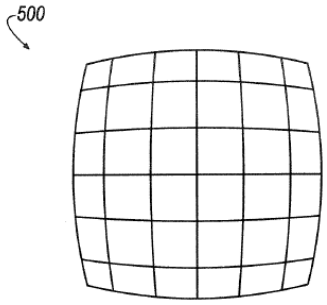


FIG. 5A

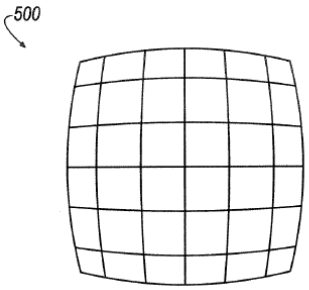


FIG. 5A

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 ¶155. 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 ¶155.

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

The '301 Patent fails to define what an edge blending bar is, rather it points to a frame in Fig. 2A that has cross hatching near the edges. EX1001, Fig. 2A. Therefore, we refer to Professor Chen a POSITA who interprets an 'edge blending

bar' to be just 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 ¶¶156-157. 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. Specifically, Shkolnik teaches that "the intensity of pixels from pattern generators that account for overlap pixel region may be reduced in intensity (e.g., 50% from each pattern generator) to reduce over-exposure of reactive material at overlap portions" EX1004, 34:10-14; Chen ¶158.

2. **Claim 2 - The additive manufacturing system of claim 1, wherein the plurality of pixel intensity levels comprises levels from 0 to 255.**

Shkolnik discloses that the plurality of pixel intensity levels—specifically teaching that "[f]or example, the electromagnetic radiation may have an intensity range scaled from zero (the minimum) to 255 (maximum)." EX1004, 9:21-23, 9:60-62; Chen ¶162.

3. **Claim 3 – The additive manufacturing system of claim 1, wherein the gamma adjustment mask further comprises a transfer function that maps an operating energy range of a printed layer to a control system operating range, wherein**

the control system operating range is a quantized set of values.

Shkolnik teaches that "the time and intensity to achieve a particular depth of cure is material dependent," and that "the percent intensity value assigned to a voxel" is likewise material dependent. EX1004, 10:22-26; 18:32-37; Chen ¶163.

Specifically, Shkolnik teaches that "a bitmap may be used by a controller to make calibrations and corrections (such as gamma corrections) on a voxel-by-voxel (or pixel-by-pixel) basis." EX1004, 5:54-6:22; 7:10-22; 8:6-32,23:17-30 and Figure 1K; Chen ¶164. Thus, Shkolnik teaches a transfer function of a bitmap mapping the pixels of a printed area. According to Shkolnik, "[t]he bitmap two-dimensional information may be a typical x/y location for a pixel (whether inherent to the file format or having specified locations)." EX1004, 6:23-25. Further, Shkolnik teaches that "the grayscale value may be used to control a pattern generator's output to provide full intensity, no output, or variations in between." EX1004, 6:25-51; Chen ¶164. Moreover, Shkolnik teaches that the grayscale values are quantized pixel intensity values of the system. EX1004, 9:47-62; Chen ¶164.

4. **Claim 4 – The additive manufacturing system 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 a gamma adjustment mask, being a mask that that necessarily includes "the time and intensity to achieve a particular depth of cure is

material dependent." EX1004, 10:22-26; Chen ¶165. Thus, a POSITA would find it is inherent in the working principles of time and intensity (gamma adjustment) that a logarithmic relationship would form. Chen ¶165. 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 additive manufacturing system of claim 1, further comprising the resin pool, wherein the resin of the resin pool is selected from a 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, 4:65-5:8; Chen ¶167.

6. **Claim 6 – The additive manufacturing system of claim 1, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 1% to 5%.**

As noted above in claim 1 (edge blending bar), Shkolnik teaches that the images or patterns of an array of image projectors or pattern generators can overlap. EX1004, 33:45-34:14, Fig. 4C, 7A; Chen ¶168.

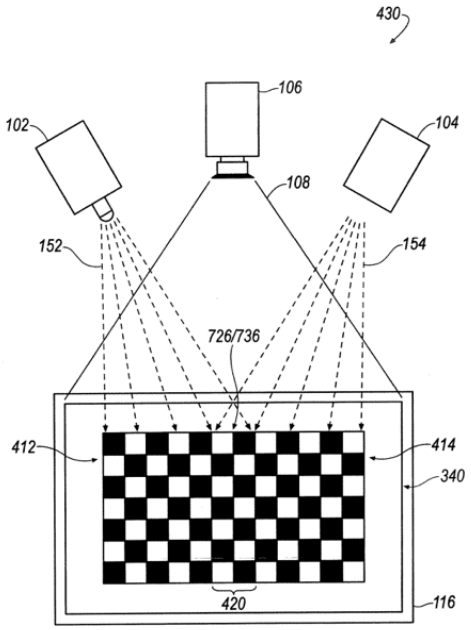


FIG. 4C

Shkolnik teaches that the "overlap regions" or "overlap portions" 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; Chen ¶168.

7. **Claim 7 – The additive manufacturing system of claim 1, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 50% to 100% to increase a local power within the composite image.**

Shkolnik teaches that the "images or patterns of an array of image projectors or pattern generators can overlap to form a composite image." EX1004, 33:45-34:14; Chen ¶169. Shkolnik teaches that an overlap region may be generated by only one pattern generator or by "both pattern generators" in a given instance. EX1004, 34:15-22. When both pattern generators are used to generate an overlap region, Shkolnik teaches that the effect of the overlap can be local "over exposure," and such over exposure, if desired, can be mitigated (or not) by reducing the intensity output "so that the combined intensity is standard." Id.

8. **Claim 8 – The additive manufacturing system of claim 1, wherein the warp correction filter corrects skew in projected images that are caused by variation in alignment within the build area.**

Shkolnik teaches that pattern generators (DLP devices) can be adjusted for distortion, such as distortion caused by defects in micro-mirrors or other optical elements. EX1004, 7:23-37; Chen ¶170. Further, Shkolnik informs of correcting for mechanical misalignment, malformed lenses or mirrors, or changes in hardware caused by heating/cooling. EX1004, 7:23-31.

9. **Claim 9 – The additive manufacturing system of claim 1, wherein the warp correction filter corrects skew in projected images that are caused by variation in projector optics.**

Shkolnik teaches that mechanical misalignment, misaligned or malformed lenses or mirrors, or changes in hardware caused by heating/cooling "may impart

geometric distortion (e.g., where an expected straight line may be curved)." EX1004, 7:23-31; Chen ¶172.

10. **Claim 10 – The additive manufacturing system of claim 1, wherein the edge blending bar comprises a blending distance and a function selected from a group consisting of linear, sigmoid and geometric.**

Shkolnik teaches that sub-images or patterns can overlap, including at their edges. EX1004, 33:45-34:14; Chen ¶173. Further, Shkolnik 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; Chen ¶173. Edge blending or "fading" of overlap regions is described in significant detail by Shkolnik, such as with reference to Figures 4 and 7. Chen ¶173. Moreover, with reference once again to Figure 7, Shkolnik teaches that the "fading effect" created by the edge blending of Shkolnik can "use a linear interpolation algorithm to reduce intensity such that when overlapped, the combined intensity is the same as the original image." EX1004, 34:53-64; Chen ¶173.

11. **Claim 11**

11[a] A method comprising:

Claims 11-20 are mirror image method claims of 1-10. Shkolnik is directed to both systems and **methods** for AM. EX1004, 4:22-23.

11[b] a. providing an additive manufacturing system, comprising:

Shkolnik is directed to systems and methods for AM. EX1004, 4:22-23; Chen. ¶175.

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

See discussion in Ground I, claim 1[b] above. Shkolnik teaches a system having an image projection system that includes one or more image projectors, such as one or more DLP devices. EX1004, 4:40-44. Such image projectors are sometimes referred to as "pattern generators" in Shkolnik. EX1004, 4:41-42; Chen. ¶176.

11[d] an image display subsystem;

See discussion in Ground I, claim 1[c] above. Shkolnik 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. Such a "controller" is denoted as element 120 in Figure 1A, and such an "imager" is denoted as element 106 in Figure 1A.

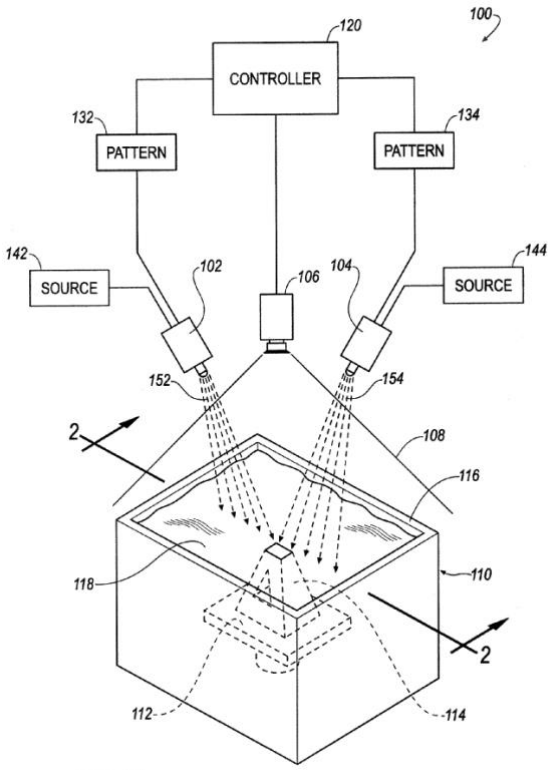


FIG. 1A

Additionally, Shkolnik teaches that the imager 106 "may be used for initial alignment and adjustment of pattern generators or for real-time, or near real-time, adjustment." EX1004, 11:23-35.

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

See discussion in Ground I, claim 1[b] above. The image projectors "pattern generators" of Shkolnik each project an image onto a reactive material, such as a container or build area of photopolymerizable resin. EX1004, 5:9-14; Chen ¶178.

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

See discussion in Ground I, claim 1[c] above. 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; Chen. ¶179.

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

See discussion in Ground I, claim 1[b] above. As shown in Figure 7A, Shkolnik teaches that the individual patterns or "sub-images" provided by the individual image projectors can together form an overall or composite image. EX1004, Fig. 7A; Chen. ¶181.

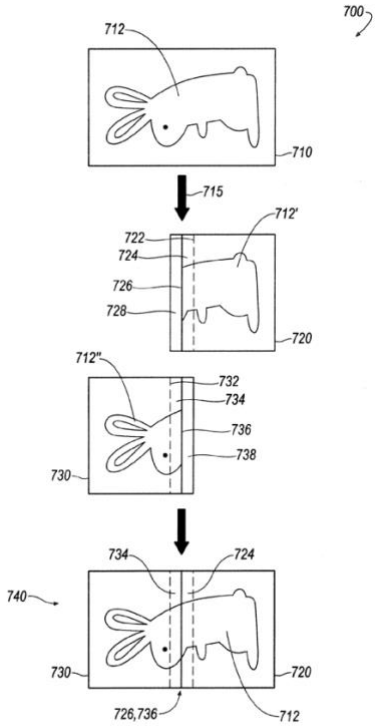


FIG. 7A

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

See discussion in Ground I, claim 1[b] above. Shkolnik teaches that the images or patterns of an array of image projectors can overlap, including at their edges. EX1004, 33:45-34:14; Chen. ¶182. Such an overlap is illustrated, for example in Figure 4C and Figure 7A of Shkolnik. EX1004, Fig. 4C, 7A.

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

See discussion in Ground I, claim 1[b] above. 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. ¶183.

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

See discussion in Ground I, claim 1[d] above. Shkolnik teaches that pattern generators produce "patterns", and that such "patterns" can be "bitmaps (digital information), physical masks (physical patterns), electronic masks (e.g., LCD or transmissive active masks), or other types of information, media, or device(s) that define a pattern." EX1004, 10:44-46; 11:4-8. Moreover, Shkolnik teaches that the patterns or sub-images produced by an array of pattern generators can be corrected or "fixed" in various ways, such as to provide positional compensation and intensity compensation. Id. 14:51-53; 17:24-27; Chen. ¶¶184-186

11[k] an irradiance mask that normalizes irradiance;

See discussion in Ground I, claim 1[e] above. Shkolnik teaches adjusting sub-image irradiance to an "ideal," "standard," "compensation," level, of which a POSITA would recognize as normalizing irradiance or intensity. EX1004, 16:5-13; Chen ¶187-190.

11[l] a gamma adjustment mask that adjusts sub-image energy by mapping a plurality of pixel intensity levels to an addressable range of reactivity for curing the resin of the resin pool, thereby reducing aliasing artifacts of curved or smooth surfaces;

See discussion in Ground I, claim 1[f] above. Shkolnik teaches a process that leads to reduced aliasing artifacts **and a "smooth surface",** which is known by a POSITA as gamma adjustment. EX1004, 26:15-33; Chen ¶¶191-196.

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

See discussion in Ground I, claim 1[g] above. Shkolnik similarly teaches all aspects as discussed in claim 1. 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 ¶197-199.

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

See discussion in Ground I, claim 1[h] above. 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; Chen ¶200-206.

12. **Claim 12 – The method of claim 11, wherein the plurality of pixel intensity levels comprises levels from 0 to 255.**

See discussion in Ground I, claim 2 above. See also Chen ¶207.

13. **Claim 13 – The method of claim 11, wherein the gamma adjustment mask further comprises a transfer function that**

maps an operating energy range of a printed layer to a control system operating range, wherein the control system operating range is a quantized set of values.

See discussion in Ground I, claim 3 above. See also Chen ¶208-209.

14. **Claim 14 – The method of claim 11, 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.**

See discussion in Ground I, claim 4 above. See also Chen ¶210-211.

15. **Claim 15 – The method of claim 11, wherein the resin is selected from a group consisting of acrylates, epoxies, methacrylates, urethanes, silicone, vinyls, and combinations thereof.**

See discussion in Ground I, claim 5 above. See also Chen ¶212.

16. **Claim 16 – The method of claim 11, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 1% to 5%.**

See discussion in Ground I, claim 6 above. See also Chen ¶213.

17. **Claim 17 – The method of claim 11, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 50% to 100% to increase a local power within the composite image.**

See discussion in Ground I, claim 7 above. See also Chen ¶214.

18. **Claim 18 – The method of claim 11, wherein the warp correction filter corrects skew in projected images that are caused by variation in alignment within the build area.**

See discussion in Ground I, claim 8 above. See also Chen ¶215-216.

19. **Claim 19 – The method of claim 11, wherein the warp correction filter corrects skew in projected images that are caused by variation in projector optics.**

See discussion in Ground I, claim 9 above. See also Chen ¶217.

20. **Claim 20 – The method of claim 11, wherein the edge blending bar comprises a blending distance and a function selected from a group consisting of linear, sigmoid and geometric.**

See discussion in Ground I, claim 10 above. See also Chen ¶218.

IX. GROUND 2: CLAIMS 1-20 ARE OBVIOUS IN VIEW OF SEKINE AND GREENE.

Sekine explicitly teaches all but one of the limitations of claims 1-20 of the '301 Patent. The remaining limitation 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 1-20 of the '301 Patent.

A. Sekine and Greene Disclose All Claim Limitations

1. Claim 1

(a) Element 1[pre]: An additive manufacturing system, comprising:

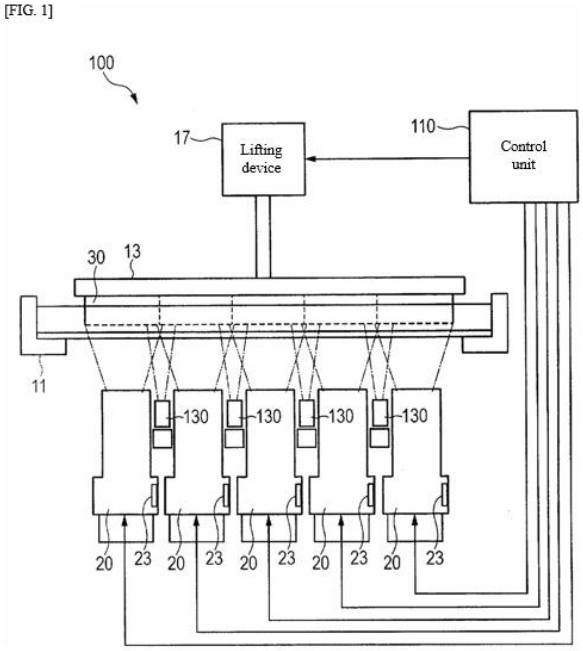
A POSITA would understand that Sekine is directed to systems and methods for additive manufacturing. See, e.g., EX1005, [0001], [0005], [0013], and [0014]; Chen ¶221. It should be noted that Sekine (as translated) sometimes uses the term

"three-dimensional shaping device" to refer to an additive manufacturing apparatus or system." Chen ¶221.

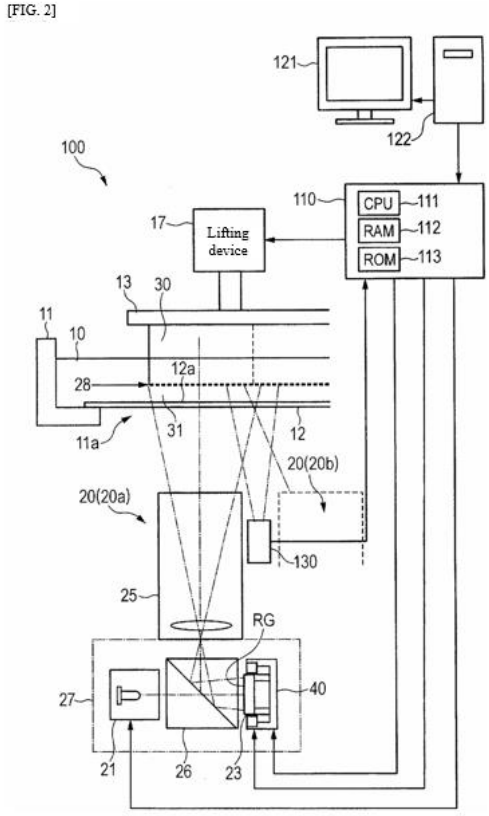
> **(b) an image projection system comprising a plurality of image projectors that project a composite image onto a build area within a resin pool, wherein each of the image projectors projects a sub-image onto a portion of the build area, wherein the composite image comprises a plurality of sub-images arranged in an array, and wherein two or more adjacent sub-images in the array overlap at two or more sub-image edges;**

Figure 1 of Sekine illustrates an AM system, and Figure 2 more specifically illustrates the configuration of the AM system's image projection system. EX1005, [0011], [0013], [0014]; Chen ¶222. With reference to Figures 1 and 2, 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 5 x 5 grid of 25 projectors total. EX1005, [0013]-[0019], [0033]; Chen ¶222.

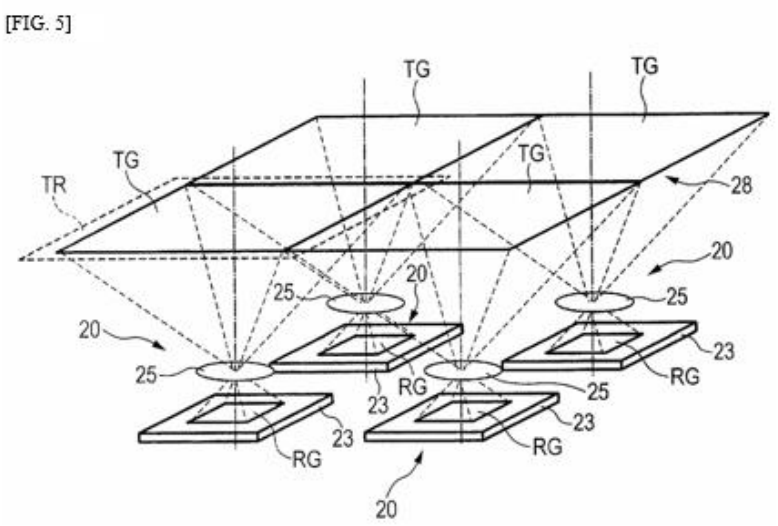
[FIG. 1]



[FIG. 2]

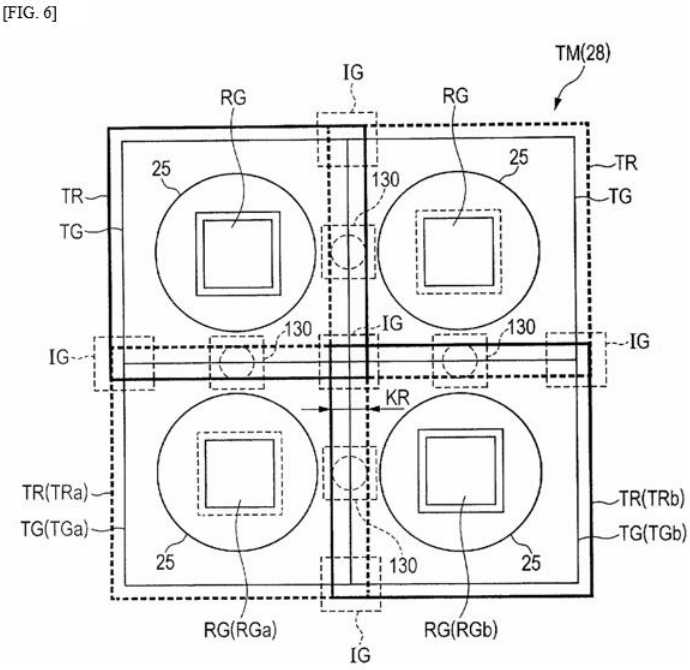


As illustrated in the "side view" of Figure 1, five projectors 20 are visible within the 5x5 grid or array; Figure 5 provides a perspective view, showing a 2x2 portion. EX1005, Figures 1, 5; Chen ¶223.



The POSITA would understand that each "projector 20 projects an image onto the surface of the liquid resin material." EX1005, [0017]; Chen ¶223. Sekine teaches that to form a large, single product with high resolution, it is possible to divide the overall or composite image into smaller pieces or sub-images, where each sub-image is provided by a separate projector in the array. EX1005, [0035]; Chen ¶223. These sub-images are "stitched" together, as shown in Figures 5 and 6, where the individual sub-images are denoted as "TG." EX1005, [0035]. As illustrated in Figure 6, the edges of "stitched" sub-images TG overlap in the boundary region denoted as "KR." EX1005, [0044]; Chen ¶223.

[FIG. 6]

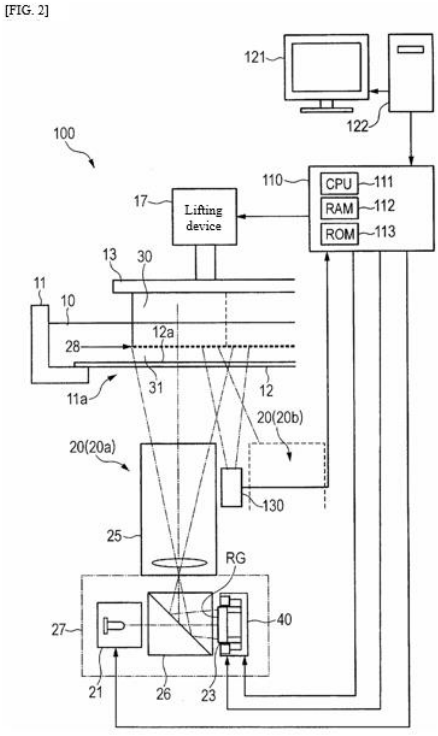


(c) a display subsystem, wherein the display subsystem controls the image projection system and each of the image projectors to adjust properties and alignment of a position of each sub-image in the array; and

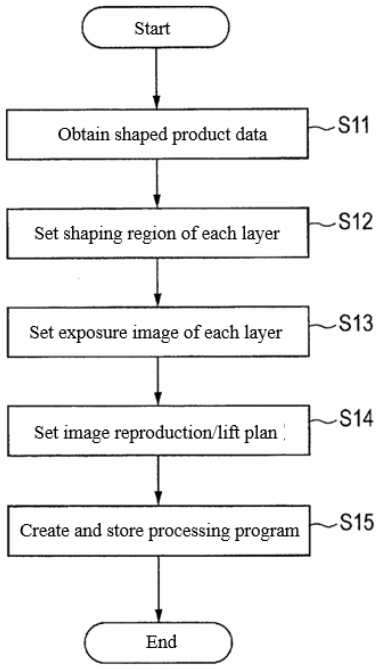
Sekine teaches a subsystem that controls the image projection system and each of the image projectors to adjust properties and alignment of the positions of the sub-images produced by the projector array. For example, with reference to the system of Figure 2 and the flowchart of Figure 3, Sekine teaches 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]. Sekine further discloses "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). Ex.1005, [0028]. The CPU 111 or the 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 ¶224.

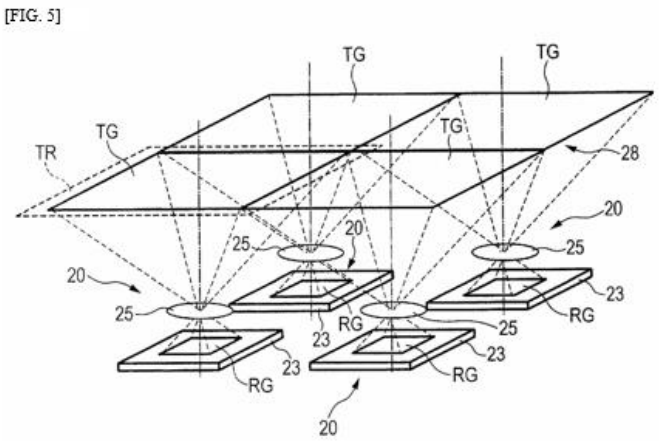
[FIG. 2]



[FIG. 3]



[FIG. 5]



Further, Sekine illustrates that the control unit 110 can adjust positions of adjacent sub-images by providing appropriate instructions to actuators EX1005, [0038]-[0041]; Chen ¶225. A POSITA would appreciate that it is these actuators that undertake the equivalent work in the '301 Patent. Chen ¶225.

(d) a stack of filters configured to adjust the properties of each sub-image in the array, the stack of filters comprising:

Sekine teaches multiple types of adjustments of sub-images, where multiple adjustment types can be used in the same print job to correct multiple types of errors. See, e.g., EX1005, [0042], [0073]. The '301 Patent refers to these correction mechanisms as "filters" or "masks." Chen ¶226. The translation of Sekine from the original Japanese describes these mechanisms using different terms, such as "illuminance correction control" or "alignment control." EX1005, [0042], [0073]; Chen ¶226. However, "the concept is exactly the same." *Id*.

To the extent that analysis in element 1[c] above is relevant to "adjust the properties of each sub-image in the array," that analysis is incorporated here. Details of the "stack" of correction mechanisms of Sekine are described in further detail below and are incorporated herein.

(e) an irradiance mask configured to normalize irradiance;

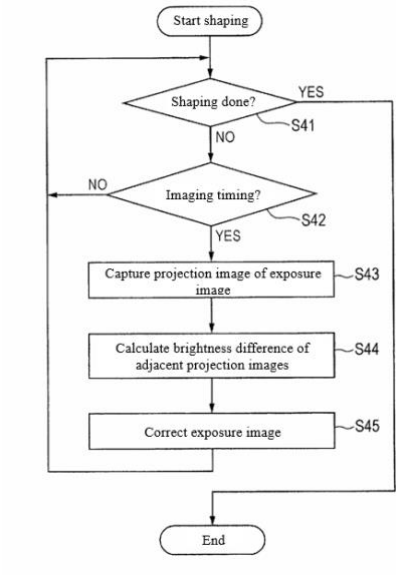
Sekine teaches that "illumination" or "brightness" of an overall or composite image can be made "uniform" and "controlled to be the same," including to correct "performance differences" within the projection system (e.g., related to the optics or

light sources)—and this normalization is desirable for the finished product. EX1005, [0070]-[0071]; Chen ¶228.

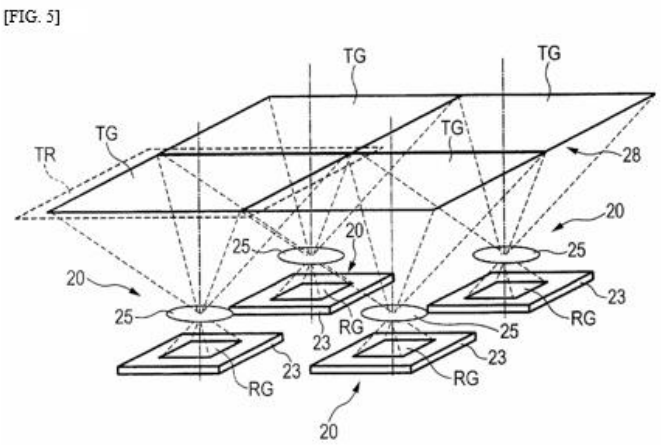
Sekine teaches a step of normalizing irradiance "to eliminate the brightness difference between adjacent projection images" and "make the illumination distribution **uniform**." EX1005, [0070]-[0071]; see Chen ¶229. Sekine further explains one way of doing so: "to ensure that the illuminance difference 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**." EX1005, [0071]; see Chen ¶229. Based on the ordinary and customary meaning of the relevant language, this is just like irradiance normalization as claimed in the '301 Patent. *See* Chen ¶¶76-78.

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, whereby each projector is projecting a sub-image within the boundary allotted to that projector—meaning that adjustment is occurring at the sub-image level. EX1005, [0042]; [0028]-[0030]; see Chen ¶229, 230 (noting that Sekine's teachings on irradiance are consistent with common knowledge in the field at the time of the filing of the '301 Patent).

[FIG. 11]



[FIG. 5]



(f) a gamma adjustment mask configured to adjust sub-image energy by mapping a plurality of pixel intensity levels to an addressable range of reactivity for curing resin of the resin pool, thereby reducing aliasing artifacts of curved or smooth surfaces;

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"). See, e.g., EX1006, [0008] [0037]-[0040], [0031], [0047]; Chen ¶¶232-243.

Like the '301 Patent, Greene teaches "**mapping** a digital model onto a three-dimensional grid" of voxels or pixels at certain "intensity levels." EX1006, [0007, [0037]-[0040]; Chen ¶233. Greene discloses that a grayscale technique can be used with this digital model "to provide sub-pixel resolution and smoothing capabilities,"

including to "smooth out edges" between different layers of a printed structure and "edges within a layer" of the printed structure. EX1006, [0008], [0031].

Greene 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**." From the POSITA's standpoint, this type of adjustment is precisely what is occurring in the gamma adjustment process of claim 1 of the '301 Patent. See Chen ¶234-237. Paragraph [0040] of Greene is reproduced below.

> At 435, the process assigns one or more grayscale intensity levels to one or more grayscale voxels based respectively on the one or more containment degrees. 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], and [0047].

Further, 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] ("The intensity levels are gamma corrected based on nonlinearities associated with the...resin"); Chen ¶239. A POSITA would appreciate that just like the gamma adjustment limitation in claim 1 of the '301 Patent ("adjust sub-image energy by mapping a plurality of pixel intensity levels to an addressable range of reactivity for curing resin of the resin pool"), "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 in a given print job." Chen ¶239. It is this adjustment process that not only (1) cures the photoactive resin at the appropriate addressable range, but also (2) ensures that that there are "smooth[ed] out edges in three dimensional printing" (EX1006, [0008]), as reflected in Greene's Figure 10B below—or to use the equivalent words in the '301 Patent itself: "thereby reducing aliasing artifacts of curved or smooth surfaces." '301 Patent, Claim 1.

By applying varying intensity levels, Greene teaches that the gamma adjustment process more "accurately represent[s] the digital model, e.g., a smoother edge is formed as shown in image l00lb rather than a jagged, stair-stepped edge as

shown in image l00la." EX1006, [0053], [0008] (the "technology can be used to smooth out edges in three-dimensional printing"); Chen ¶240.

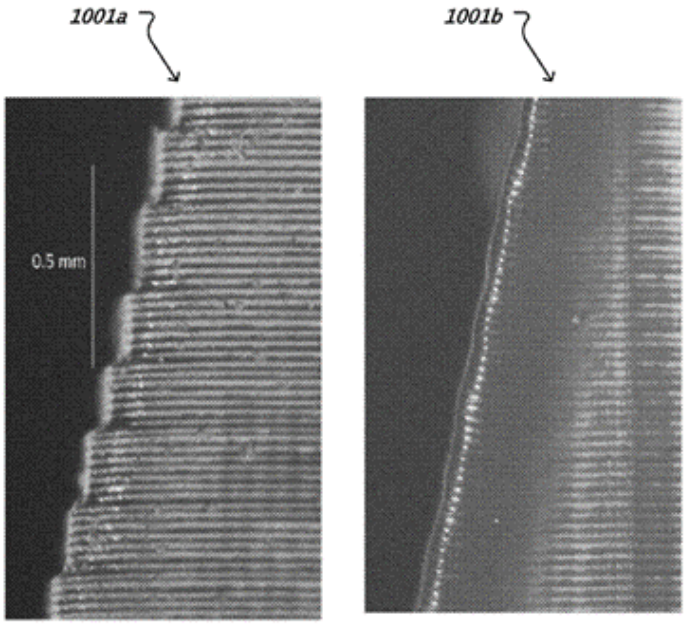


FIG. 10A FIG. 10B

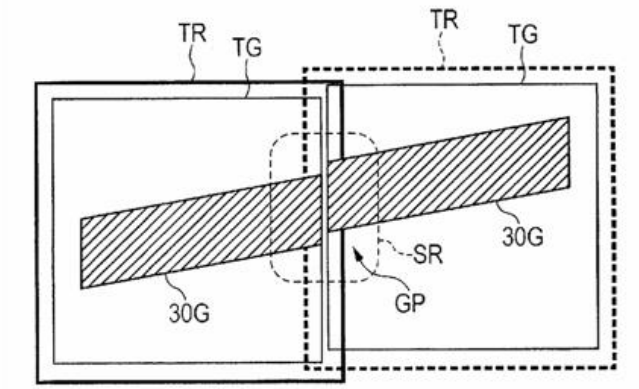
In sum, the gamma correction process disclosed in Greene is precisely what the '301 Patent claims. *Compare* Chen ¶240 *with* ¶79-82. For example, the '301 Patent (just like Greene) teaches that "resins tend to have **nonlinear** response curves with respect to energy," so that a "[g]amma correction filter provides resin reactivity leveling, and enables correct **smoothing**…of pixels by mapping the pixel intensity range (e.g., 0-255) to the minimum and maximum reactivity characteristics of the pixel." '301 Patent, 12:4-10, Claim 1; Chen ¶240.

(g) a warp correction filter configured to provide geometric correction; and

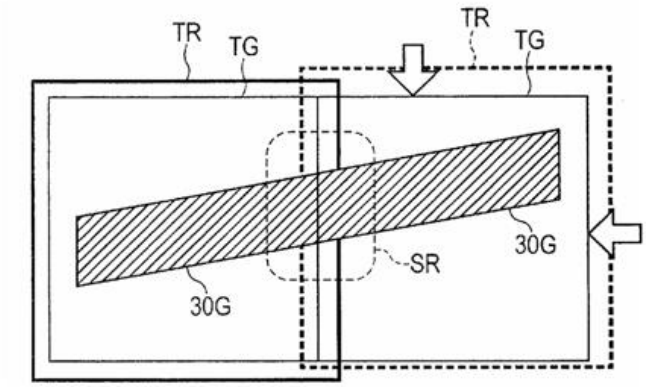
Sekine states the following at paragraph [0062]: "when using multiple projectors 20 to project individual exposure images RG formed by dividing the overall exposure image…**distortion** of the image itself" can occur, such as indicated by a "**displacement of the [overall] image pattern** at the boundary of the adjacent [sub-images]." To address such distortion, Sekine teaches correction of the sub-images so that the overall image matches the designed position, rather than being distorted. EX1005,[0063]. Moreover, each projector projects a sub-image within the boundary allotted to that projector—meaning that adjustment is occurring at the sub-image level. EX1005, [0042]; Chen ¶244.

One example of geometric correction is described in Figures 9 and 10. EX1005, [0064]-[0068]; Chen ¶245. Figure 9 is a flowchart for "displacement correction control." Figures 10A and 10B show **"before"** and **"after"** depictions of a geometrically displaced image (Figure 10A) and corrected image (Figure 10B).

[FIG. 10A]



[FIG. 10B]



A POSITA would understand from the depiction that "if a displacement error occurs between adjacent projection regions TR, a gap GP may form in the desired product image." EX1005, [0067]; Chen ¶245. In Figure 10, the desired image is depicted as a hatched rectangle, denoted as 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 ¶245.

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 ¶246.

A POSITA would understand that these position and angle adjustments remove the distortion and correct the geometry of the printed article. *Id.* ¶247. Consistent with the ordinary and customary meaning, (*id*. ¶85), a POSITA would understand that the geometric correction techniques of Sekine are just like the techniques used in the '301 Patent where, for example, "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." '301 Patent., 8:34-37, 18:16-28, FIG. 3; Chen ¶86.

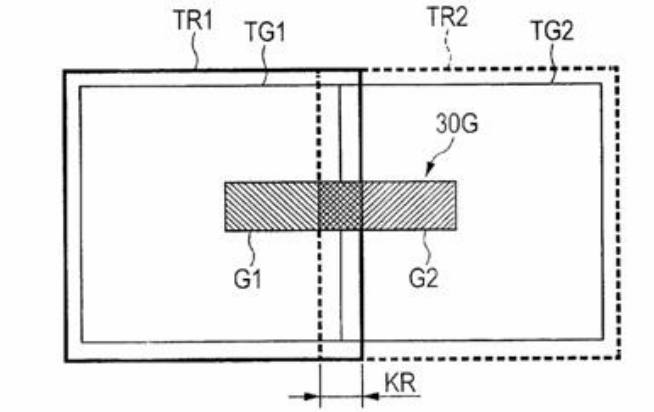
(h) an edge blending bar at one or more sub-image edges.

"Edge blending," "pixel blending," "image blending," and "stitching" can all be used to refer to the management of overlapping regions in a composite image, such as described in the '301 Patent using the term "edge blending bar." Chen ¶51. For example, as taught by the '301 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 '301 Patent. See *id*. ¶88-89 (quoting '301 Patent, 9:1-3). Further,

as taught by the ’301 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.” ’301 Patent, 9:7-8; Chen ¶88-89.

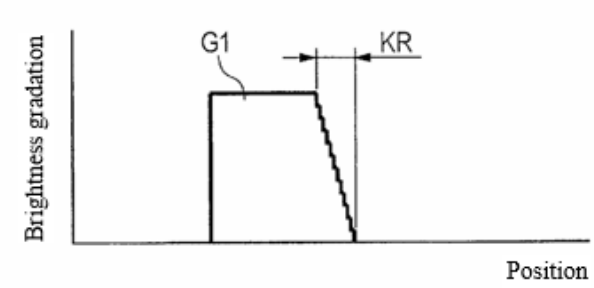
A POSITA would readily appreciate that, Sekine teaches a mechanism for improving printing resolution by blending the ends of adjacent sub-images. *Id*. ¶249. More specifically, Sekine teaches the use of “grayscaling” or “stepping” of adjacent sub-images where their edges overlap, such that the two sub-images blend into one another gradually. EX1005, [0101]-[0105], Figure 17; Chen ¶¶250. This correction mechanism is described in detail with reference to Figure 17. Here, the desired overall image 30G is rectangle shaped and includes two parts, denoted as G1 (left half of the rectangle in Figure 17) and G2 (right half of the rectangle in Figure 17). EX1005, [0101]-[0105], Figure 17; Chen ¶¶250. The first part G1 is included in a first sub-image (TG1) produced by a first projector. EX1005, [0101]-[0105], Figure 17; Chen ¶¶250. 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 ¶¶250. The element “KR” in Figure 17 shows the boundary region where the sub-images TG1 and TG2 overlap. EX1005, [0101]-[0105], Figure 17. Moreover, because each projector is projecting the sub-image within the boundary allotted to that projector, the edge blending mechanism is occurring at the sub-image level. EX1005, [0042].

[FIG. 17A]

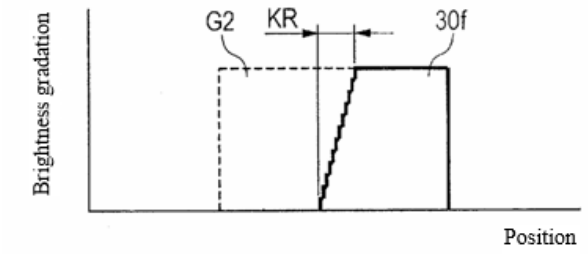


Notably, as shown in Figure 17B, the brightness or irradiation is G1 is graded or "grayscaled" within the overlap region KR —that is, G1 has a "stair step" brightness, with brightness decreasing as G1 gets closer to G2. Similarly, as shown in Figure 17C, the brightness of G2 is also graded or grayscaled, with brightness decreasing as G2 gets closer to G1. EX1005, [0101]-[0105]; Chen ¶¶251. In this way, the 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. 17B]



[FIG. 17C]



2. **Claim 2 – The additive manufacturing system of claim 1, wherein the plurality of pixel intensity levels comprises levels from 0 to 255.**

Greene teaches that "[i]n 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, [0040].

3. **Claim 3 – The additive manufacturing system of claim 1, wherein the gamma adjustment mask further comprises a transfer function that maps an operating energy range of a printed layer to a control system operating range, wherein**

the control system operating range is a quantized set of values.

Greene teaches a process that assigns grayscale intensity levels to various voxels or pixels of the digital model. EX1006, [0040]. With reference to Figure 4, Greene teaches that the foregoing process "generates one or more graphic files based on the white, grayscale, and black voxels, and the assigned intensity levels." EX1006, [0041]. Additionally, the digital representation or model of the final printed article "is sliced into *N* layers in the *Z* dimension and the process outputs a graphic file…for each layer," such as "a graphic file containing multiple bitmaps for respective layers." *Id*. Then, "the process sends the one or more graphic files to the 3D printer," and the "3D printer can receive the digital model itself, perform the process of FIG. 4, and send the contents of the one or more graphic files to a light projection device within the 3D printer." EX1006, [0042]. In this manner, the quantized pixel intensity values (ranging from 0 to 255) are mapped to the operating range of the light projection device for each printed layer.

4. **Claim 4 – The additive manufacturing system 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, being a mask that 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[f]; Chen

¶256. 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. *Id*. ¶257.

5. **Claim 5 – The additive manufacturing system of claim 1, further comprising the resin pool, wherein the resin of the resin pool is selected from a group consisting of acrylates, epoxies, methacrylates, urethanes, silicone, vinyls, and combinations thereof.**

Sekine teaches this limitation. Sekine specifically contemplates different "resin materials," including resins recited here. EX1005, [0024].

6. **Claim 6 – The additive manufacturing system of claim 1, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 1% to 5%.**

As noted above for claim 1, Sekine teaches a mechanism for improving printing resolution by blending the ends of adjacent sub-images. This mechanism is described with reference to Figure 17. In Figure 17A, the overall image 30G is rectangle shaped and includes two parts, denoted as G1 (left half) and G2 (right half). The first part G1 is included in a first sub-image (TG1) produced by a first projector. The second part G2 is included in a second sub-image (TG2) produced by

a second projector. Element "KR" shows the boundary region where the sub-images TG1 and TG2 overlap. EX1005, [0101]-[0105].

Sekine teaches that the amount of overlap in a given instance can be based on the size of a "gap" denoted as "GP." EX1005, [0066]. For example, Sekine teaches that "[t]he CPU 111 compares the images located in the boundary region KR among the captured product projection images 30G to the exposure image RG before division projected in the boundary region KR to determine whether a gap GP has occurred." *Id*. Sekine further teaches that, "[w]hen a gap GP has occurred, correction amounts for the positional displacement and tilt of the projection region TR are calculated based on the number of pixels of the gap GP and the number of pixels of the positional displacement along the direction of the gap (S34)." *Id*.

Sekine further teaches that the boundary region KR can be quite small, such as "only about 10 pixels (0.75 mm) of overlap" in the embodiment discussed in Figure 6. EX1005, [0044]. Therefore, the amount of overlap taught by Sekine is adjustable in size as needed, ranging from only a few pixels (e.g., 10 pixels) and up to a size needed to correct any gap "GP" that may occur in a given instance. The range of overlap thus necessarily covers any particular percent overlap, such as 1% to 5%. Chen ¶¶259-261.

7. **Claim 7 – The additive manufacturing system of claim 1, wherein adjacent sub-areas overlap by a percentage of their**

areas, wherein the percentage is from 50% to 100% to increase a local power within the composite image.

As noted above for claim 6, Sekine teaches that the amount of overlap of adjacent sub-areas in a given instance can be based on the size of a "gap," which is variable. EX1005, [0066]. Thus, the percent overlap taught by Sekine is adjustable as needed, ranging from only a few pixels and up to a size needed to correct any gap that may occur in a given instance. The range of overlap thus necessarily covers any particular percent overlap, such as 50% to 100%.

Moreover, Sekine teaches that "when overlapping of the optical images of the pattern occurs, regions set for ultraviolet light incidence overlap, resulting in a local exposure amount that is doubled." EX1005, [0072]. That is, the local power is increased in the overlap region (e.g., doubled). As a result, Sekine teaches that "the degree of polymerization of the resin material 10 in that part increases, or pattern dimensions become thicker, causing streak patterns in the shaping direction." *Id.* Further, Sekine teaches that it may be desirable to "lower the illumination of the ultraviolet light so that the total irradiation amount from both adjacent regions equals that of the non-overlapping region." EX1005, [0072]. Chen ¶¶262-263.

8. **Claim 8 – The additive manufacturing system of claim 1, wherein the warp correction filter corrects skew in projected images that are caused by variation in alignment within the build area.**

As noted above for claim 1, Sekine discloses multiple types of sub-image adjustments, where multiple adjustment types can be used in the same print job to correct multiple types of errors. EX1005, [0042], [0073]. With respect to corrections caused by variation in alignment within the build area, Sekine provides a detailed description at [0108]-[0111], for example. Chen ¶264.

9. **Claim 9 – The additive manufacturing system of claim 1, wherein the warp correction filter corrects skew in projected images that are caused by variation in projector optics.**

As noted above for claim 8, Sekine discloses multiple types of sub-image adjustments. EX1005, [0042], [0073]. It is well understood that variation in projector optics 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]. *See also* EX1005, Figure 2 and [0038]-[0041]. Chen ¶265.

10. **Claim 10 – The additive manufacturing system of claim 1, wherein the edge blending bar comprises a blending distance and a function selected from a group consisting of linear, sigmoid and geometric.**

As described above for claim 1, Sekine teaches a mechanism for improving printing resolution by blending adjacent sub-images. For example, 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 ¶267-268.

11. **Claim 11**

(a) A method comprising:

The limitations of claim 11 correspond to the limitations of claim 1, discussed above in Ground II, claim 1, though the limitations of claim 11 are arranged to recite a "method" rather than a "system." Sekine teaches both systems and methods. EX1005, [0001], [0005], [0013], [0014]. Chen ¶269.

(b) a. providing an additive manufacturing system, comprising:

See discussion in Ground II, claim 1[a] above. Sekine is directed to systems and methods for AM. EX1005, [0001], [0005], [0013], [0014]. Chen ¶270.

(c) an image projection system comprising a plurality of image projectors; and

See discussion in Ground II, claim 1[b] above. Figures 1 and 2 of Sekine illustrate an additive manufacturing system having 25 projectors. EX1005, [0011], [0013]-[0019], [0033], Figures 1, 2. Chen ¶271-273.

(d) an image display subsystem;

See discussion in Ground II, claim 1[c] above. Sekine teaches a subsystem that controls the image projection system and each of the image projectors to adjust properties and alignment of the positions of the sub-images produced by the projector array of Sekine. EX1005, [0027]-[0030], [0038]-[0042], Figures 2, 3, 5; Chen ¶274-276.

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

See discussion in Ground II, claim 1[b] above. Sekine teaches a 5 x 5 array of projectors, where each projector projects an image onto the surface of the liquid resin, EX1005, [0017], Figure 5. Additionally, Sekine teaches that to form a large, single product (denoted as element 30 in Sekine) 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]; Chen ¶277.

(f) the image projection system is controlled by the image display subsystem;

See discussion in Ground II, claim 1[c] above. Sekine teaches a subsystem that controls the image projection system and each of the image projectors to adjust properties and alignment of the sub-images. EX1005, [0027]-[0030], [0038]-[0042], Figures 2, 3, 5. Chen ¶278-280.

(g) the composite image comprises a plurality of sub-images arranged in an array;

See discussion in Ground II, claim 1[b] above. Sekine teaches a 5x5 array of projectors, where each projector projects an image onto the surface of the resin, EX1005, [0017], Figure 5. Chen ¶281-283.

(h) two or more adjacent sub-images in the array overlap at two or more sub-image edges; and

See discussion in Ground II, claim 1[b] above. Sekine teaches multiple projectors, where each projector projects an image onto the surface of the resin. Sekine teaches that to form a large, single product with high resolution, it is possible to divide the overall or composite image into smaller sub-images, where each sub-image is provided by a separate projector. EX1005, [0017], [0035]. These sub-images are "stitched" together, as shown in Figures 5 and 6, and the edges of sub-images overlap. EX1005, [0035], [0044]. Chen ¶284.

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

See discussion in Ground II, claim 1[b] above. Sekine teaches an array of projectors, where each projector projects an image onto the surface of the resin, EX1005, [0017], [0035], Figure 5. Chen ¶284.

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

See discussion in Ground II, claims 1[c] and 1[d] above. EX1005, [0042], [0073]. Chen ¶286-287.

(k) an irradiance mask that normalizes irradiance;

See discussion in Ground II, claim 1[e] above. Chen ¶288-291.

(l) a gamma adjustment mask that adjusts sub-image energy by mapping a plurality of pixel intensity levels to an addressable range of reactivity for curing the resin of the resin pool, thereby reducing aliasing artifacts of curved or smooth surfaces;

See discussion in Ground II, claim 1[f] above. Chen ¶292-303.

(m) a warp correction filter that provides geometric correction; and

See discussion in Ground II, claim 1[g] above. Chen ¶304-308.

(n) an edge blending bar at one or more sub-image edges.

See discussion in Ground II, claim 1[h] above. Chen ¶309-312.

12. **Claim 12 – The method of claim 11, wherein the plurality of pixel intensity levels comprises levels from 0 to 255.**

See discussion in Ground II, claim 2 above. Chen ¶313.

13. **Claim 13 – The method of claim 11, wherein the gamma adjustment mask further comprises a transfer function that maps an operating energy range of a printed layer to a control system operating range, wherein the control system operating range is a quantized set of values.**

See discussion in Ground II, claim 3 above. Chen ¶314-315.

14. **Claim 14 – The method of claim 11, 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.**

See discussion in Ground II, claim 4 above. Chen ¶316-317.

15. **Claim 15 – The method of claim 11, wherein the resin is selected from a group consisting of acrylates, epoxies, methacrylates, urethanes, silicone, vinyls, and combinations thereof.**

See discussion in Ground II, claim 5 above. Chen ¶318.

16. **Claim 16 – The method of claim 11, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 1% to 5%.**

See discussion in Ground II, claim 6 above. Chen ¶319-321.

17. **Claim 17 – The method of claim 11, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 50% to 100% to increase a local power within the composite image.**

See discussion in Ground II, claim 7 above. Chen ¶322-323.

18. **Claim 18 – The method of claim 11, wherein the warp correction filter corrects skew in projected images that are caused by variation in alignment within the build area.**

See discussion in Ground II, claim 8 above. Chen ¶324.

19. **Claim 19 – The method of claim 11, wherein the warp correction filter corrects skew in projected images that are caused by variation in projector optics.**

See discussion in Ground II, claim 9 above. Chen ¶325-326.

20. **Claim 20 – The method of claim 11, wherein the edge blending bar comprises a blending distance and a function selected from a group consisting of linear, sigmoid and geometric.**

See discussion in Ground II, claim 10 above. Chen ¶327-328.

B. Motivation to Combine Sekine with Greene.

A POSITA would be motivated to combine Sekine and Greene. Chen ¶¶329-337. First, the references are directed towards the same field of endeavor—identifying problems (and solutions) for "improving precision and accuracy in the formation of 3D printed products formed by light projection such as DLP." *Id*. ¶330. Mindful of the problems in the field that both references teach—and the design needs associated with accuracy and precision—these teachings supply "good reason to pursue the known options" disclosed in these references, all preceding the priority date. *KSR Int'l Co. v. Teleflex Inc*., 550 U.S. 398, 421 (2007); Chen ¶330-334 (discussing identification of the problem and solution). Second, there are no teachings in the references that would "disparage or teach away" from the combination. Chen ¶332. Third, where a technique "has been used to improve one device and it would improve a similar device in the same way, using the technique is obvious." *KSR*, 550 U.S. at 417. This principle applies here with Greene's disclosures in paragraphs [0037]-[0040] summarized above (EX1006)—and how that same technique could be used in the same way to improve Sekine to arrive at the claimed invention. Chen ¶¶333-336.

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 ¶¶335-336 (Sekine and Greene "would work together...operating as they are expected to function").

X. GROUND 3: CLAIMS 1-20 ARE OBVIOUS IN VIEW OF SHKOLNIK AND SEKINE.

A. Shkolnik and Sekine Disclose All Claimed Limitations

1. Claim 1

1[a] An additive manufacturing system, comprising:

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

1[b] an image projection system comprising a plurality of image projectors that project a composite image onto a build area within a resin pool, wherein each of the image projectors projects a sub-image onto a portion of the build area, wherein the composite image comprises a plurality of sub-images arranged in an array, and wherein two or more adjacent sub-images in the array overlap at two or more sub-image edges;

Shkolnik teaches this limitation in Ground I. Claim 1[b], EX1004, 4:40-44, 7:56-57, 33:45-34:14, Figures 1A, 4C, 7A.

1[c] a display subsystem, wherein the display subsystem controls the image projection system and each of the image projectors to adjust properties and alignment of a position of each sub-image in the array; and

Shkolnik teaches this limitation in Ground I. Claim 1[c], EX1004, 7:10-22, 8:6-32, 7:18-22, 11:23-35, Figure 1A.

1[d] a stack of filters configured to adjust the properties of each sub-image in the array, the stack of filters comprising:

Shkolnik teaches this limitation in Ground I. Claim 1[d], EX1004, 10:44-46, 11:4-8, 14:51-53, 17:24-27, 7:18-22, 2:9-11, 2:22-26, Figures 1K, 1ME.

1[e] an irradiance mask configured to normalize irradiance;

Sekine teaches this limitation in Ground II. Claim 1[e], EX1005, [0070]-[0071], [0042], [0028]-[0030], Figures 5, 11.

1[f] a gamma adjustment mask configured to adjust sub-image energy by mapping a plurality of pixel intensity levels to an addressable range of reactivity for curing resin of the resin pool, thereby reducing aliasing artifacts of curved or smooth surfaces;

Shkolnik teaches this limitation in Ground I. Claim 1[f], EX1004, 26:15-33, 9:47-55, 9:59-62, 10:22-26, 18:32-42, 31:51-53, 7:18-22, Figures 2A, 1MA-1MG, 1MBB.

1[g] a warp correction filter configured to provide geometric correction; and

Shkolnik teaches this limitation in Ground I. See Claim 1[g], EX1004, 32:64-33:10, 33:18-45, 31:51-53, 7:18-22, FIGS. 5A-5C, 6.

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

Shkolnik teaches this limitation in Ground I. Claim 1[h], EX1004, 4:40-44, 33:45-34:14, 34:35-43m 31:51-53, 7:18-22, Figures 4C, 7A.

2. **Claim 2 – The additive manufacturing system of claim 1, wherein the plurality of pixel intensity levels comprises levels from 0 to 255.**

Shkolnik teaches this limitation in Ground I. Claim 2, EX1004, 9:21-23, 9:60-62, 9:21-28.

3. **Claim 3 – The additive manufacturing system of claim 1, wherein the gamma adjustment mask further comprises a transfer function that maps an operating energy range of a printed layer to a control system operating range, wherein the control system operating range is a quantized set of values.**

Shkolnik teaches this limitation in Ground I. Claim 3, EX1004, 10:22-26, 18:32-37, 4:48-58, 5:54-6:22; 7:10-22; 8:6-32, 23:17-30, Figure 1K.

4. **Claim 4 – The additive manufacturing system 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, as evidenced by EX1007, page 204.

5. **Claim 5 – The additive manufacturing system of claim 1, further comprising the resin pool, wherein the resin of the resin pool is selected from a 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.

6. **Claim 6 – The additive manufacturing system of claim 1, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 1% to 5%.**

Shkolnik teaches this limitation in Ground I. Claim 6, EX1004, 33:45-34:14, Figures 4C, 7A.

7. **Claim 7 – The additive manufacturing system of claim 1, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 50% to 100% to increase a local power within the composite image.**

Shkolnik teaches this limitation in Ground I. Claim 7, EX1004, 33:45-34:22.

8. **Claim 8 – The additive manufacturing system of claim 1, wherein the warp correction filter corrects skew in projected images that are caused by variation in alignment within the build area.**

Shkolnik teaches this limitation in Ground I. Claim 8, EX1004, 7:23-37, 32:64-33:10, Figures 5A-5C.

9. **Claim 9 – The additive manufacturing system of claim 1, wherein the warp correction filter corrects skew in projected images that are caused by variation in projector optics.**

Shkolnik teaches this limitation in Ground I. Claim 9, EX1004, 7:23-37, 32:64-33:10, Figures 5A-5C.

10. **Claim 10 – The additive manufacturing system of claim 1, wherein the edge blending bar comprises a blending distance and a function selected from a group consisting of linear, sigmoid and geometric.**

Shkolnik teaches this limitation in Ground I. Claim 10, EX1004, 33:45-34:14, 34:53-64, Figures 4, 7.

11. **Claim 11**

(a) A method comprising:

Shkolnik teaches this limitation in Ground I. Claim 11[a], EX1004, 4:22-23.

(b) a. providing an additive manufacturing system, comprising:

Shkolnik teaches this limitation in Ground I. Claim 11[b], EX1004, 4:22-23.

(c) an image projection system comprising a plurality of image projectors; and

Shkolnik teaches this limitation in Ground I. Claim 11[c], EX1004, 4:40-44, 7:56-57.

(d) an image display subsystem;

Shkolnik teaches this limitation in Ground I. Claim 11[d], EX1004, 7:10-22, 8:6-32, 7:18-22, 11:23-35, Figure 1A.

(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. See Claim 11[e], EX1004, 5:9-14, 33:59-63, Figures 1A, 7.

(f) the image projection system is controlled by the image display subsystem;

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

(g) the composite image comprises a plurality of sub-images arranged in an array;

Shkolnik teaches this limitation in Ground I. Claim 11[g], EX1004, 4:40-44; 5:9-14, Figure 7A.

(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 11[h], EX1004, 33:45-34:14, Figures 4C, 7A.

(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 11[i], EX1004, 5:9-14, Figure 1A.

(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 11[j]. EX1004, 10:44-46, 11:4-8, 14:51-53, 17:24-27, 7:18-22, 2:9-11, 2:22-26, 2:36-38, 5:38-53, 10:7-13, 14:26-31, 14:51-56.

(k) an irradiance mask that normalizes irradiance;

Sekine teaches this limitation in Ground II. See Claim 11[k], EX1005, [0070]-[0071], [0042], [0099], Figures 5, 11.

(l) a gamma adjustment mask that adjusts sub-image energy by mapping a plurality of pixel intensity levels to an addressable range of reactivity for curing the resin of the resin pool, thereby reducing aliasing artifacts of curved or smooth surfaces;

Shkolnik teaches this limitation in Ground I. See Claim 11[l], EX1004, 9:47-55, 9:59-62, 10:22-26, 18:32-42, 31:51-53, 7:18-22, Figures 2A, 1MA-1MG, 1MBB.

(m) a warp correction filter that provides geometric correction; and

Shkolnik teaches this limitation in Ground I. See Claim 11[m], EX1004, 7:18-37, 31:51-53, 32:64-33:16, 33:18-45, FIGS. 5A-5C, 6.

(n) an edge blending bar at one or more sub-image edges.

Shkolnik teaches this limitation in Ground I. See Claim 11[n], EX1004, 4:40-44, 33:45-34:14, 34:35-43m 31:51-53, 7:18-22, Figures 4C, 7A.

12. **Claim 12 – The method of claim 11, wherein the plurality of pixel intensity levels comprises levels from 0 to 255.**

Shkolnik teaches this limitation in Ground I. See Claim 12, EX1004, 9:21-23, 9:60-62, 9:21-28.

13. **Claim 13 – The method of claim 11, wherein the gamma adjustment mask further comprises a transfer function that maps an operating energy range of a printed layer to a control system operating range, wherein the control system operating range is a quantized set of values.**

Shkolnik teaches this limitation in Ground I. See Claim 13, EX1004, 10:22-26, 18:32-37, 4:48-58, 5:54-6:22; 7:10-22; 8:6-32, 23:17-30, 6:23-51, 9:47-62, Figure 1K.

14. **Claim 14 – The method of claim 11, 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. See Claim 14, EX1004, 10:22-26, as evidenced by EX1007, page 204.

15. **Claim 15 – The method of claim 11, wherein the resin is selected from a group consisting of acrylates, epoxies, methacrylates, urethanes, silicone, vinyls, and combinations thereof.**

Shkolnik teaches this limitation in Ground I. See Claim 15, EX1004, 5:17-24, 4:65-5:8.

16. **Claim 16 –The method of claim 11, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 1% to 5%.**

Shkolnik teaches this limitation in Ground I. See Claim 16, EX1004, 33:45-34:14, Figures 4C, 7A.

17. **Claim 17 – The method of claim 11, wherein adjacent sub-areas overlap by a percentage of their areas, wherein the percentage is from 50% to 100% to increase a local power within the composite image.**

Shkolnik teaches this limitation in Ground I. See Claim 17, EX1004, 33:45-34:22.

18. **Claim 18 – The method of claim 11, wherein the warp correction filter corrects skew in projected images that are caused by variation in alignment within the build area.**

Shkolnik teaches this limitation in Ground I. See Claim 18, EX1004, 7:23-37, 32:64-33:10, Figures 5A-5C.

19. **Claim 19 – The method of claim 11, wherein the warp correction filter corrects skew in projected images that are caused by variation in projector optics.**

Shkolnik teaches this limitation in Ground I. See Claim 19, EX1004, 7:23-37, 32:64-33:10, Figures 5A-5C.

20. **Claim 20 – The method of claim 11, wherein the edge blending bar comprises a blending distance and a function selected from a group consisting of linear, sigmoid and geometric.**

Shkolnik teaches this limitation in Ground I. See Claim 20, EX1004, 33:45-34:14, 34:53-64, Figures 4, 7.

B. Motivation to Combine Shkolnik with Sekine.

A POSITA would be motivated to combine Shkolnik and Sekine. Chen ¶¶423-433. First, the references are directed towards the same field of endeavor—identifying problems (and solutions) for "improving precision and accuracy in the formation of 3D printed products formed by light projection such as DLP." Id. ¶425 Mindful of the problems in the field that both references teach—and the design needs associated with accuracy and precision—these teachings supply "good reason to pursue the known options" disclosed in these references, all preceding the priority date. *KSR Int'l Co. v. Teleflex Inc*., 550 U.S. 398, 421 (2007); Chen ¶425,426-429 (discussing how Sekine identifies the problem and solution). Second, there are no teachings in the references that would "disparage or teach away" from the combination. Chen ¶¶426-427. Third, where a technique "has been used to improve one device and it would improve a similar device in the same way, using the technique is obvious." *KSR*, 550 U.S. at 417. This principle applies here with Sekine's disclosures in paragraphs [0070]-[0071] summarized above (EX1005)—and how that same technique could be used in the same way to "improve Shkolnik to arrive at the claimed invention." Chen ¶¶430-431.

Importantly, the combination would lead to a reasonable expectation of success. 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 in a 3D product)." Chen ¶¶432, 433 (Shkolnik and Sekine "would operate exactly as they are expected to function").

XI. OBJECTIVE INDICIA OF NON-OBVIOUSNESS

There is no objective indicia that support the non-obviousness of the '301 Patent. Chen ¶ 434.

XII. 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.

XIII. MANDATORY NOTICES

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 '301 Patent is or was involved in the following cases:

Case	Number	Court	Filed	Status
Intrepid Automation, Inc. v. 3D Systems Corporation et al.	3-24-cv-02262	SDCA	Dec. 4, 2024	Active

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

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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.

XIV. CONCLUSION

For the reasons set forth above, the Challenged Claims of the ’301 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 8, 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 8, 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

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Dated: July 8, 2025

/Bryan L. Baysinger/
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