

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

GIESECKE+DEVRIENT GMBH, GIESECKE+DEVRIENT CURRENCY
TECHNOLOGY GMBH, AND PAPIERFABRIK LOUISENTHAL GMBH
Petitioners

v.

LUMENCO, LLC
Patent Owner

U.S. Patent No. 11,448,863
IPR No. 2024-00838

DECLARATION OF LAMBERTUS HESSELINK, PH.D.

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CHALLENGED CLAIMS

Claim 1	
[1Pre]	A method of fabricating a security element, comprising:
[1a]	assigning a first object in a starting digital image to a first image display plane and a second object in the starting digital image to a second image display plane;
[1b]	with a processor of a computing device, executing code to provide an array design module that operates to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of the first object in the first image display plane and to display each of the pixels of the second object in the second image display plane;
[1c]	for each of the pixels, determining with the array design module an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors;
[1d]	generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors; and
[1e]	forming the array of the micro mirrors according to the design output file.
Claim 2	
2	The method of claim 1, wherein the angular orientation is defined by coordinates of a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels.
Claim 3	
3	The method of claim 1 wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of micro mirrors.
Claim 4	
4	The method of claim 3, wherein the cone has an apex coinciding with coordinates of one of the pixels on the first or second image display planes.
Claim 5	

5	The method of claim 1, wherein the angular orientations are calculated based on heights of the first and second image display.
Claim 6	
6	The method of claim 1, wherein the angular orientations are calculated to provide a predefined angular offset of at least 10 degrees between the first and second image display planes.
Claim 7	
[7Pre]	A method of fabricating a security element, comprising:
[7a]	with a processor of a computing device, executing code to provide an array design module configured to select a set of micro mirrors in an array of the micro mirrors to display pixels of a first object in a first image display plane and to display pixels of a second object in a second image display plane spaced apart from the first image display plane;
[7b]	for each of the pixels, determining, with the array design module, an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors;
[7c.1]	generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors,
[7c.2]	wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of the micro mirrors; and
[7.d]	forming the array of the micro mirrors according to the design output file.
Claim 8	
7	8. The method of claim 7, wherein the cone has an apex coinciding with coordinates of one of the pixels on the first or second image display planes.
Claim 9	
8	9. The method of claim 7, wherein the angular orientation is defined by coordinates of a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels.
Claim 10	

9	10. The method of claim 7, wherein the angular orientations are calculated based on heights of the first and second image display.
Claim 11	
10	11. The method of claim 7, wherein the angular orientations are calculated to provide a predefined angular offset of at least 10 degrees between the first and second image display planes.
Claim 12	
[12Pre]	A method of fabricating a security element useful on paper and coin currency and on product labels, comprising:
[12a]	with a processor of a computing device, executing code to provide an array design module configured to define an array of micro mirrors to be formed on a surface of a substrate;
[12b]	generating a design output file including an angular orientation and location coordinates in the array for each of the micro mirrors; and
[12c]	forming the array of micro mirrors according to the design output file,
[12d]	wherein the array of micro mirrors is configured, when formed on the surface of the substrate, for receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate,
[12e]	wherein the image comprises a plurality of pixels, and
[12f]	wherein the array of micro mirrors includes for each of the pixels a different set of the micro mirrors each having a reflective surface oriented, in a fixed manner, with a body of each of the micro mirrors rotated about at least one of first and second rotation axes extending through the body, to reflect the ambient light toward a point on the plane corresponding to one of the pixels.
Claim 13	
13	The method of claim 12, wherein a voxel is created at each of the point on the plane via intersection of two or more beams of the reflected ambient light, and wherein each of the created voxels produces an effect of a point source of light floating above the surface of the substrate in the plane.

Claim 14	
14	The method of claim 12, wherein each of the different sets concurrently reflect the ambient light to concurrently generate the plurality of pixels.
Claim 15	
15	The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by casting the micro mirrors with a mirror tool in contact with the surface of the substrate.
Claim 16	
16	The method of claim 15, wherein the substrate provided in the providing step comprises a clear, energy-cured polymer.
Claim 17	
17	The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by metallization of surfaces of the micro mirrors, wherein the metallization applies a layer of aluminum, gold, or silver to form reflective surfaces.
Claim 18	
18	The method of claim 17, wherein the forming the array of micro mirrors includes, prior to the metallization of the surfaces of the micro mirrors, embossing the surface of the substrate to form the surfaces of the micro mirrors and wherein the surface of the substrate includes an embossable coating or layer.
Claim 19	
19	The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by filling in recessed surfaces associated with the micro mirrors with a filler comprising at least one of an ultraviolet (UV) varnish, an e-beam solvent, and a water-based varnish.
Claim 20	
20	The method of claim 19, wherein the filler has a refractive index of at least 1.55, whereby at least a portion of the received ambient light at extreme angles is reflected to sharpen the displayed image.

I. INTRODUCTION

1. My name is Dr. Lambertus Hesselink. I have been retained by Petitioners Giesecke+Devrient GmbH, Giesecke+Devrient Currency Technology GmbH, and Papierfabrik Louisenthal GmbH (collectively, “G+D” or “Petitioners”) to provide expert opinions with respect to U.S. Patent No. 11,448,863 (the “’863 Patent”), which I understand is assigned to Patent Owner Lumenco, LLC (“Lumenco” or “Patent Owner”).

2. I am being compensated at my standard consulting rate of \$675 per hour for my time, plus reasonable out-of-pocket expenses. I have received no additional compensation for my work in this matter, and my compensation does not depend upon the content of my opinions, any testimony that I may provide, or the ultimate outcome of the matter. All of the opinions set forth in this declaration are my own.

II. BACKGROUND AND QUALIFICATIONS

3. Full descriptions of my educational background, professional work, qualifications, and publications are set forth more fully in my curriculum vitae, which is attached to this declaration as Exhibit 1036. Here, I provide a summary of my background and qualifications.

4. I am currently a Professor of Electrical Engineering in the Department of Electrical Engineering at Stanford University, and by courtesy in the Departments of Applied Physics and Aeronautics and Astronautics.

5. In 1970 I received a Bachelor of Science degree in Mechanical Engineering from the Twente Institute of Technology in Enschede, Netherlands, and a Bachelor of Science degree in Applied Physics from the same institution in 1971. The following year, I received my Master of Science degree in Mechanical Engineering from California Institute of Technology. In 1974, I obtained an Applied Mechanics engineering degree from the Twente Institute of Technology, and then I subsequently continued my studies at the California Institute of Technology and, in 1977, earned my doctorate degree in Applied Mechanics and Physics/Applied Physics.

6. My expertise is in ultra-high density optical data storage, and optical information systems generally, as well as optical communication components, nano photonics, optics and optical systems, and optical interconnects. I have been awarded several scientific awards from scientific and professional societies, including the Fulbright Scholarship, Stheeman Price Award, DARPA Award, Best Paper Awards from the Institute of Electrical and Electronics Engineers (IEEE) and OSA, Fellow of the Optical Society of America (OSA), the Society of Photo- Optical Instrumentation Engineers (SPIE), and the National Information Solutions Cooperative (NISC), among others. In addition to being an assistant, associate, or full Professor performing research in these fields for over 30 years, I am a member of the Royal Dutch Academy of Arts and Sciences, the National Academy of

Inventors, have been the keynote or invited speaker in over 290 scientific meetings and the organizer of over 70 scientific meetings, have authored more than 500 papers in scientific journals, have written over 15 book chapters on optics, data analysis and visualization, optical storage, and image processing, and have been the editor of several scientific publications, including *Applied Optics*, *Applied Scientific Research*, and *IEEE Transaction on Visualization*.

7. I have had an intimate knowledge of the technology of optical systems since at least 1978. I have taught courses at the California Institute of Technology and Stanford University on optical systems design, modern optics, optical signal processing and digital image processing, among others, for over 40 years, covering specific topics that include the design and operation of optical display systems. Since at least the early 1980s I have been leading research and development of 3-D displays, including autostereoscopic holographic displays, 3-D up conversion display, 3-D displays for security applications, grating-based displays, as well as data analysis of complex 3-D flow visualizations using scanning laser systems, tomography, and mathematical topology. We invented numerous 3-D display and storage devices and used interferometry to determine the 3-shape of objects using optical and X-ray scanners. Using the Stanford nano-fabrication facilities we implemented and tested our displays using CMOS fabrication technology, among others.

8. In addition to my academic experience, I have extensive corporate and consulting experience. I have founded three high-technology companies, I have been Chief Technology Officer in the Branded Products division of Western Digital, I have been a member of the Scientific Advisory Board of the United States Air Force, and I was a member of one of the two NASA Ad Hoc Advisory Committees tasked with repairing the Hubble Space Telescope just after its launch. With a broad knowledge of optics, optical systems and devices, optical storage systems, a solid grounding in 3-D displays and its underlying technologies and components, and experience with the patent and trade secret process, I believe that I am qualified to provide an accurate assessment of the technical issues addressed in this declaration.

9. In particular, as noted in Section VII below, my opinion is that a POSITA as of December 3, 2015 would have had an undergraduate degree in mechanical or electrical engineering or physics and at least two years of experience in micro-optics design. I met and exceeded those requirements as of December 2015.

10. Given my experience in the field, I am familiar with the knowledge that a person of ordinary skill in the art would have had at the time and the manner in which such a person would have viewed the available information at the time. My testimony is offered from this perspective, even if it does not specifically refer to the perspective of a person of ordinary skill in the art in every instance.

11. My opinions are also based on investigation and study of the patent at issue, its file history, and the prior art. In the course of forming my opinions, I have reviewed all the relevant exhibits submitted with the Petition, which are specifically identified herein.

12. I may rely upon these materials and/or additional materials to rebut arguments raised by Lumenco. Further, I may also consider additional documents and information in forming any necessary opinions including documents that may not yet have been provided to me.

III. LEGAL UNDERSTANDING

13. I understand that issues such as invalidity and claim construction are analyzed based on certain legal standards. Counsel for Petitioners have provided me with an understanding of these standards, and I have applied them in my analysis set forth in this declaration.

A. The Person of Ordinary Skill in the Art

14. I understand that a person of ordinary skill in the art (“POSITA”) is a hypothetical person who is presumed to be aware of all pertinent prior art, thinks along conventional wisdom in the art, and is a person of ordinary creativity—not an automaton.

15. I understand the level of ordinary skill in the art is evaluated based on various factors, including: the level of education and work experience of persons in the field; the type of problems encountered in the field; and the sophistication of the technology at issue.

B. Claim Construction

16. I understand that, as a general rule, the claim terms of a patent are understood to have their ordinary and customary meaning to a POSITA at the time of the invention when read in the context of the patent and its prosecution history. I understand that there are certain exceptions to the general rule, including lexicography and disavowal, but I have not been asked to analyze those exceptions in connection with this proceeding.

C. Obviousness

17. I understand a patent claim is still invalid if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person of ordinary skill in the pertinent art.

18. I understand an obviousness determination includes the consideration of various factors, including the scope and content of the prior art, the differences, if any, between the prior art and the claimed subject matter, the level of ordinary skill in the art, and any “secondary considerations,” also called objective indicia of obviousness or non-obviousness.

19. I understand an obviousness determination can be based on a single prior art reference or a combination of multiple prior art references and the knowledge of a POSITA. I understand the prior art itself may provide a suggestion, motivation, or reason to combine or modify the teachings of the prior art, or that such a reason may come from other sources, such as the knowledge of a POSITA, common sense, and market forces. However, I understand it is impermissible to rely on hindsight or to use the claimed invention as a roadmap to reach a finding of obviousness.

20. I understand the following rationales may support a finding of obviousness:

- Combining prior art elements according to known methods to yield predictable results;
- Simple substitution of one known element for another to obtain predictable results;
- Use of known technique to improve similar devices (methods, or products) in the same way;
- Applying a known technique to a known device (method or product) ready for improvement to yield predictable results;
- “Obvious to try” – choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art;
- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

21. I understand an obviousness finding requires a reasonable expectation of success in achieving the claimed invention. The expectation of success need only be reasonable; a perfect implementation or commercial embodiment of the invention is not required.

22. I understand that objective indicia of obviousness or non-obviousness may include commercial success attributable to the alleged invention; a long-felt but unmet need for the alleged invention; praise of the alleged invention by others in the field; and skepticism towards the alleged invention by experts. I understand that any secondary considerations must bear a nexus to the alleged invention. I understand

the nexus requirement is not satisfied if, for example, the purported commercial success is tied to features of a product that were known in the prior art rather than the alleged invention.

IV. SUMMARY OF INVALIDITY GROUNDS

23. For purposes of this declaration, I have been asked to analyze claims 1-20 (“Challenged Claims”) of the ’863 patent in view of the prior art. In my opinion, the challenged claims are obvious based on the following grounds:

Ground	Claims	References
1	1-2, 4-6, 12-14	Fuhse847 in view of Rich
2	3, 6-14	Fuhse847 and Rich (Ground 1) in view of Fuhse925
3	15-18	Fuhse847 and Rich (Ground 1) in view of Sauvage-Vincent
4	15-18	Fuhse847, Rich, and Fuhse925 (Ground 2) in view of Sauvage-Vincent
5	19-20	Fuhse847 and Rich (Ground 1) in view of Morford
6	19-20	Fuhse847, Rich, and Fuhse925 (Ground 2) in view of Morford

V. TECHNICAL BACKGROUND

A. Optical Security Features

1. Historical Development

24. 3-D security stickers or devices have been utilized on valuable items such as bank notes, clothing (such as NFL paraphernalia), equipment, devices, instruments since at least the early 1990s. In the middle 1990s, I invented a holographic recording device that incorporated a security feature that could only be activated by a known optical readout with a random phase distribution. Holographic stickers have been applied to cereal boxes, toys, clothing, credit cards, banknotes even earlier. The underlying key enabling technology is based on optical readout of micro and nano structures embedded in a substrate. For holograms, it is a diffractive structure.

25. For displays, micromirrors are often utilized to create a specific optical two- or three-dimensional image that is only visible under certain readout conditions of ambient light, enabling widespread applications. One of the key requirements of the security labels is to prevent copying of the labels using readily available commercial copying machines. As these machines rely on 2-D optical readout of the information, 3-D micro- or nanostructures are the medium of choice for recording the security information. Besides holographic diffraction gratings, micromirrors are frequently embedded in a substrate to create 3-D visual displays that are difficult to copy with low-cost, commercially available copiers.

26. Optically variable devices (“OVDs”) for document anti-counterfeiting were introduced in the 1980s. For example, Australian commemorative ten-dollar plastic banknote issued in January 1988 using an OVD. EX1026, p. 22. The OVD on the 1988 banknote took the form of the schematic portrait of Captain Cook. *Id.*

27. By the late 1980’s OVDs with arrays and feature sizes on the order as those contemplated in the ’863 Patent were already being produced. For example, the Commonwealth Scientific and Industrial Research Organisation (“CSIRO”) in Australia developed a diffraction based OVD at that time, as explained in the article *Development of Optically Variable Devices for Document Security in CSIRO* (published in 2005):

“A further advance in OVD technology by CSIRO was implemented in 1989 as PixelgramTM. In this technology, the image was comprised of 30 x 30 µm or 60 x 60 µm pixel elements with the flexible allocation of a groove structure from a palette of fine gratings. Improved portraiture was among the technical capabilities of Pixelgram. By 1993, a new development of the technology was named ExelgramTM. The prefix “*exel*” was derived from “*exposure element*”, a term devised to indicate that the diffraction pattern was written with the high resolution of electron beam equipment. Each Exelgram image was based on a very large number of gratings with the individual spacing of the grooves selected from a range of 10 different levels. The choice of groove spacing provided the corresponding iridescent colour in the individual 30 x 30 µm regions of the image.”

EX1026, p. 22.

28. OVDs are broadly applicable to many applications that require anti-counterfeiting, including currency, passports, ID cards, and product labels, these solutions use optical features to verify the authenticity of documents.

29. OVD technology has advanced rapidly over the years in order to “stay ahead” of rapidly advancing counterfeiting technology, including the proliferation of low-cost digital scanners and high-resolution color copiers.

2. Micro-Mirror Arrays

30. Micro-mirror arrays are structures embedded in a substrate that upon illumination of light create a visual image(s). The mirrors are typically small, on the order of 25-50 microns, so that they can be fabricated by electronic manufacturing techniques. Each of the mirrors in the array will reflect incident light in a certain direction determined by the orientation of the micro-mirror surface and the angle of incidence of the light, following well known laws of geometrical optics. By directing the reflected light of a collection of micro-mirrors 2D or 3D objects can be created floating in space. An observer of the floating images can often manipulate the images by changing the orientation of the micro-mirrors with respect to the illumination light beam. The illumination light beam is often a so-called plane wave, i.e., a beam in which all the rays are substantially parallel to each other, such as light coming from the sun. Often this light beam is referred to as ambient light. As an example,

by rotating or tilting the security label, multiple images can be visualized, or their geometry changed.

31. Micro-mirror arrays are also used for telecom applications involving optical communication beams or scanners, and in this application are often referred to as optical switches, because the orientation of the mirror surfaces can be dynamically changed by applying, for example, an electrical force. For security applications, which must be low cost for use on consumer products, the micro-mirror arrays are embedded into the substrate. To avoid copying and replication of the surface micro-mirror arrays using surface topology scanners, the micro-mirror arrays are typically covered by an optically transparent medium that is flat and smooth.

32. In the early 2000s, over a decade before the '863 Patent's earliest possible priority date, micro-mirror OVD had become well-known, which replaced diffraction gratings with arrays of micro-mirrors. Micro-mirror OVD technology advanced rapidly in the period from the early 2000s through December 2015 (the '863 Patent's earliest possible priority date).

33. As explained in the article *Development of Optically Variable Devices for Document Security in CSIRO* (published in 2005), micromirror arrays for document security and their methods of production were well-established, including the ability to individually orient each micromirror:

“A typical OVD microstructure comprised of a micro-mirror array (Figure10) may contain up to one million mirrors of dimensions 60 x

60 μm or less. Each mirror is arranged at a predetermined angle according to the input picture in formation.

The procedure for producing a micromirror OVD involves three main phases — i) production of an image specific mask by electron beam lithography, ii) UV exposure through the mask to produce the required micro-mirror surface relief structure in a thick layer of optical resist and iii) electroplating of this resist layer to produce a hard nickel tool.”

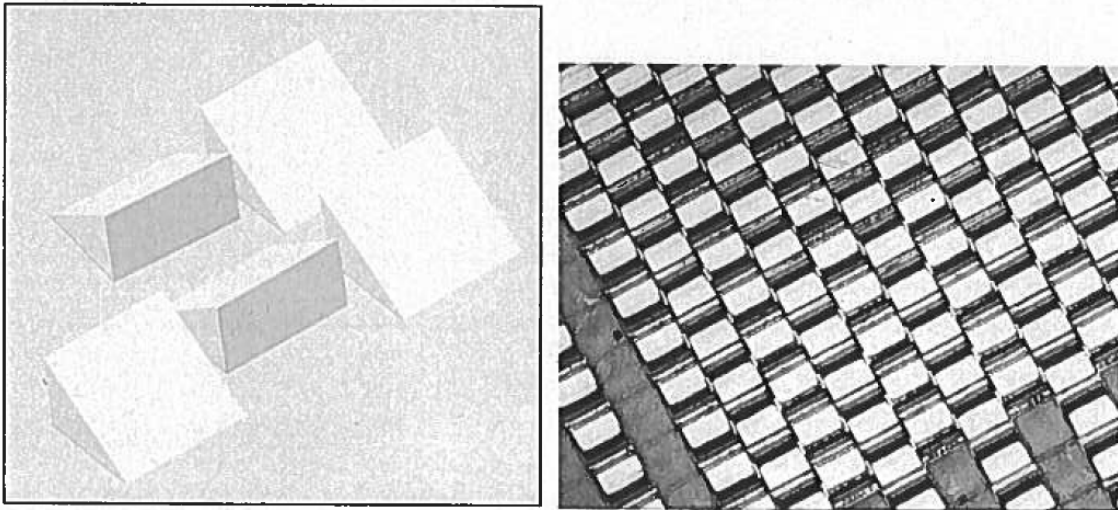


Figure 10. Optical micrograph of an experimental micro-mirror structure. Rows of micro-mirrors of opposing slopes can be seen here. In this particular case, each micro-mirror has a dimension of 30 x 30 μm .

EX1026, p. 26, FIG. 10.

34. This experimental micro-mirror OVD also provided “two angles of view” corresponding to the two images produced by the micromirror arrays.

EX1026, p. 26, FIG. 12.



B. Ray Optics

1. The Ray Model

35. The propagation of optical radiation such as solar beams, lasers and flashlights is governed by the laws of geometrical optics. Early experiments and quantitative analysis of light propagation dates back at least four hundred years ago, and rudimentary knowledge of light propagation was used by the Romans and the Greek for warfare. Three basic laws describe the propagation of rays. In this model, rays are mathematical entities with zero width along which energy flows (i.e. photons). Rays can be thought of as small pencils of light emanating in a particular direction from a source such as the sun, a laser, or a distant light in the room. Grouped together they form a bundle of light, such as a beam of light. The three laws for propagation of a light ray (i.e. a single ray, which may be part of a bundle.

The laws apply to the ray, and to a bundle when considering all the rays making up the bundle of light) are:

36. **(1)** Rays in a uniform medium (i.e. a medium that consists of one material only, such as air having the same properties everywhere) propagate along straight lines. See EX1027 (*Optics*, Hecht, 4th Edition (2002)), p. 98 (“In a medium that is uniform (homogeneous), rays are straight”); EX1028 (*Fundamentals of Photonics*, Saleh & Teich, 1st Edition (1991)), p. 4 (“in a homogeneous medium, light rays travel in straight lines”).

37. **(2)** Snell’s Law. A ray incident on the interface between two media, such as air and glass, follow Snell’s Law which says that the product of the sine of the angle of incidence of the ray on the medium times the index of refraction of the medium is constant across the interface of the two media. The index of refraction is a quantity that determines how much of the energy of the ray propagating in the medium gets absorbed and how fast the rays are propagating in the medium. See EX1028 (*Fundamentals of Photonics*, Saleh & Teich, 1st Edition (1991)), p. 5-6 (providing a proof of Snell’s Law).

38. **(3)** The law of reflection. This law states that the angle of incidence of a ray on a mirror is equal to the angle of reflection of the ray from the mirror. The angle of incidence and reflection are the angle between the surface normal and the incoming ray, and the angle between the reflected ray and the normal to the surface,

respectively. See EX1027 (*Optics*, Hecht, 4th Edition (2002)), pp. 98-99 (“the Law of Reflection means the *“angle-of-incidence equals the angle-of-reflection”*”); EX1028 (*Fundamentals of Photonics*, Saleh & Teich, 1st Edition (1991)), p. 5 (“*the angle of reflection equals the angle of incidence*”).

39. Ray equation mathematics applied to micromirror arrays for security elements were well-known before the relevant time. For example, “Micromirror array nanostructures for anticounterfeiting applications” (published 2004) provided a derivation of the ray equations associated with a reflective micromirror, beginning with the following discussion:

2.1 Ray equations

Figure 2 shows a single reflecting pixel element of arbitrary surface form illuminated by a point light source at “A”, a distance R_{00} from a point “P” on the pixel surface and producing a reflected optical field. Point “B” is a point in the reflected optical field, a distance R_{10} from the point P. “O” is the origin of the coordinate system and X_0, Y_0, Z_0 represents the coordinates of the source point “A”, while X_1, Y_1, Z_1 are the coordinates of the point “B”. X, Y, Z are the coordinates of point P on the surface of the pixel.

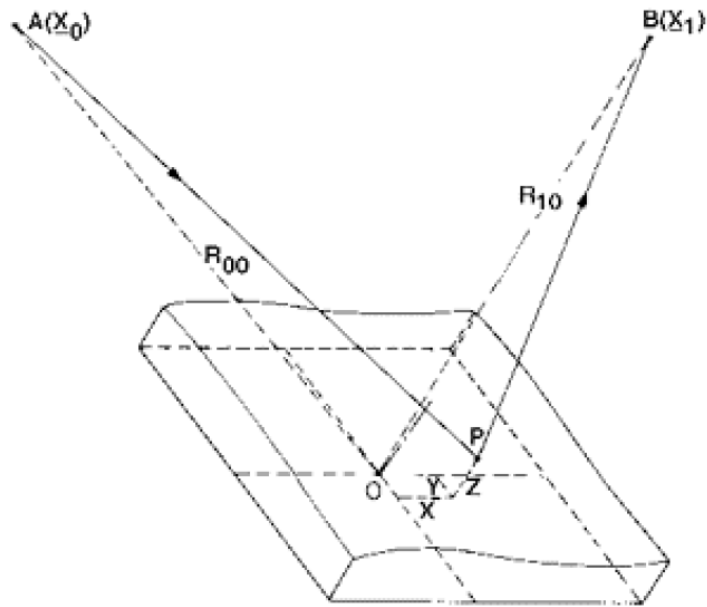


Figure 2. Pixel optical geometry

40. Additionally, CODEV and Zemax are commercially available ray trace programs that have been developed and used since the invent of digital computers for commercial applications. After the microcomputer became widely available as a personal computational tool (i.e. the Digital Equipment Corporation VAX 11-750 and VAX 11-780 from the early 1980s), these lens design programs became widely available around the world.

2. Ray Diagrams

41. Ray propagation is often visualized by drawing cartoons referred to as ray diagrams. Ray diagrams visualize the ray paths as a result of rays interacting with optical elements such as mirrors and lenses. Ray paths can be computed for a

given arrangement of lenses and mirrors using the three laws of geometrical optics. See EX1027 (*Optics*, Hecht, 4th Edition (2002)), pp. 243-52.

42. As any light beam would have an infinite number of rays (they are infinitesimally thin), a theoretical framework has been developed over decades to determine which rays are critical to the (imaging) performance of the optical system.

43. This framework includes defining key rays whose paths through the optical system must be considered to determine optical performance. One of these is called a chief ray.

44. **Chief ray.** A chief ray is a ray that comes from an off-axis object point through the center of the aperture stop. The aperture stop is that stop in the system (say camera), that limits the amount of light that passes through the system from an on-axis object point. For example, cameras have variable aperture stops for adjusting the amount of light that falls on the detector.. The chief ray for a micro-mirror element is the ray coming from the source, say the sun, and passing through the center of the micro-mirror. Knowing the direction at which the ray falls on the mirror (i.e. the angle between the mirror normal and the incoming light ray) the angle of reflection will be equal to the angle of incidence. See EX1027 (*Optics*, Hecht, 4th Edition (2002)), p. 172. As discussed in *Optics* (Hecht, 4th Edition (2002)), which states that “[t]he chief ray, associated with a conical bundle of rays from a point on

the object, effectively behaves as the central ray of the bundle and is representative of it.” See EX1027, p. 172.

45. When using parallel light (i.e. as used in the patent) all incident rays that are parallel to each other experience the same direction in which they are reflected.

3. Ambient Light

46. Ambient light generally refers to light in the ambient, or environment. This could be coming from the sun or a local light source. In the patent, ambient light refers to parallel light, i.e., all the rays coming from the source are parallel to each other.

C. Surface Orientations

1. Planar Surfaces

47. The position and orientation of planar surfaces with respect to a coordinate system, such as the x-y-z orthogonal coordinate system, is fully determined by its center position and the orientation of the surface as expressed by the normal vector. The vector is characterized by a length (typically normalized to one) and an orientation with respect to the coordinate system given by the projection of the vector on each of the three orthogonal coordinate axes, x, y, and z. As the normal vector to the surface is known, mathematical geometry allows computation of the so-called direction cosines, i.e. the angles the planar surface makes with respect to the coordinate axes. Each representation, based on either the direction

cosines or the normal to the planar surface is interchangeable with the other through straight forward geometrical mathematics.

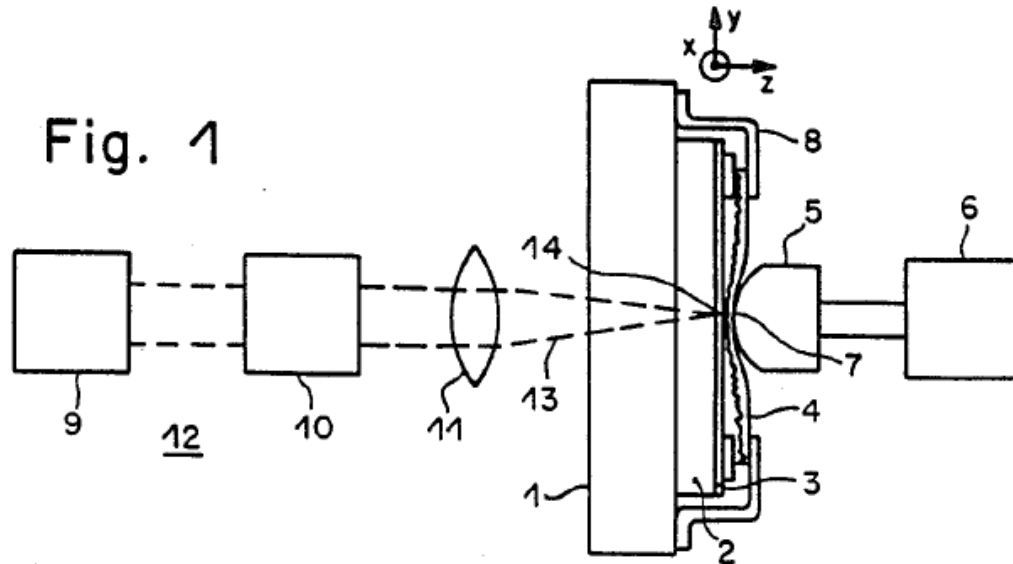
D. Fabrication Methodologies

1. Embossing

48. Various embossing techniques were conventional for producing optical microstructures, including micromirrors, before the relevant date.

49. The state of the art for embossing optical structures was very advanced by 2015, as these processes had been in commercial use for many decades across different industries. For example, the mass production of optical discs (such as DVDs) involved various kinds of embossing techniques on polymer substrates.

50. For example, U.S. Patent No. 4,761,253 (“Antes”)(EX1047) assigned to Landis+Gyr was filed in 1985, and discloses methods for embossing thermoplastics to create optical diffraction gratings with “microscopic relief structures.” EX1047, Abstract, 2:43-3:15. Just like the ’863 Patent, and as shown in Figure 1 below, Antes teaches a polymer (thermoplastic layer 3) that is embossed with nickel embossing die 4. *Id.*



51. “Embossing”, and in particular “hot embossing” “is the name used for volume stamping of MEMS structures, and is sometimes referred to as hot embossing lithography (HEL).” See EX1030 (*Introduction to Microfabrication*, Franssila, 1st Edition (2004)), p. 183.

52. Embossing was a conventional technique for producing microstructures such as micromirrors before the relevant period. Hot embossing may be described as follows:

“18.3.1 Hot embossing

Hot embossing involves pressing a master against a polymer at a temperature slightly above the polymer glass transition temperature. The equipment for hot embossing is shown in Figure 18.8. The process has three major issues: filling of structures by polymer (Figure 18.8(b)), reproduction fidelity and master separation and de-embossing.

Both the wafer and the master stages are heated above the polymer glass transition temperature T_g . Widely used polymers such as PMMA have a T_g of 106 °C and polycarbonate (PC) has a T_g of 150 °C. The master is then pressed against the polymer. The

embossing force is of the order of 20 to 30 kN and the hold time is of the order of one minute. De-embossing takes place after cooling below the glass transition temperature.

Polymeric materials have coefficients of thermal expansion (CTE) of the order of 20 to 100 ppm, whereas silicon has a CTE of 2.6 ppm and nickel, a typical electroplated master material, 13 ppm. Thermal cycling is mandatory for hot embossing but it should be minimized to around T_g to avoid thermal mismatch cracking.

The thickness of hot embossed structures can be varied enormously, from 150 nm to 150 μm . There is no resolution limit, and embossing can replicate structures down to 10 nm size; making the master becomes the limiting factor. The aspect ratios of embossed structures can be as high as 20:1, and up to 50:1 when special release coatings have been applied.

Hot embossing is suitable for simple structures, preferably involving only one patterning step. Various microfluidic and biomedical microdevices fall under this category, especially if they need to be cheap enough to be disposable.”

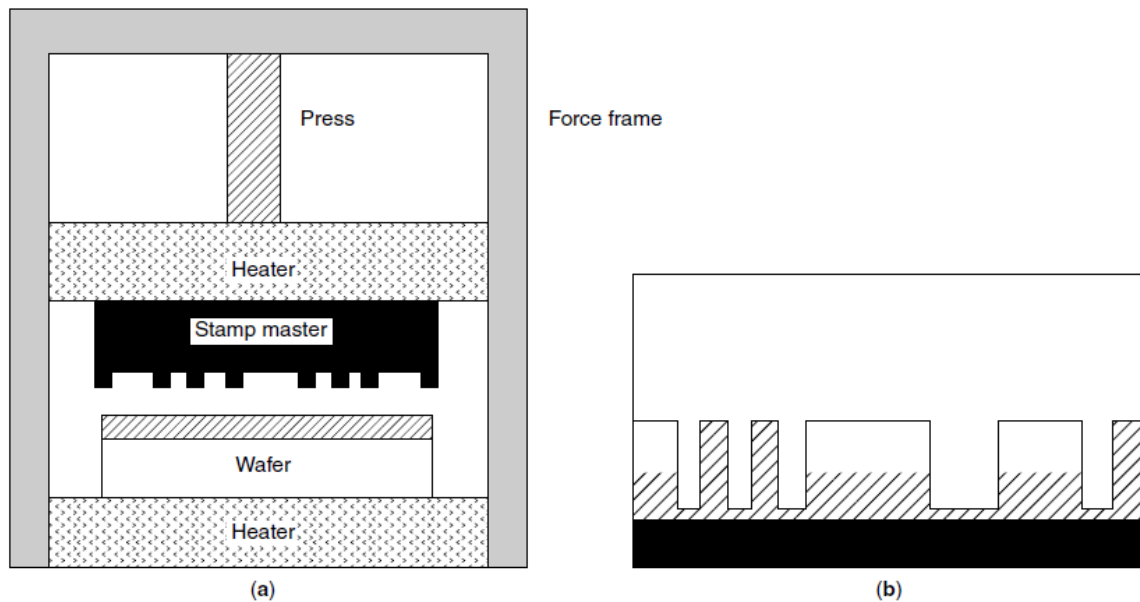


Figure 18.8 (a) Schematic hot embossing equipment and (b) unequal stamp cavity filling of variable aspect ratio structure

See EX1030 (*Introduction to Microfabrication*, Franssila, 1st Edition (2004)), pp. 187-88.

2. Micromirrors Reflective Coatings

53. Before the relevant timeframe, aluminum was prevalent and well-known as a reflective coating to produce a highly reflecting mirror. See EX1027 (*Optics*, Hecht, 4th Edition (2002)), p. 172 (“Vacuum evaporated coatings of aluminum on highly polished substrates have become the accepted standard for quality mirrors.”).

54. Gold, silver, and aluminum were all commonly used as mirror coatings due to their high reflectivity in the visible spectrum (about 380 to 700 nanometers). The following shows the reflectivity for these three materials (as well as copper), and I have annotated to show the visible spectrum.

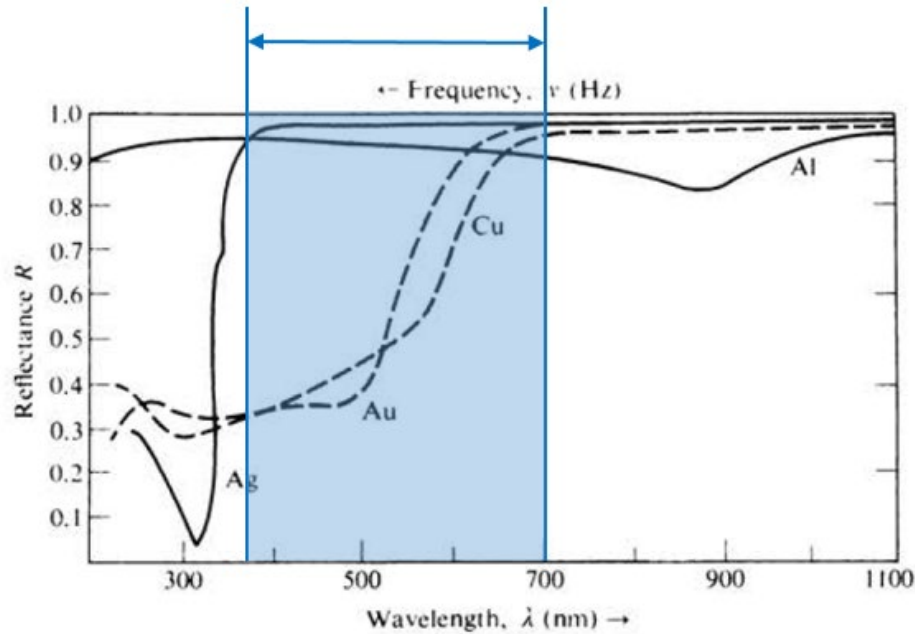


Figure 4.59 Reflectance versus wavelength for silver, gold, copper, and aluminum.

See EX1027 (*Optics*, Hecht, 4th Edition (2002)), p. 172.

3. Polymer Substrates

55. Polymers are often used to produce embossed structures due to their thermal response. Thermoplastic polymers have properties that are advantageous for embossing, in particular, their ability to soften under heat (to allow the embossing tool or stamping tool to imprint the desired shape) and retain the structure while hardening once the heat is removed. This was common knowledge before the relevant time period. As explained in *Polymer Science and Technology* (2000):

“For engineering purposes, the most useful classification of polymers is based on their thermal (thermomechanical) response. Under this scheme, polymers are classified as *thermoplastics* or *thermosets*. As the name suggests, **thermoplastic polymers soften and flow under the action of heat and pressure. Upon cooling, the polymer hardens and**

assumes the shape of the mold (container). Thermoplastics, when compounded with appropriate ingredients, can usually withstand several of these heating and cooling cycles without suffering any structural breakdown. This behavior is similar to that of candle wax. Examples of thermoplastic polymers are polyethylene, polystyrene, and nylon.”

See EX1029 (Polymer Science and Technology, Ebewele, 1st Edition (2000)), p. 31.

56. Materials such as polyethylene (PE), polyethylene terephthalate (PET), and polypropylene are common polymers used as an embossing substrate.

57. For example, polypropylene is a polymer. *See EX1029 (Polymer Science and Technology, Ebewele, 1st Edition (2000)), pp. 18 (“Other examples of polymers of this type are ... polypropylene”), 30, 43, 80, 97-98.* In particular, polypropylene is a polymer derived from the monomer Propylene:

Table 2.1 *Some Representation Addition Polymers*

$ \begin{array}{ccc} \text{H} & \text{H} & \\ & & \\ n \text{ C} = \text{C} & \longrightarrow & \left[\begin{array}{cc} \text{H} & \text{H} \\ & \\ -\text{C} & -\text{C}- \\ & \\ \text{H} & \text{R} \end{array} \right]_n \\ & & \\ \text{H} & \text{R} & \\ \text{monomer} & & \text{polymer} \end{array} $		
R	Monomer	Polymer
H	Ethylene	Polyethylene
CH ₃	Propylene	Polypropylene
Cl	Vinyl chloride	Poly(vinyl chloride)
CN	Acrylonitrile	Polyacrylonitrile
	Styrene	Polystyrene
$ \begin{array}{c} \text{O} \\ \\ \text{C} = \text{O} \\ \\ \text{CH}_3 \end{array} $	Vinyl acetate	Poly(vinyl acetate)
$ \begin{array}{c} \text{C} = \text{O} \\ \\ \text{O} \\ \\ \text{CH}_3 \end{array} $	Methyl acrylate	Poly(methyl acrylate)

See EX1029 (*Polymer Science and Technology*, Ebewele, 1st Edition (2000)), p. 43.

58. Materials such as polypropylene have long been effective in use as substrates for hot-embossing for optical security devices. For example, transparent, biaxially-oriented polypropylene (BOPP) was demonstrated as an effective embossed substrate for arrays of 30 x 30 µm optical elements:

“Micrographic features generated by electron beam lithography have been hot embossed in biaxially-oriented polypropylene (BOPP). Each micrographic element consisted of a sub-field of 30 x 30 µm with a specific configuration of symbols, lettering and graphics. The micrographic elements were integrated with arrays of diffractive gratings in the form of an optically variable device. A high quality embossing of various micrographic elements has been demonstrated in features with a linewidth dimension ≥ 365 nm and depth ≥ 255 nm. The

replication of arrays of micrographic elements was achieved uniformly over an area of 20 x 20 mm in the BOPP film by embossing at a temperature of 130 °C.”

EX1034, p. 109.

4. Protective Coatings

59. The micromirror structures are often coated with a protective layer of a transparent material, such as a high index polymer. The overcoat protects the underlying micromirror array from contamination and abrasion. Additionally, the overcoat prevents determining the structure of the micromirror array through imprinting and copying. The overcoat layer affects the ray paths of the incident ambient rays, as the incoming light is refracted at the interface of air-polymer media. The reflected ray path is further modified through refraction at the polymer-air medium when leaving the protective layer. These effects are well understood and are taken into account when designing the micromirror array.

60. The protective layer typically has a high index of refraction to reduce the effect of refraction on the ray path of the reflected rays from the micromirror array. As a result of refraction air-polymer and polymer-air interfaces, the floating height reduces to approximately $1/n$ of the height without the protective coating. This effect can be compensated for by properly orienting the micromirrors to achieve the desired floatation height of the light spots after embedding. This is a well-known effect and is well understood by a POSITA.

E. Computer-Implemented Methodologies

1. Computer-Implemented Methodologies Known in the Art

61. Decades before the relevant date (Dec. 2015), it was well-known that arbitrary input images could be implemented as security elements on banknotes.

62. This included complex images, such as portraits, that were generated from digital images and displayed with high resolution. For example, in 1988, the below portrait of Captain Cook was implemented on an OVD on an Australian banknote.

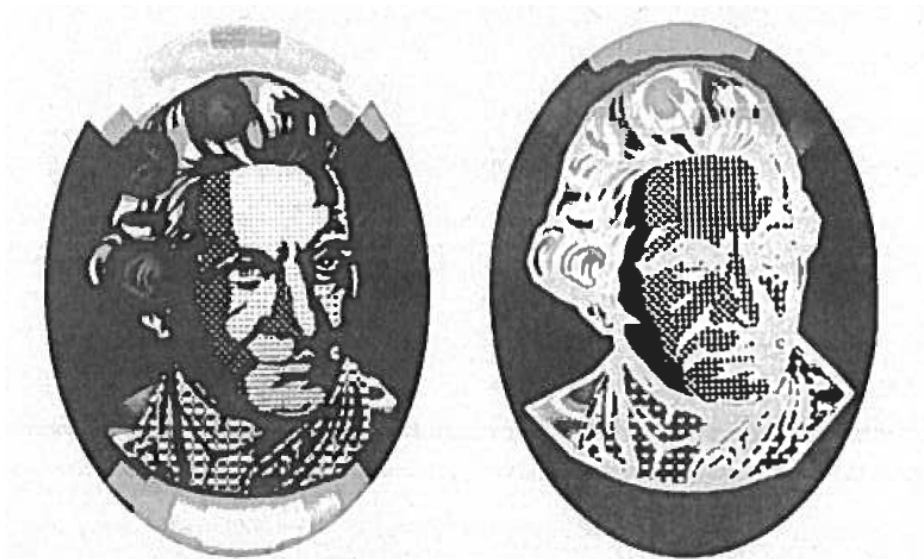


Figure 1. Two angles of view of the Captain Cook Catpix OVD; the first OVD to be used as an anti-counterfeiting device on a banknote. The height of the ellipse on the banknote was ~20 mm.

EX1026 (“Development of Optically Variable Devices for Document Security in CSIRO”), p. 22.

63. For example, one process (published a decade before the relevant date of the '863 Patent) took images from Adobe Photoshop and produced arrays of

micro-optic elements to reproduce the images as security elements. EX1026, p. 22.

As explained:

“The sequence of production of a grating-based OVD has comprised three stages: a) artwork development, b) conversion of artwork to electron beam format and c) fabrication of the master image plate. During the design stage, artwork was prepared as an Adobe Photoshop file using a palette developed by CSIRO with 26 different elements. The group of 10 colour elements in the palette was used to define the switch effect in the Exelgram image (for example, Figure 5). Each colour within this 10 element group corresponded to a particular pitch of the tracks in the range 0.7-1.3 μm .

The OVD pattern was exposed into a layer of electron-sensitive resist using a finely focused beam of a Leica EBMF 10.5 e-beam lithography system (as schematically shown in Figure 9). The master plate for the exposure consisted of a quartz base (12.5 x 12.5 mm) overlaid by a thin layer of Cr and a film of resist. The electron beam was exposed across each of the 30 x 30 μm sub-fields in the images on the plate.

Following the exposure, the layer of resist was developed in a standard solvent to reveal the fine structure of grooves. The OVD array was then copied from the Master plate as a nickel shim. The shim was produced by an initial sputtering of a thin film of Ni (~100 nm) followed by the electroplating of a thicker layer (~150 μm) in a nickel sulphamate bath. The nickel shim has been used as a die plate in the mass production of embossed foil. The metallized foil comprised multiple polymer layers including a lacquer coat, a metal coating and an adhesive layer. The image was embossed into a polymer layer using a rotary embossing process. The embossed polymer was then vacuum metallized with aluminium and coated with adhesive on the metallized side. The multilayered foil is then separately transferred onto the document by a “hot stamping” process which involves various combinations of heat, pressure and dwell time.”

EX1026, p. 24.

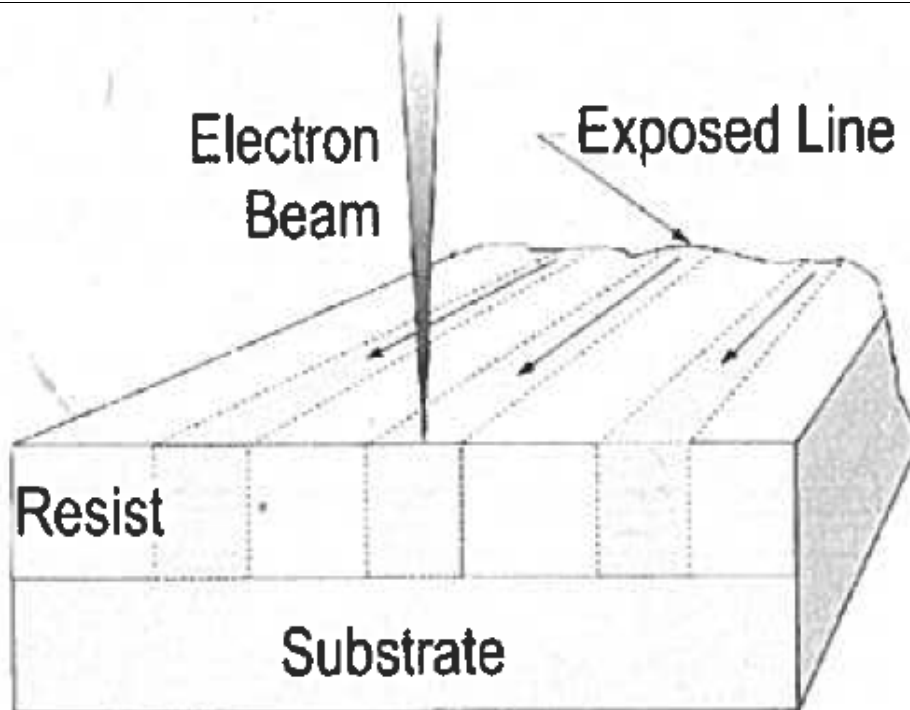


Figure 9. Schematic illustration of the finely focused electron beam exposing a grating pattern in resist.

EX1026, FIG. 9

64. It should be noted that the 30 x 30 μm sub-fields are of the same order as contemplated in the '863 Patent. See EX1001, 17:34-39 (“mirrors in the 35 to 70 micron range likely being desirable (with 50 micron square mirrors being used in a prototype/model)”).

65. It should also be noted that this process (described above) of converting input images to photoresist patterns, using lithography to create nickel shims, and

using the nickel shims to emboss end-product security elements is the same process described by the '863 Patent:

“As discussed earlier, the design program or software generates an output file (as explained in more detail below). To form the micro mirrors according to this output file, a laser system is used to **expose the photo resist material**, usually on a quartz or lime glass master. The photo resist material is normally at least 25 microns thick. The laser or laser system may expose the material in steps such as in about 0.5 μ steps. The exposure settings correspond to the amount of material that will be washed away and not hardened, and this exposure creates a “Z” axis or height of the feature. The resulting micro mirrors (which may be flat or may be concaved for better focus depending upon design) are made in the photo resist material. The photo resist is generally still light sensitive and will “melt” in white light. In some cases, the photo resist is chrome plated in house before processing. The photo resist is then placed in an electroforming tank. The resist is charged and attracts nickel (or other metallic) particles, and **nickel is “grown” on the photo resist as a nickel “shim.”** This nickel shim can be “turned” as needed from negative to positive and back again for tooling. **The nickel shim is then used in the cast and cure process to form the array of micro mirrors oriented as indicated by the output file of the design program or software.”**

EX. 1001, 16:1-29 (emphasis added).

66. This general process was also known to be applied to reflecting micro mirror OVDs and involved orienting the micro mirrors according to the input images, over a decade before the relevant date of the '863 Patent.

“A typical OVD microstructure comprised of a micro-mirror array (Figure 10) may contain up to one million mirrors of dimensions 60 x 60 im or less. **Each mirror is arranged at a predetermined angle according to the input picture information.**

The procedure for producing a micromirror OVD involves three main phases — i) production of an image specific mask by electron beam

lithography, ii) UV exposure through the mask to produce the required micro-mirror surface relief structure in a thick layer of optical resist and iii) electroplating of this resist layer to produce a hard nickel tool.”

EX1026, p. 26.

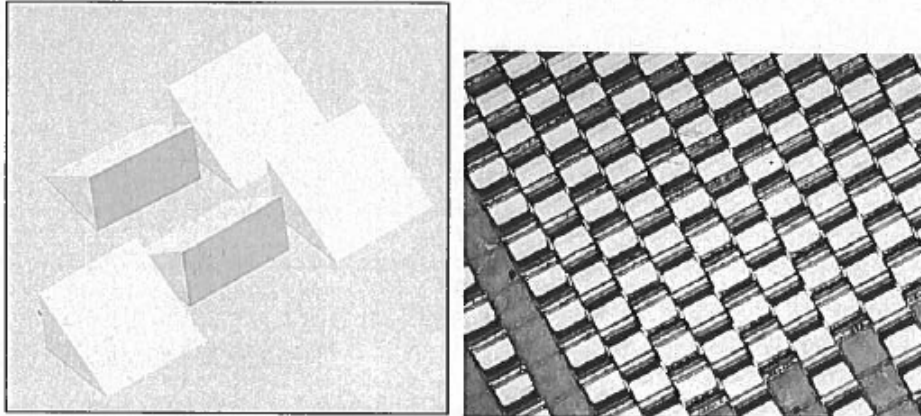


Figure 10. Optical micrograph of an experimental micro-mirror structure. Rows of micro-mirrors of opposing slopes can be seen here. In this particular case, each micro-mirror has a dimension of $30 \times 30 \mu\text{m}$.



Figure 11. Example of artwork to be converted into an optically variable micro-mirror microstructure.



Figure. 12. Images of an experimental micro-mirror optically variable device at two angles of view showing the corresponding images embedded into each channel. Micro-mirrors of opposite slope have been used to reflect the two images into two different viewing directions.

EX1026, FIG. 10-12

67. Computer-implemented software tools to convert geometries and images into lithographically-produced micro-structures was well-known long before the priority date. In fact, most lithography processes begin with a visualization of the images or structures that are to be produced by lithography.

68. As one example, there were well-known software tools to output data files representing images in packages such as 3D-CAD and STL to lithography tools that would produce micro-structures according to images. For example, a research team from Philips published the below methods in an article (*Data preparation for focused ion beam machining of complex three-dimensional structures* (EX1046)) to do so in 2007. According to this method, “complex surfaces can be designed easily in any three-dimensional computer-aided design (CAD) package and then converted into GDSII streams for FIB sputtering or deposition.” EX1046, p. 67-70.

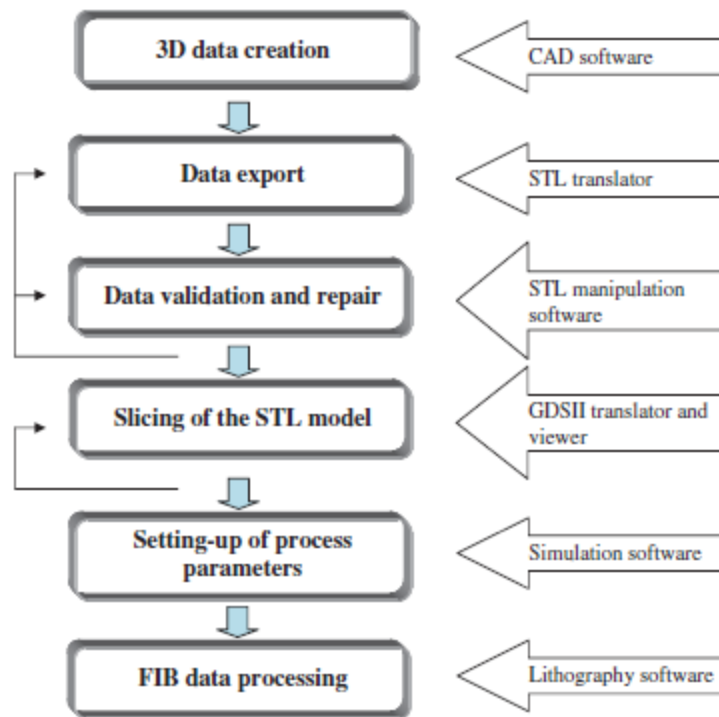


Fig. 1 The key steps of the proposed CAD/CAM method for layer-based FIB processing

VI. THE '863 PATENT

69. In this section, I provide an overview of the '863 patent, a summary of the prosecution history, and a listing of the challenged claims.

A. Overview

70. The '863 patent is titled *Method of fabricating arrays of individually oriented micro mirrors for use in imaging security devices*. Ex. 1001. The '863 patent issued from United States Patent Application No. 17/152,623 ('623 application), which was filed on Jan. 19, 2021. I understand that the '623 application is a continuation of application No. 16/203,128, filed on Nov. 28, 2018, now U.S. Patent No. 10,901,191, which is a divisional of U.S. patent application No.

15/162,113, filed on May 23, 2016, now U.S. Patent No. 10,189,294 ('294 patent). *Id.* The '294 patent claims priority from Provisional Application No. 62/262,767, filed on December 3, 2015. *Id.* Thus, for purposes of my analysis, I have used the provisional application filing date as the effective filing date for the challenged claims. As detailed below, all of the prior art discussed herein was filed, issued, published, or claims priority to a date before December 3, 2015.

B. Specification

71. The '863 patent concerns the problem of designing and fabricating anti-counterfeiting security elements that can be used on documents and products such as currency, and which are more difficult to replicate, and therefore more secure, than anti-counterfeiting elements based on, *e.g.*, moiré pattern printing and holograms. Ex. 1001, 1:19-2:35.

72. The solution described in the '863 patent is a security element that “is configured to ‘write’ images with light in one, two, or more spatial planes above and below the surface of an array of micro mirrors” on a substrate “which may be part of the object upon which the security element is provided such as a piece of currency or a product label”. Ex. 1001, 2:39-42, 3:15-20.

73. A micro mirror is simply a very small mirror. For example, the '863 patent states that the reflecting surface of each micro mirror may be rectangular in shape with a side length of around 50 micrometers (50×10^{-6} meters), and in other

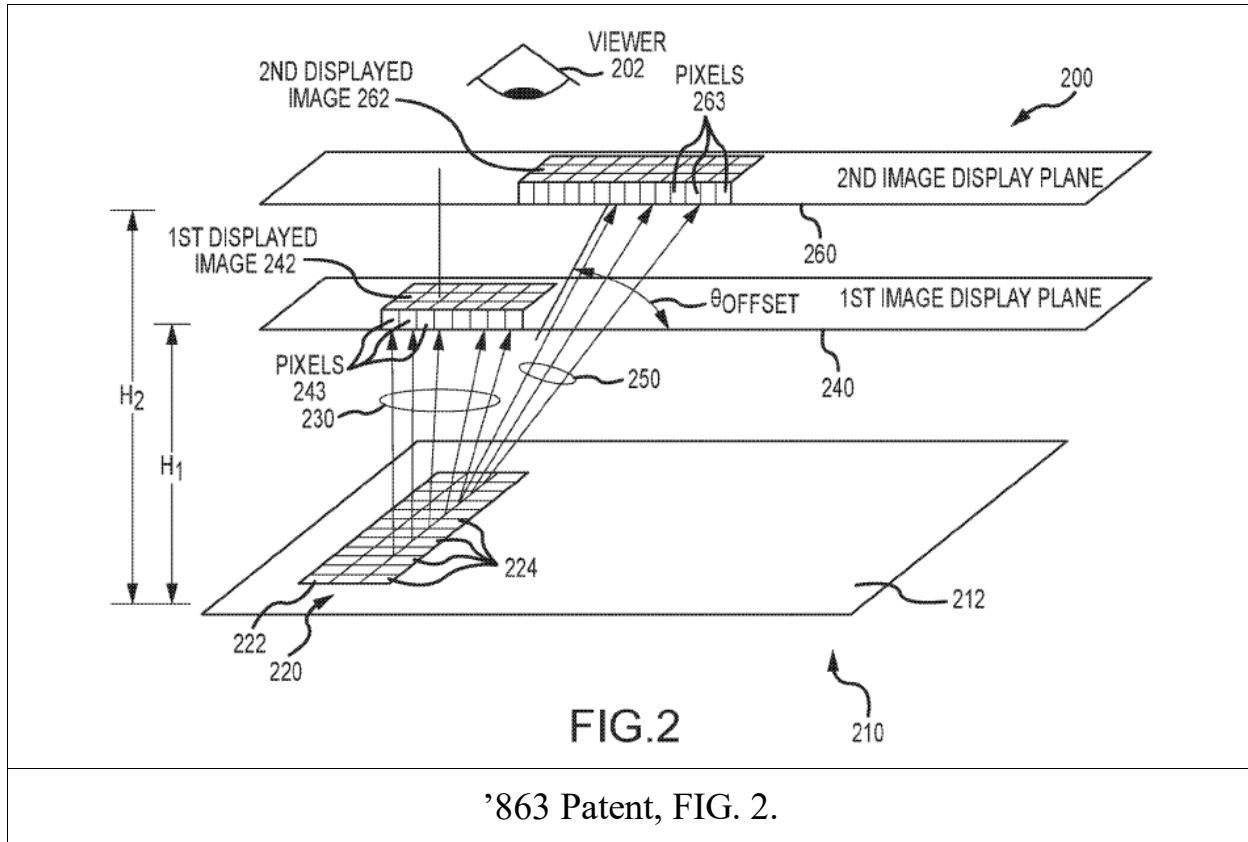
examples, it is circular in shape with a diameter of around 50 micrometers. Ex. 1001, 4:8-13. Each micro mirror “typically will be formed of a metal or metallic compound or other material chosen for its reflective properties.” Ex. 1001, 6:39-44.

74. The concept described in the '863 patent is to split the array of micro mirrors into different subsets, each of which is designed to reflect ambient light to produce a “point source of light,” or “pixel.” These pixels together form an image in a common “image display plane.” Multiple images may be produced in different image display planes. The result is to create “floating image(s)” “a height or distance above (or below in some cases) the place of the supporting surface containing the array of micro mirrors.” Ex. 1001, 5:14-6:15.

75. FIG. 2 illustrates this: a “security device 220 has an exposed or upper surface 222 that is configured to provide an array of micro mirrors 224, which may be individually oriented to provide reflection of ambient light striking the surface 222 of the security element 220 so as to display one or more floating images that can be observed by a viewer 202.” Ex. 1001, 7:35-41.

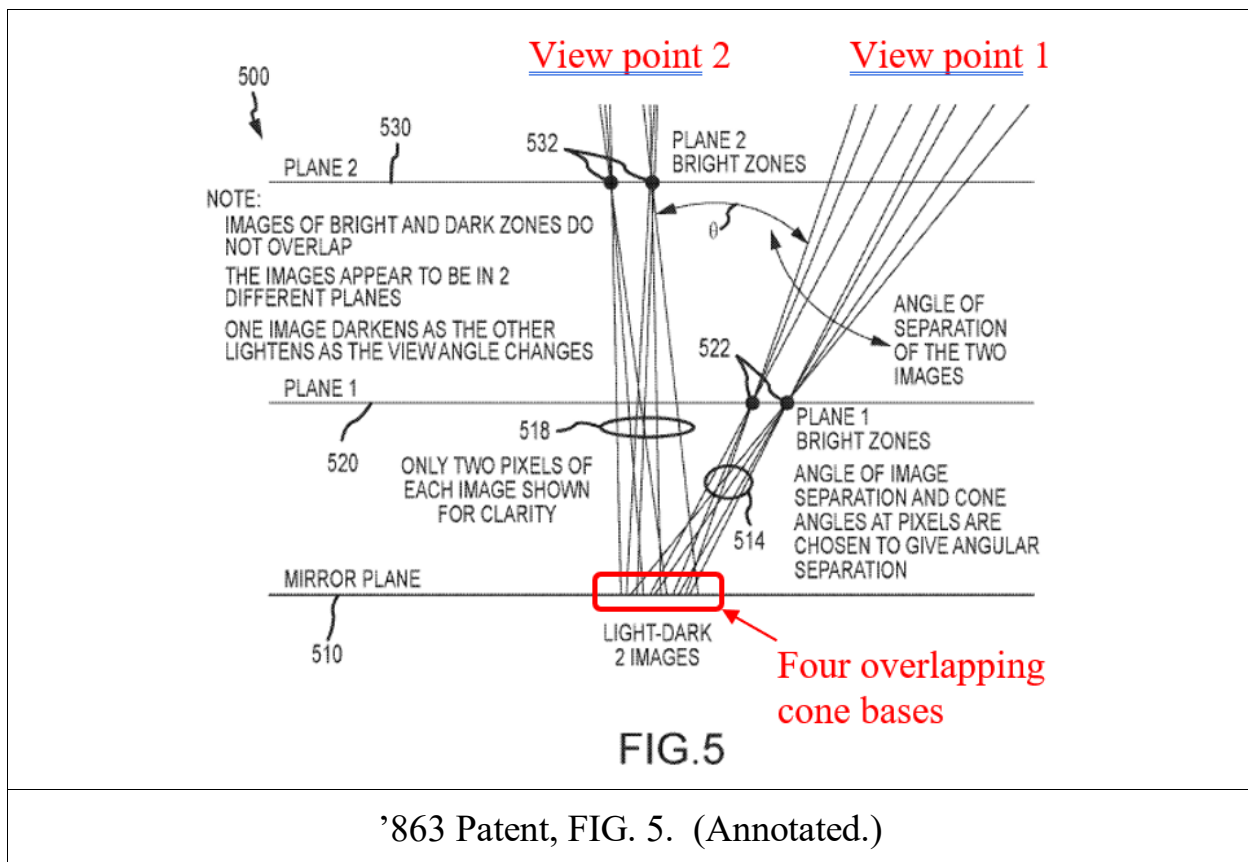
76. The micro mirrors in the subsets that create the first displayed image are oriented relative to those in the subsets that create the second displayed image “so that the pixels 243 of the first image 242 are a viewing angle offset, θ_{Offset} , (e.g., 10 to 30 degrees) from the pixels 263 of the second image 262 so that the viewer

202 typically only views one of the floating images 242, 262 at a time.” Ex. 1001, 8:6-12.



77. FIG. 5 illustrates the intersection of light rays from different subsets of micro mirrors to form pixels in different image display planes. In most embodiments, each pixel can be considered the apex of a cone whose base on the substrate contains the subset of micro mirrors that produce that pixel. Ex. 1001, 7:61-65. Not all of the micro mirrors in the base of the cone that corresponds to a given pixel are contained in the subset which produces that pixel. Ex. 1001, 8:25-29.

78. In FIG. 5 all four sets of rays, i.e., the two sets of “beams/rays 514” that intersect to produce the two distinct “pixels 522” in image display plane 1 and the two sets of “beams/rays 518” that intersect to produce the two distinct “pixels 532” in image display plane 2, are reflected in four cones whose bases overlap. Ex. 1001, 9:24-50.

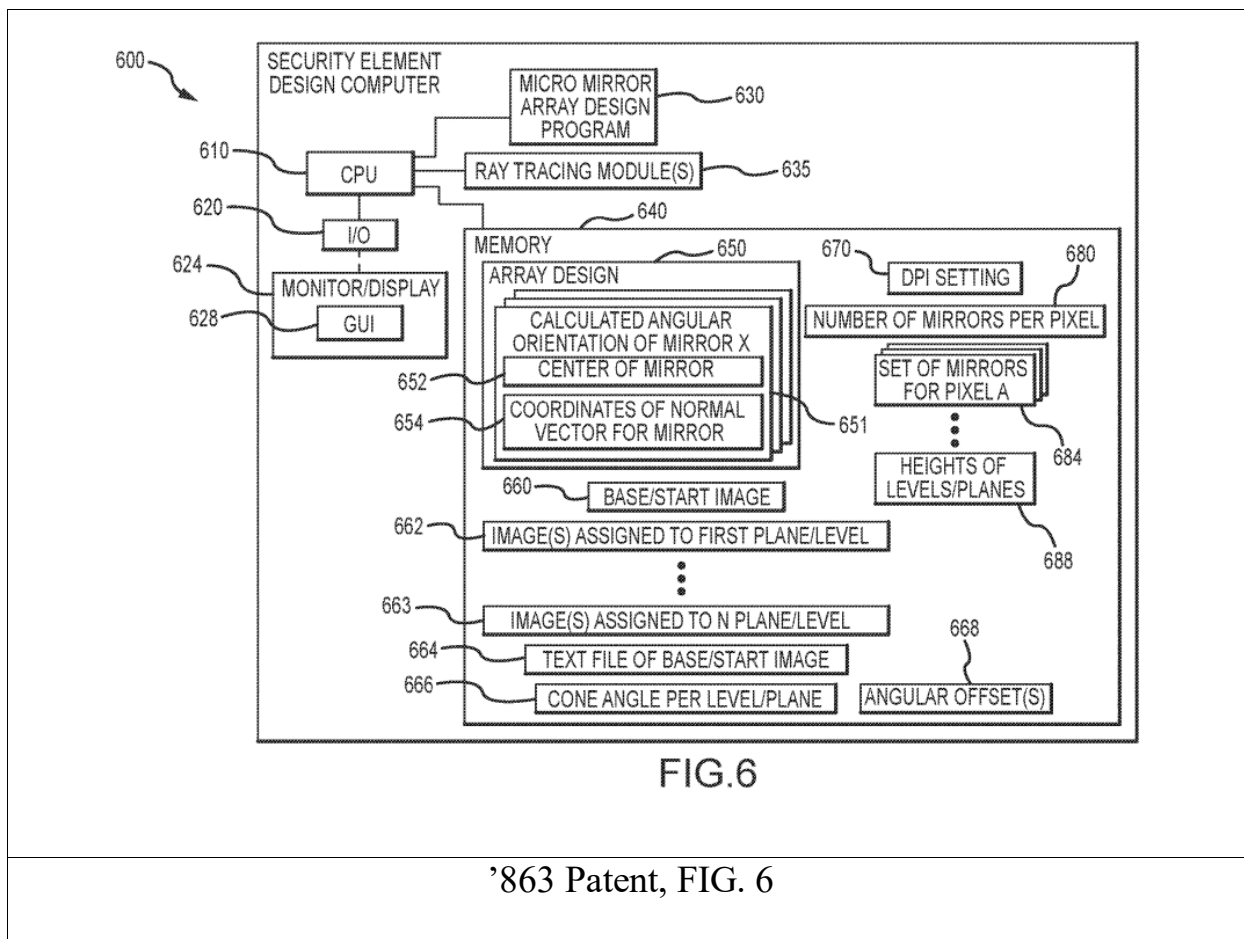


79. In embodiments such as that illustrated in FIG. 5, the micro mirrors are “adapted specifically to provide two light and dark images.” Ex. 1001, 9:24-27. When the security element is viewed from viewpoint 1, which is illuminated by the reflected rays that form “pixels 522”, the image in image display plane 1 will appear

light and the image in image display plane 2, the rays of which are directed away from viewpoint 1, will appear dark. When the security element is viewed from viewpoint 2, which is illuminated by the reflected rays that form “pixels 532”, the situation reverses: “One image darkens as the other lightens as the view angle changes.” The “angle of image separation, ϕ ” (“ θ ” in FIG. 5) and the cone angles at the pixels, i.e., the angles made by the sides of the cones where they meet at the apex, are chosen to give the angular separation between the viewpoints. Ex. 1001, 9:51-63. Because the image can appear to change as the viewing angle changes, it is possible to produce an “animation effect.” Ex. 1001, 17:40-63.

80. In association with Figure 6 and its related discussion, the '863 teaches “a computer” “to run an array design program to allow an operator to generate a design of an array of micro mirrors for displaying a particular image(s) when provided in a security element (e.g., to perform steps of the method of manufacturing a security element with an array of micro mirrors according to the present description).” Ex. 1001, 9:64-11:44.

81. The computer 600 includes processor 610 that executes code to run micro mirror array design program 630, as shown in Figure 6 below. *See* Ex. 1001, 10:3-8.



C. Prosecution History

82. One non-final Office Action was issued during the prosecution of the application from which the ’863 patent issued.

83. On July 6, 2022, a non-final rejection was issued where claims 1-20 were rejected as being indefinite. Ex. 1002, p. 51-55. The Examiner explained:

“Claims 1, 7, 12 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being incomplete for omitting essential steps, such omission amounting to a gap between the steps. See MPEP § 2172.01. The omitted steps are: the claims fail to recite further limitations or steps for fabricating said security element. A design output file is generated, however, the claims lack limitations or

steps as to how the design output file is used to fabricate the security element. For purposes of examination, it is suggested to add the limitation ‘and forming the array of micro mirrors according to the design output file.’ Appropriate correction is required.”

Ex. 1002, p. 53.

84. Dependent claims 2-6, 8-11, 13-20 were rejected for inheriting the same deficiencies as claims 1, 7 and 12. *Id.*, p. 54.

85. On, July 18, 2022, Applicant amended claims 1, 7 and 12 “to address the indefiniteness rejection presented in the Office Action by adding a step as urged by the Office.” Ex. 1002, p. 41-47. *Id.* Applicant explained that it “amended the claims as suggested by the Examiner to include the step of ‘forming the array of micro mirrors according to the design output file’ (or similar language) in each of these independent claims.” *Id.*, p. 46. Applicant also amended claim 15 to correct a typographical error. *Id.*, pp. 44, 46.

86. On August 1, 2022, the Examiner allowed the claims. Ex. 1002, pp. 21-29. Examiner’s statement of reasons for allowance stated as follows:

“Claim 1 is allowable over the prior art of record for at least the reason that even though the prior art discloses a method of fabricating a security element, comprising: assigning a first object in a starting digital image to a first image display plane and a second object in the starting digital image to a second image display plane; with a processor of a computing device, ***the prior art fails to teach or reasonably suggest***, executing code to provide an array design module that operates to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of the first object in the first image display plane and to display each of the pixels of the second object in the second image display plane; for each of the pixels, determining with the array design

module an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors and forming the array of the micro mirrors according to the design output file, in combination with the other limitations of claim 1. . . .

Claim 7 is allowable over the prior art for at least the reason that even though the prior art discloses a method of fabricating a security element, comprising: with a processor of a computing device, ***the prior art fails to teach or reasonably suggest***, executing code to provide an array design module configured to select a set of micro mirrors in an array of the micro mirrors to display pixels of a first object in a first image display plane and to display pixels of a second object in a second image display plane spaced apart from the first image display plane; for each of the pixels, determining, with the array design module, an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors; generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors, wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of the micro mirrors; and forming the array of the micro mirrors according to the design output file, in combination with the other limitations of claim 7. . . .

Claim 12 is allowable over the prior art of record for at least the reason that even though the prior art discloses a method of fabricating a security element useful on paper and coin currency and on product labels, comprising: with a processor of a computing device, ***the prior art fails to teach or reasonably suggest***, executing code to provide an array design module configured to define an array of micro mirrors to be formed on a surface of a substrate; generating a design output file including an angular orientation and location coordinates in the array for each of the micro mirrors, and forming the array of micro mirrors according to the design output file, wherein the array of micro mirrors is configured, when formed on the surface of the substrate, for receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate, wherein the image comprises a plurality of pixels, and wherein the array of micro mirrors

includes for each of the pixels a different set of the micro mirrors each having a reflective surface oriented, in a fixed manner, with a body of each of the micro mirrors rotated about at least one of first and second rotation axes extending through the body, to reflect the ambient light toward a point on the plane corresponding to one of the pixels, in combination with the other limitations of claim 12.”

Ex. 1002, pp. 26-28.

87. However, as will be discussed throughout this declaration, these elements were known in the art.

VII. LEVEL OF ORDINARY SKILL IN THE ART

88. In my opinion, a POSITA as of December 3, 2015, would have had an undergraduate degree in mechanical or electrical engineering or physics and at least two years of experience in micro-optics design. The following factors support my opinion.

89. First, the typical level of education for persons working in the field would include an undergraduate degree in mechanical or electrical engineering or physics. Micro-optic based security features are a combination of optical and mechanical design elements. For example, I would expect a typical engineer who works for a micro-optic design company to have an undergraduate degree in one of these fields.

90. Certain engineers will have more advanced degrees, such as a masters or Ph.D. in a more-specialized area of optics or optoelectronics, but an undergraduate degree in mechanical or electrical engineering or physics would be

the typical background and would provide engineers in the field with a baseline knowledge of the optical and mechanical design principles underlying micro-optic based security features. I also note that a student on track for a degree in mechanical or electrical engineering or physics would have sufficient exposure to optics principles to then work or conduct research in that area in academia or industry.

91. Second, at least two years of experience in the field would be typical for a person deemed to have ordinary skill in the technology underlying the '863 patent. This level of experience would provide an engineer with more specialized focus in optics and device structure. He or she would have been familiar with the design principles and tradeoffs underlying the subject matter of the '863 patent.

92. Third, the types of problems typically encountered in the field relate to improving anti-counterfeit ability, image quality, cost, visual appeal, and mechanical stability. An engineer with a mechanical or electrical or physics background and at least two years of work experience with micro-optic based security features would have been familiar with these problems and working on solutions to address them. For example, a typical engineer at that level would be tasked with evaluating different types of micro-optic based security features to decide whether they improve accuracy and detection capability and are cost-effective. He or she would also be tasked with evaluating different optics elements for the same reasons.

93. Fourth, the proposed level of skill is consistent with the sophistication of the technology claimed in the '863 Patent. The patent concerns micro-optic design, including the use of certain micro mirrors and substrates. The level of sophistication is such that an advanced degree or work experience beyond two years would not be necessary to understand the technology and make informed design decisions.

94. For the above reasons, it is my opinion that the appropriate level of skill in the art is an undergraduate degree in electrical engineering, mechanical engineering, or physics and at least two years of experience in micro-optic based security features.

VIII. CLAIM CONSTRUCTION

95. For purposes of this proceeding, I have applied the ordinary and customary meaning of the claim terms as they would have been understood to a POSITA at the time of the alleged invention of the '863 Patent, and I have considered that meaning in the context of the patent and its prosecution history.

96. I reserve the right to offer additional claim construction opinions in other proceedings, including indefiniteness opinions that I understand are not at issue in this proceeding. I also reserve the right to respond to any claim construction positions put forward by Patent Owner.

IX. OVERVIEW OF THE PRIOR ART

97. In this section, I provide an overview of the prior art references that I have relied on to inform my opinions.

A. PCT Pub. No. WO2012/048847 (“Fuhse847”)(Ex. 1022)

98. Fuhse847 relates to a security element (for example on banknotes) created from an array of optical reflective or refractive elements (such as micromirrors) which create a two or three-dimensional motif consisting of multiple components which “float at several different floating heights above or below the surface region in order to form a three-dimensional motif.” Fuhse847, p. 5.

99. The motifs may correspond to various objects in digital images in various forms, such as 3D-CAD, computer-aided technical drawings, and images produced through 3D laser scanning of real three-dimensional bodies. Fuhse847, p. 10.

100. An image can also contain multiple two-dimensional images that are “visible from the same or different viewing angles.” Fuhse847, p. 26. Each image is “only visible in a limited angle range.” Fuhse847, p. 25.

101. With respect to the optical elements, Fuhse847 recognizes that curved mirrors and lenses may be broken down into arrays of smaller, flat micromirrors, with the advantage of easier fabrication and calculation:

“In addition, when breaking down a convex mirror or a curved lens into a plurality of micro-optical elements, the surfaces of the

micro-optical elements, which in principle are also initially curved, can generally be replaced by flat surfaces because of their small size. This replacement has no adverse effects on the light-spot image produced, particularly if the dimensions of the micro-optical elements are smaller than the resolution of the viewing situation. The advantage is that micro-optic elements with flat surfaces are easier to calculate and produce. From this point of view, it may even be advisable to break down convex mirrors or lenses into small micro-optical elements with flat surfaces if nesting several groups of micro-optical elements is not desired or necessary.”

Fuhse847, p. 19.

102. Fuhse847 continues that curved mirrors may be replaced by “an arrangement of $n \times n$ micromirrors.” Fuhse847, pp. 19-20. The micromirrors may, for example, have “a flat mirror surface” with a “dimension of $50 \mu\text{m} \times 50 \mu\text{m}$.” Fuhse847, pp. 19-20.

103. Figure 2 shows a simplified example with three image points produced by three mirrors, but in practice “a security element 20 will typically have a large number, for example a few tens, a few hundred or even several thousand, refractive and/or reflective optical elements 24.” Fuhse847, pp. 13-14.

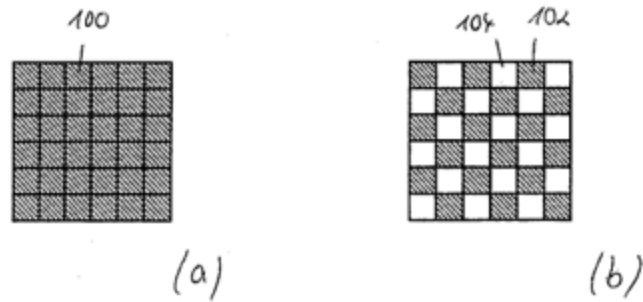


Fig. 8

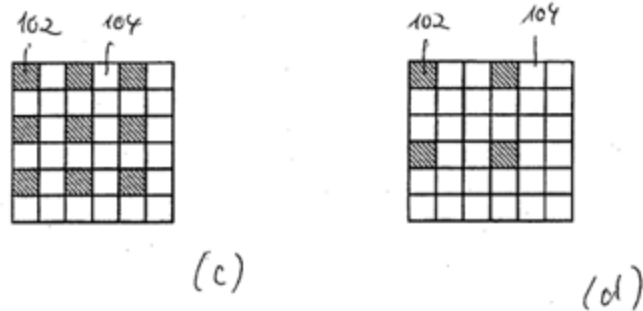
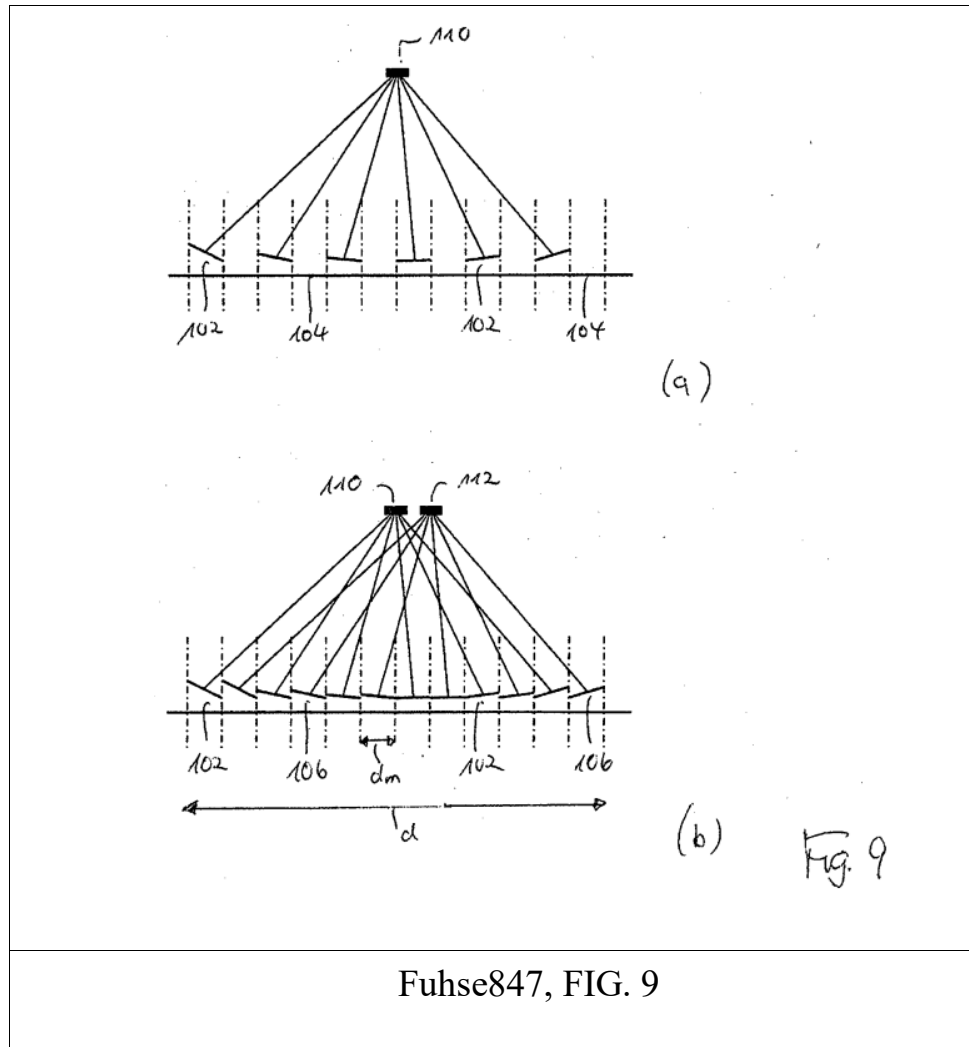


Fig. 8

Fuhse847, pp. 19-20.

106. The flat micromirrors may be an array of “ $n \times n$ micromirrors” that each have “a flat mirror surface” with a “dimension of $50 \mu\text{m} \times 50 \mu\text{m}$.” Fuhse847, pp. 19-20. Further, a plurality of micromirrors may be “assigned to every light spot of the light-spot image,” as shown in Figure 9 below.

107. As Fuhse847 explains, “not only one optical element, but a plurality of optical elements is assigned to every light spot of the light-spot image.” Fuhse847, p. 6. This is shown in Figure 9:



Fuhse847, FIG. 9

108. Fuhse847 describes an exemplary method for producing its images:

“— a desired three-dimensional motif having image points P_j and height values Z_j above an xy plane is specified, the image points corresponding to the light spots created upon illumination,

— for every image point P_j , a brightness I_j between 0% and 100% is defined,

— there are assigned to the image points P_j aperture cones that have an aperture ratio > 0.2 ,

- for every image point P_j , a sphere of influence E_j is determined by an intersection of the aperture cone originating from the image point with the x-y plane,
- the x-y plane is divided into a number of coarse fields, and the coarse fields are each divided into a number of fine fields,
- for every image point P_j , based on the defined height value Z_j and the defined brightness value I_j , a number of fine fields to be filled in is determined,
- the fine fields to be filled in determined for the image point P_j are distributed substantially evenly across the coarse fields in the sphere of influence E_j of the image point P_j , and
- the fine fields to be filled in are covered with refractive and/or reflective optical elements that, upon illumination of the depiction element, contribute to producing the light spot that corresponds to image point P_j .”

Fuhse847, pp. 9-10.

109. This method is described in further detail at pp. 27-29.

110. Fuhse847 describes an exemplary method for producing its images that in part includes defining the image points for the image, defining a cone for each image point such that a “sphere of influence” is defined on the substrate plane for assigning micromirrors to that image point. Fuhse847, pp. 9-10, 27-29. Fuhse847’s Figure 10 and associated descriptions further teach how to orient each micromirror in the array such that it reflects light to its assigned light spot. Fuhse847, pp. 21-22.

111. Fuhse847 teaches that the orientation of each mirror within the array necessary to form the required images can be calculated as follows:

“For the calculation, (x_0, y_0, z_0) denotes the position of light spot 110 to be produced with $z_0 > 0$, $(x, y, 0)$ denotes the position of the mirror element to be calculated. $\vec{n}$ is the normal vector of the mirror at position $(x, y, 0)$, $\vec{k}$ is the direction vector of the incident light ray and $\vec{p}$ is the direction vector of the reflected light ray.

The position of the mirror surfaces, i.e. the normal vector n , is to be determined in such a way that the light incident from a specified direction $\vec{k}$ is reflected onto the focal point (x_0, y_0, z_0) for all micromirrors 102 assigned to light spot 110.

According to the invention, this is achieved by

$$\vec{n} = \frac{\frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|}}{\left| \frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|} \right|}, \quad \vec{p} = \begin{pmatrix} x_0 - x \\ y_0 - y \\ z_0 \end{pmatrix}, \quad |\vec{p}| = \sqrt{(x_0 - x)^2 + (y_0 - y)^2 + z_0^2}$$

[0098] If the light source 120 is at the position (x_L, y_L, z_L) , then

$$\frac{\vec{k}}{|\vec{k}|} = \frac{\begin{pmatrix} x_L - x \\ y_L - y \\ z_L \end{pmatrix}}{\sqrt{(x_L - x)^2 + (y_L - y)^2 + z_L^2}}$$

[0099] If the micromirror group 102 is designed for vertical incidence of light, then

$$\frac{\vec{k}}{|\vec{k}|} = \begin{pmatrix} 0 \\ 0 \\ -1 \end{pmatrix} ,$$

resulting in the normal vector $\vec{n}$

$$\vec{n} = \frac{\frac{\vec{p}_n}{|\vec{p}_n|} - \frac{\vec{k}}{|\vec{k}|}}{\left| \frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|} \right|} = \frac{\begin{pmatrix} x_0 - x \\ y_0 - y \\ z_0 + \sqrt{} \end{pmatrix}}{\sqrt{(x_0 - x)^2 + (y_0 - y)^2 + (z_0 + \sqrt{})^2}} ,$$

wherein the abbreviation

$$\sqrt{} = \sqrt{(x_0 - x)^2 + (y_0 - y)^2 + z_0^2}$$

was used.”

Fuhse847, pp. 21-22.

112. The images may be any arbitrary three-dimensional image, including any two-dimensional image “that floats at a certain height above or below the substrate surface.” Fuhse847, pp. 16, 13-14.

113. It is possible to create darker areas in the image using “mirrors that are oriented in such a way that spatial regions that do not contain any light sources are reflected.” Fuhse847, p. 24.

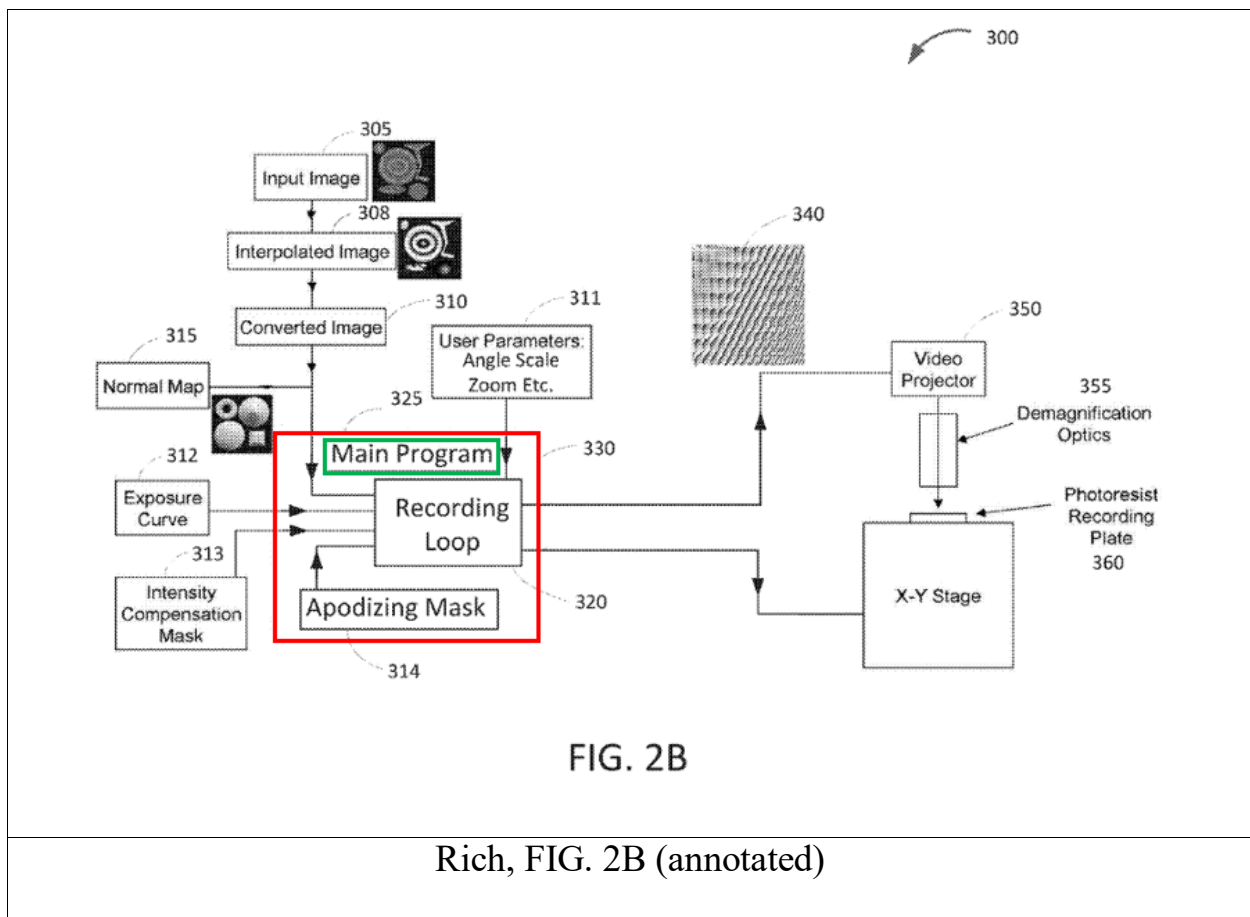
114. Fuhse847 also describes a “further development of the invention” regarding providing different images to the viewer when viewed at different angles (*see* pp. 25-26) and describes a “preferred procedure” to produce the structures of these combined teachings. Fuhse847, pp. 27-28, 9-10.

115. In the combined teachings of FIG. 2 and FIGs. 8-10, Fuhse847 teaches a substrate and ambient light source (as described in FIG. 2), as well as arrays of micromirrors that include assignments of sets of micromirrors to light spots that form light spot images.

B. U.S. Patent No. 10,859,851 (“Rich”)(Ex. 1039)

116. Rich relates to “[a]n optical product” that “can be configured to be an anti-counterfeit feature such as a patch, a window, or a thread on a banknote,” and further configured “when illuminated, to reproduce by reflected or refracted light, a 3D image of at least a part of a 3D object.” Rich, Abstract.

117. Rich discloses processor 330 (shown in red) running main program 325 (shown in green), as shown below in Figure 2B of Rich. Rich discloses that FIG. 2B “illustrates an example method that can be used to manufacture the master 10 and also to determine the data file to be used to manufacture the master 10, *e.g.*, to determine the pattern of the features $F_1, F_2, \dots F_n$ on the surface 12 of the master 10.” Rich, 16:33-17:7. The “master” is the “shim” used to mass-produce the “optical products” (*e.g.*, on currency) that “when illuminated, can reproduce an overt 3D image (*e.g.*, an image that appears 3D to the naked eye) of a 3D object. Rich, 4:25-56.



C. U.S. Patent No. 10,639,925 (“Fuhse925”)(Ex. 1008)

118. Fuhse’925 relates to an optical security element that shows different images (such as characters, numbers or shapes, referred to as curves in the patent) at different viewing/tilt angles, that “float alternatingly a few millimeters above or below the plane of the security thread.” Fuhse925, Abstract, 6:67-7:1.

119. These images are created using an array of micro mirrors orientated at different inclination angles on a substrate. Fuhse925, Abstract, 6:67-7:1.

D. Sauvage-Vincent (Ex. 1033)

120. Sauvage-Vincent relates to manufacturing techniques of a reflective optical security element, such as would be applied to a banknote. EX1033, ¶¶0002, Abstract. Sauvage-Vincent teaches a “die” or “master” that provides a “stamping operation” to produce the microstructure pattern of the desired optical elements. EX1033, ¶¶71, 73, 43, Abstract. The “stamping operation is performed from the die to transfer the microstructure onto a film and structure the layer of dielectric material 101,” such as a film of polymer material. EX1033, ¶¶71, 73, 43, Abstract. This “stamping may be done by hot pressing of the dielectric material (‘hot embossing’) or by molding then cross-linking (‘UV casting’).” *Id.*

E. Morford (Ex. 1024)

121. Morford relates to materials for use in optical components that have properties such as flexibility, high refractivity, and is curable with ultraviolet (UV) light. Morford, Abstract.

X. INVALIDITY ANALYSIS

122. Below I provide a summary of the prior art combinations that I address in more detail below.

- Ground 1: Claims 1-2, 4-6, 12-14 of the '863 Patent are rendered obvious under 35 U.S.C. §103 by Fuhse847 in view of Rich;
- Ground 2: Claims 3, 6-14 of the '863 Patent are rendered obvious under 35 U.S.C. §103 by Ground 1 in further view of Fuhse925;
- Ground 3: Claims 15-18 of the '863 Patent is rendered obvious under 35 U.S.C. §103 by Ground 1 in further view of Sauvage-Vincent.
- Ground 4: Claims 15-18 of the '863 Patent is rendered obvious under 35 U.S.C. §103 by Ground 2 in further view of Sauvage-Vincent.
- Ground 5: Claims 19-20 of the '863 Patent is rendered obvious under 35 U.S.C. §103 by Ground 1 in further view of Morford.
- Ground 6: Claims 19-20 of the '863 Patent is rendered obvious under 35 U.S.C. §103 by Ground 2 in further view of Morford.

A. Ground 1: Fuhse847 in view of Rich Renders Obvious Claims 1-2, 4-6, and 12-14

123. In my opinion, Fuhse847 in view of Rich render obvious claims 1-2, 4-6, and 12-14 of the '863 patent.

1. Combined Teachings of Fuhse847

a) Motivation to Combine

124. Fuhse847 describes an invention of “a depiction” element. Fuhse847, 4, Abstract. This invention is described by several Figures and accompanying descriptions that are relied on in this declaration, including Figures 1-2, 8(a)-(d), and 9-10. To the extent that these descriptions represent different embodiments for purposes of obviousness, in my opinion, it would have been obvious to combine them.

125. Fuhse847 provides express motivation and direction to combine the features of its embodiments. Figure 2 of Fuhse847 shows various aspects and elements “[t]o explain the principle of the invention.” Fuhse847, 13-15. Figures 8(a)-(d) build on Figure 2 by replacing the “curved concave mirror” of Figure 2 by using micromirrors. Fuhse847, 12 (“Fig. 8 shows in (a) to (d) four exemplary embodiments in which a curved concave mirror is broken down into micro-optical elements with a square base and a flat mirror surface”). Fuhse847 explicitly refers back to the “previous exemplary embodiments” in building on those teachings. Fuhse847, 19-20. Also, the Figures 8(a)-8(d) show different variations of the same teachings, such as different numbers of groupings of micromirrors. Fuhse847

provides explicit motivation to replace the curved mirrors of Figure 2 with flat micromirrors, including that “higher resolution” is obtained and that “flat surfaces are easier to calculate and produce.” Fuhse847, 19.

126. Likewise, Figure 9 builds on the teachings of Figures 8(a)-8(d) by illustrating them “in a sectional view” and providing further explanation. Fuhse847, 20-21, 13. Finally, Figure 10 builds on the teachings of Figures 8(a)-8(d) and 9 by describing how to calculate the orientation of the surfaces of the micromirrors. Fuhse847, 21-23, 13 (“Fig. 10 illustrates the calculation of the flat mirror surfaces of the micromirrors of Figs. 8 and 9”). Fuhse847 also describes a “further development of the invention” regarding providing different images to the viewer when viewed at different angles (*see* 25-26) and describes a “preferred procedure” to produce the structures of these combined teachings. Fuhse847, 27-28, 9-10.

b) Reasonable Expectation of Success

127. In my opinion, there would have been a reasonable expectation of success combining the embodiments of Fuhse847. As a POSITA would have recognized, the teachings of Fuhse847 relied on in this Ground (discussed in the Motivation) represent different aspects of the purported invention that all operate on the same principle, and work to disclose different aspects that rely on the same principles. The aspects of the Figure 2 disclosures relied on – such as the substrate and ambient light (*see* Ground 1, elements [1a] and [1b.1]) – would operate on the

same principles, serve the same purpose, and maintain the same relevant characteristics when applied to the array of micromirrors of Figure 8-10. Fuhse847 teaches to “replace[]” the curved mirrors of Figure 2 with the plurality of flat micromirrors 100 (*see* Fuhse847, 19), and a POSITA would have reasonably been able to adapt those teachings regarding Figure 2 to flat micromirrors. Likewise, the different specific implementations, such as possible arrays sizes of 100 micromirrors (*see* 19-20) or 288 micromirrors (*see* 20-21), would have been routinely and predictably implemented by a POSITA.

128. The art was relatively predictable in the relevant timeframe (2015). *Id.* The predictable nature of the combination is confirmed by evidence showing that the operation of micromirror arrays—and their application to security elements—was well-understood at the time of the alleged priority date. Given that micromirror arrays of the type contemplated in the ’863 Patent were textbook knowledge at the time of the alleged invention, a POSITA would have no difficulty combining embodiments of Fuhse847. Thus, a POSITA would have been able to implement the obviousness modifications in this ground without difficulty and with a reasonable expectation of success. *Id.*

2. Combined Teachings of Fuhse847 in view of Rich

a) Motivation to Combine

129. It is my opinion that a POSITA would have found it obvious to apply the teachings of Rich to Fuhse847. Fuhse847 and Rich both relate to security elements for data carriers (e.g., banknotes, etc.) with arrays of reflective micro mirrors that are arranged to produce, upon illumination, three-dimensional motifs, and thus are in the same field. Fuhse847, Abstract; Rich, Abstract.

130. It is my opinion that a POSITA would have looked to Rich when reviewing Fuhse847. Fuhse847 teaches that techniques that require software running on processors of computer systems, such as 3D-CAD (3D Computer Aided Design), computer-aided technical drawings, and 3D laser scanning of real three-dimensional bodies. Fuhse847, pp. 10-11. These techniques are required to implement aspects of Fuhse847's invention, such as the creating of the "data sets" describing the pixels of the images to be displayed and assigning micromirrors to pixels. *Id.*

131. Fuhse847 also discloses steps and techniques that a POSITA would understand would be implemented by software running on processors of computer systems because they would be very difficult, if not impossible, to manually perform without the aid of computing. For example, Fuhse847's methods include arrays of

“several thousand” micro mirrors that all require individual vector computations to fabricate their correct orientation. Fuhse847, pp. 14, 21-24.

132. Given these explicit and implicit teachings, a POSITA would understand that software running on processors of computer systems would be necessary to implement Fuhse847’s teachings, and would look to computer implementations in the art to do so. However, it is not expressed in explicit detail how to implement this computing. Rich teaches what Fuhse847 does not explicitly disclose, namely, that a Rich discloses processor 330 running a main program 325, as shown in Figure 2B of Rich. Rich, 16:33-17:7.

133. It would therefore have been obvious for a POSITA to examine how computing methods in micro mirror design are implemented when reviewing Fuhse847 in order to implement what is taught in Fuhse847.

134. Rich provides explicit detail for implementing what Fuhse847 teaches, namely a software running on processors of computer systems to take input images and output files to construct micro mirror arrays that produce those images.

135. As Rich explains, and as shown in Figure 2B, Rich teaches that processor 330 running a main program 325 takes input image files and “determine[s] the pattern of the features” for the surfaces of the micro mirrors, and outputs data files that provide the “orientation” and placement of each micromirror to be produced by lithography techniques. Rich, 16:33-17:7.

136. Whereas Fuhse847 discloses methods for preparing micro mirror arrays according to digital images that require computing and software, Rich provides further explicit detail for how to implement software running on processors of computer systems in order to do. Thus, it is my opinion that it would have been obvious for a POSITA to combine Fuhse847 and Rich.

137. Additionally, using Rich's teachings regarding software running on processors of computer systems in Fuhse847's system would have involved using a known technique to improve Fuhse847 in a known way, without unpredictable results, and would thus also have been obvious.

b) Reasonable Expectation of Success

138. It is my opinion that a POSITA would have had a reasonable expectation of success in implementing the combination of Fuhse847 and Rich. Here, the art was relatively predictable in the relevant timeframe (2015). A POSITA would have been able to implement the obviousness modifications in this ground without difficulty. The predictable nature of the art is confirmed by evidence showing that the operation and preparation of micromirror arrays—and their application to security elements—was well-understood at the time of the alleged priority date. As I have detailed in the Technical Background (see Section V), the various aspects of the technology at issue, including micro-mirror arrays (V.B.2), ray optics (V.B), orientations of mirrors (V.C), and fabrication of optical micro-

devices (V.D), and computer-implemented methodologies (V.E), were all well-known and known to work well before 2015. As discussed in Section V.A, the technology at issue was mature and known to work. Accordingly, a POSITA would have no difficulty implementing the modifications discussed. Further, given that micromirror arrays of the type contemplated in the '863 Patent were textbook knowledge at the time of the alleged invention, a POSITA would have no difficulty combining embodiments of Fuhse847.

139. The art related converting input images into formats for lithography, and fabrication of OVDs according to the input images was mature and known to work. As I mentioned above and discussed in Section V.E (Technology Background, Computer-Implemented Methodologies), decades before the relevant date, it was well-known to generate complex images, such as portraits, in OVDs (e.g., on banknotes) from images using lithographic tools.

140. For example, a decade before known methods were known in the art to develop an OVD by: preparing artwork in an Adobe Photoshop file using software, converting the artwork to electron beam format, and fabricating a master (i.e., a die for mass production of OVDs) with feature sizes the same as or smaller than those contemplated in the '863 Patent. Section V.E, ¶¶61-68. In other examples, micro-mirror arrays with similar feature sizes to those the same as or smaller than those

contemplated in the '863 Patent were developed using similar processes, including orienting the mirrors according to the input picture.

141. Other well-known software tools were widely available to output data files representing images in packages such as 3D-CAD and STL to lithography tools that would produce micro-structures according to images. For example, a research team from Philips published the below methods in an article (*Data preparation for focused ion beam machining of complex three-dimensional structures* (EX1046)) to do so in 2007. According to this method, “complex surfaces can be designed easily in any three-dimensional computer-aided design (CAD) package and then converted into GDSII streams for FIB sputtering or deposition.” EX1046, p. 67-70.

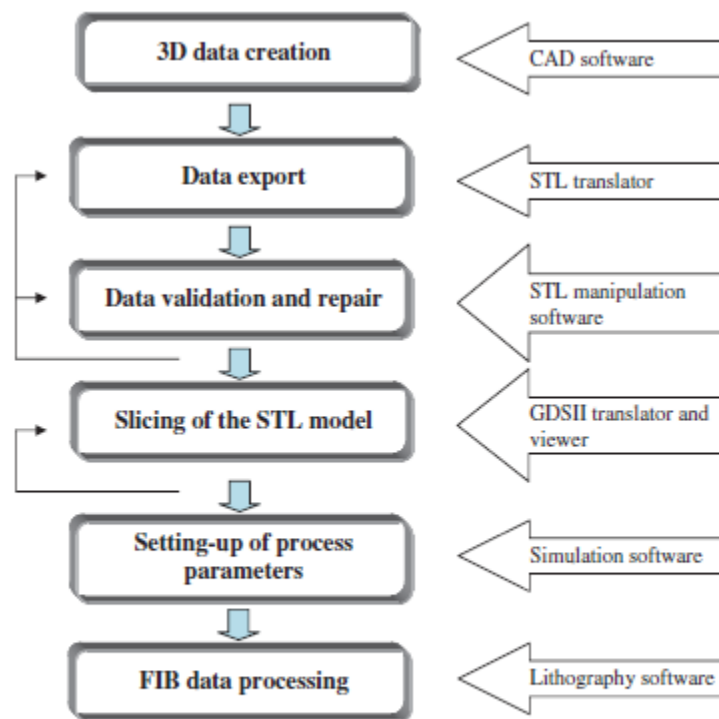


Fig. 1 The key steps of the proposed CAD/CAM method for layer-based FIB processing

EX1046, FIG. 1. Fuhse847 recognizes that these tools would be known to a POSITA, explaining that “data formats and processing methods” for software tools such as 3D-CAD, VRML, and STL were “basically known to the person skilled in the art.” Fuhse847, p. 10.

142. Given the mature state of the art, it would be routine and predictable for a POSITA to implement the system of Fuhse847 teachings according to the computer-implemented methodologies of Rich in 2015. The use of software programs like 3D-CAD would fall squarely within the level of skill of a POSITA, as computer-aided design was an integral part of the art before the relevant date. In this regard, Rich shows precisely how to implement a computer-implemented design flow to prepare an OVD, and it would have been routine for a POSITA to apply those teachings to Fuhse847.

3. Application to the Challenged Claims

143. In my opinion, Fuhse847 in view of Rich teaches the limitations of claim 1. The mapping below provides my analysis on a limitation-by-limitation basis, with relevant citations to the teachings of Fuhse847.

a) Claim 1

144. In my opinion, Fuhse847 teaches claim 1, as detailed below.

i. Claim 1, Element [1Pre]: *A method of fabricating a security element, comprising:*

145. In my opinion, the preamble simply provides a self-contained description of the purpose of the claim.

146. No terms in the preamble are later provided in the claim body, so the preamble does not complete the structure of the claim body. The terms “security element” and “fabricating” are not later recited in the claim body.

147. In my opinion, to the extent the preamble is limiting, Fuhse847 teaches the preamble.

148. Fuhse847’s invention relates to “a method for manufacturing such a depiction element” ([a] **method of fabricating a security element**) “[f]or security applications.” Fuhse847, pp. 4-5, 9-10. The depiction element is for a “data carrier” and “[t]he data carrier can in particular be a value document,” such as a “paper banknote.” Fuhse847, p. 11, FIG. 1.

ii. **Claim 1, Element [1a]: *assigning a first object in a starting digital image to a first image display plane and a second object in the starting digital image to a second image display plane;***

149. In my opinion, Fuhse847 teaches element [1a].

150. Fuhse847 teaches **assigning a first object in a starting digital image to a first image display**.

151. Fuhse847 teaches **a first object** in the form of “a body.” Fuhse847, pp. 10-11. The body may represent a certain motif, such as a two-dimensional or three-

dimensional motif, as further discussed below (see ¶¶162-177). Fuhse847, pp. 10-

11, 4, 7, 9, cl. 23. Fuhse847's body is described here in part:

“According to a further advantageous variant of the invention, a **three-dimensional body** is depicted by floating light spots. This is preferably based on a data set which describes the surface of **the body** to be depicted by spots in space, corner spots of polygons, normal vectors and absorption behavior (color, brightness).

Such data sets, suitable data formats and processing methods are basically known to the person skilled in the art, examples include, for example, VRML (Virtual Reality Modeling Language), STL (Surface Tesselation Language; Standard Triangulation Language) or 3D-CAD (3D Computer Aided Design).

Data sets describing the surface of a **body** can, for example, be generated in computer-aided technical drawing or through 3D laser scanning of real three-dimensional bodies. In the latter method, spots in space are captured that describe **the body** when scanning **the body**. These spots can, for example, be stored on the computer in so-called point cloud format.

To create a 3D light spot image of a **three-dimensional body**, such data set must be processed as described below using steps a) to c) as an example:”

Fuhse847, p. 10 (annotated).

152. Fuhse847 teaches that the body is **in a starting digital image** in various forms. Fuhse847 explains that the body may be provided in a **starting digital image** that may be provided in a number of forms:

“According to a further advantageous variant of the invention, a three-dimensional body is depicted by floating light spots. This is preferably based on a data set which describes the surface of the body to be depicted by spots in space, corner spots of polygons, normal vectors and absorption behavior (color, brightness).

Such data sets, suitable data formats and processing methods are basically known to the person skilled in the art, examples include, for example, **VRML (Virtual Reality Modeling Language), STL**

(Surface Tessellation Language; Standard Triangulation Language) or 3D-CAD (3D Computer Aided Design).

Data sets describing the surface of a body can, for example, be generated in **computer-aided technical drawing** or through **3D laser scanning of real three-dimensional bodies**. In the latter method, spots in space are captured that describe the body when scanning the body. These spots can, for example, be stored on the computer in so-called **point cloud format**.

To create a 3D light spot image of a three-dimensional body, such data set must be processed as described below using steps a) to c) as an example:”

Fuhse847, p. 10 (annotated).

153. Thus, the **starting digital image** is shown in a number of forms, including, for example, in “3D-CAD (3D Computer Aided Design).” Fuhse847, pp. 10-11. 3D-CAD was a well-known computer program before the relevant date that provided digital images.

154. Fuhse847 further teaches that the body may be depicted in “computer-aided technical drawing,” which is another example of **a starting digital image**. Fuhse847, p. 10.

155. Fuhse847 further teaches that the body may be depicted in **a starting digital image** “through 3D laser scanning of real three-dimensional bodies.” Fuhse847, p. 10. 3D laser scanning of real objects was a known method to produce digital images. In fact, the purpose of such 3D laser scanning techniques was so that a physical object could be represented by a digital image. Well-known programs

were widely available to provide digital images from the laser scanning physical objects.

156. Fuhse847 teaches **assigning** the body in the starting digital image **to a first image display plane**. This is performed by Fuhse847 by defining “light spots” for every point in the digital image in data sets, which correspond to image points P_j in the **first image display plane**. Fuhse847, pp. 9-10, 28.

157. Fuhse847 teaches methods for defining “light spots” for each digital image in “a data set which describes the surface of the body.” Fuhse847, p. 10. As Fuhse847 explains:

“According to a further advantageous variant of the invention, a three-dimensional body is depicted by **floating light spots**. This is preferably **based on a data set which describes the surface of the body to be depicted by spots in space, corner spots of polygons, normal vectors and absorption behavior (color, brightness)**.”

Such data sets, suitable data formats and processing methods are basically known to the person skilled in the art, examples include, for example, VRML (Virtual Reality Modeling Language), STL (Surface Tessellation Language; Standard Triangulation Language) or 3D-CAD (3D Computer Aided Design).

Data sets describing the surface of a body can, for example, be generated in computer-aided technical drawing or through 3D laser scanning of real three-dimensional bodies. In the latter method, **spots in space are captured that describe the body when scanning the body. These spots can, for example, be stored on the computer in so-called point cloud format.”**

Fuhse847, p. 10 (annotations added).

158. In other words, the “light spots” are defined in data sets that include data such that fully describe the surface of the body, including where the spot is “in space,” normal vectors of surfaces, color, and brightness of each spot.

159. Tools such as “3D-CAD” were well-known tools for preparing data sets that describe 2-D and 3-D digital images with such data.

160. It was also known to capture “spots in space... that describe the body when scanning the body,” and that “[t]hese spots can, for example, be stored on the computer in so-called point cloud format.” Fuhse847, p. 10. “3D laser scanning” was a well-known technique for producing digital images with data sets for image spots.

161. Fuhse847 teaches methods to define the brightness of each image point, explaining that “for every image point P_j , a brightness I_j between 0% and 100% is defined”. Fuhse847, p. 9. Fuhse847 also describes the following “lighting concept” to define the brightness of each light spot:

“In order give visibility to the body surface light - dark contrasts are required. A body appears most natural when these light - dark contrasts are generated by means of a lighting concept. For this purpose, one or more light sources are imagined to be attached outside the body, and the surface brightness at all relevant spots of the body are identified using Lambert’s cosine law, the law of reflection or another suitable physical laws from the directions of the fictional light sources, the surface normals and the absorption behavior.”

Fuhse847, pp. 10-11.

162. The objects assigned in the starting digital image may take the shape and form of any “desired” or “specified” “motif.” Fuhse847, pp. 4, 7 (“the specified motif produced by the depiction arrangement is a three-dimensional body formed by the light spots”), 9. They may also be “two-dimensional image content (*e.g.*, a font or a logo).” Fuhse847, p. 7.

163. Importantly, Fuhse847 teaches “a desired three-dimensional motif having image points P_j and height values Z_j above an xy plane is specified, the image points corresponding to the light spots created upon illumination.” Fuhse847, p. 9. These “image points P_j and height values Z_j above an xy plane” define a **first image display plane**.

164. In particular, Fuhse847 teaches producing a floating image in a two-dimensional plane where all “the light spots of the light-spot image” float “at the same floating height above or below the surface.” Fuhse847, pp. 5, 16.

165. Fuhse847 makes clear the image is in an **image display plane** in multiple ways. *First*, Fuhse847 states that the image may be two-dimensional, and a POSITA would understand that a floating two-dimensional image in space defines it in an image display plane based on Fuhse847’s teaching. Fuhse847 teaches that all the light spots may be at the “same floating height” or “a certain height above or below the substrate surface.” *Second*, Fuhse847 teaches that arbitrary three-dimensional images may be produced. A POSITA would understand that planed

images are within this teaching because a two-dimensional plane is a three-dimensional space with one dimension fixed. For example, when the height (z-dimension) is fixed for an image, the image is defined in the x-y plane at that height.

166. These two teachings are explained in further detail below.

167. Fuhse847 teaches that while “a truly three-dimensional” image can be formed by using light spots of “different floating heights above and/or below the substrate surface,” alternatively, “all light spots in the light-spot image [may] have the same floating height,” (forming a **first image display plane**) which provides a two-dimensional image “that floats at a certain height above or below the substrate surface.” Fuhse847, pp. 16, 5.

168. Fuhse847 teaches that any arbitrary “desired three-dimensional motif having image points P_j and height values Z_j above an xy plane” may be “specified,” meaning that providing image points P_j of all the same height values Z_j above the surface of the substrate results in displaying **image display plane**. Fuhse847, pp. 9-10, 27-28, cl. 26.

169. A two-dimensional image in a plane is simply a three-dimensional image with a small or zero thickness. For example, the surface of the substrate defines a “xy plane” with $z=0$. Fuhse847, pp. 27-28, 24-25. By teaching any arbitrary three-dimensional image in space (*i.e.*, x, y, z space) can be constructed of light points, it is obvious that a two-dimensional image in a plane can be constructed

by simply fixing the height (z) values of the pixels, provided the x-y plane is the plane of the surface of the substrate.

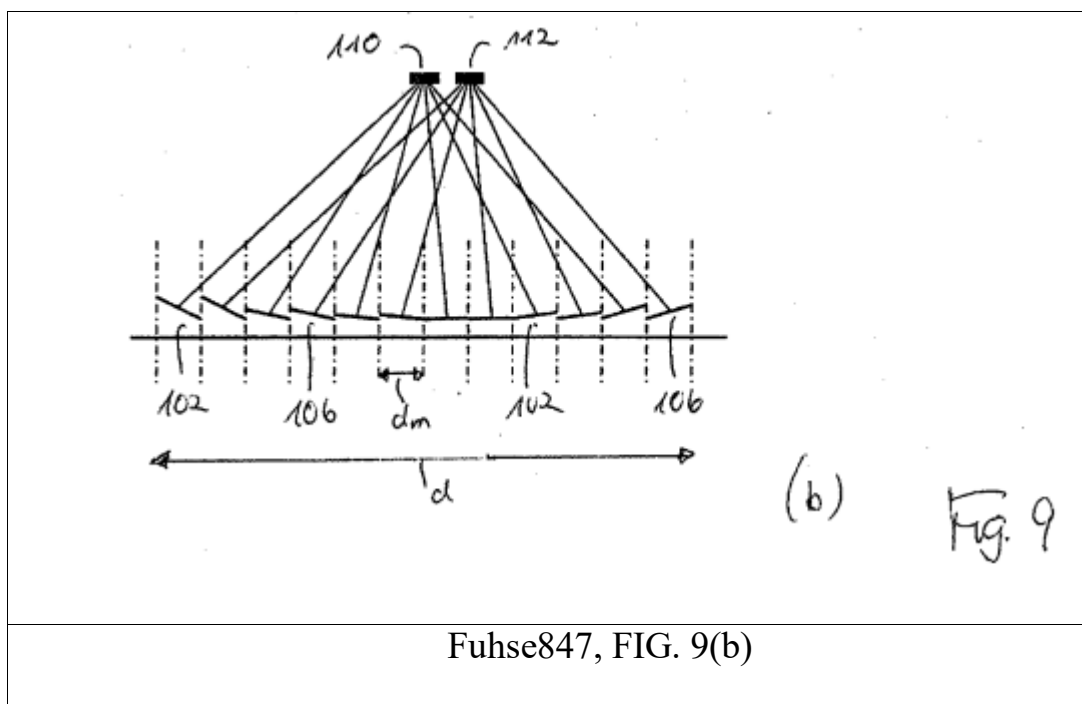
170. While providing a two-dimensional image plane is obvious based on teaching an arbitrary three-dimensional image, Fuhse847 *explicitly* teaches that a two-dimensional image plane may be formed by fixing the height (z) values of the pixels:

“If the convex mirrors of a security element have several different focal lengths, i.e. if the light spots of the light-spot image have several different floating heights above and/or below the substrate surface, a truly three-dimensional motif is created. In some configurations, however, it may also be advisable to design all convex mirrors with the same focal length, so that **all light spots in the light-spot image have the same floating height**. In this way, a backdrop motif is created that floats at a certain height above or below the substrate surface.”

Fuhse847, pp. 16, 5 (emphasis added). In fact, Fuhse847 refers to the resulting image as “a two-dimensional motif,” such as “a font or a logo.” Fuhse847, pp. 5, 7, 26.

171. For the given fixed height of the two-dimensional motif (for example, $z = z_1$), the image is in an **image display plane** defined by (x, y, z_1).

172. For example, Figure 9(b) shows “two closely adjacent light spots” 110 and 112 (two pixels) formed at the same height:



Fuhse847, pp. 13, 20-21.

173. Fuhse847 teaches assigning... **a second object in the starting digital image to a second image display plane.** Other than being in **a second image display plane, a second object in the starting digital image** has only the same requirements of the **first object in a starting digital image** and is therefore satisfied by the same teachings discussed above.

174. Fuhse847 teaches producing multiple images, including “a light-spot image A” and “a light-spot image B.” Fuhse847, pp. 25-27. Both images are produced in the same manner as previously discussed. As discussed, Fuhse847 teaches “two-dimensional” images such as “a font or a logo” (see Fuhse847, pp. 5, 7, 26), and teaches that “several” images may be produced. Fuhse847, p. 26.

175. Fuhse847 also teaches that the two images may be in different planes. Fuhse847 teaches that two images to be in the “foreground” and “background” of each other. Fuhse847, p. 26. This is accomplished by selecting all of the image points P_j of the **second image display plane** to have a height values Z_j that is different from height values Z_j of the **first image display plane**. Fuhse847, pp. 9-10, 27-28, cl. 26.

176. It would have been obvious that the second image is from a **second object in the starting digital image**. For example, in the case that the two images are two different “two-dimensional” images such as “a font or a logo” (*see* Fuhse847, pp. 5, 7, 26), those two fonts or logos represent two different objects. It would have been obvious that they were both provided in the same **starting digital image**. For example, it was well-known that formats like 3D-CAD, “computer-aided technical drawing,” and “3D laser scanning of real three-dimensional bodies” could provide multiple objects in their images.

177. To the extent it could be argued that Fuhse847 only explicitly discloses a three-dimensional image in the foreground of a two-dimensional image (*see* ¶0117), it would have been obvious to provide two two-dimensional images. As discussed above, by teaching any arbitrary three-dimensional image in space (*i.e.*, x, y, z space) can be constructed of pixels, a POSITA would understand that a two-dimensional image in an image plane can be constructed by fixing the height (z)

values of the pixels. Based on Fuhse847's teachings that multiple images may be created in the foreground and background of each other, and that images may be two-dimensional, it would have been obvious to a POSITA to provide two two-dimensional image planes at different heights (*i.e.*, in different planes).

178. Accordingly, Fuhse847 teaches the element [1a].

iii. Claim 1, Element [1b]: *with a processor of a computing device, executing code to provide an array design module that operates to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of the first object in the first image display plane and to display each of the pixels of the second object in the second image display plane;*

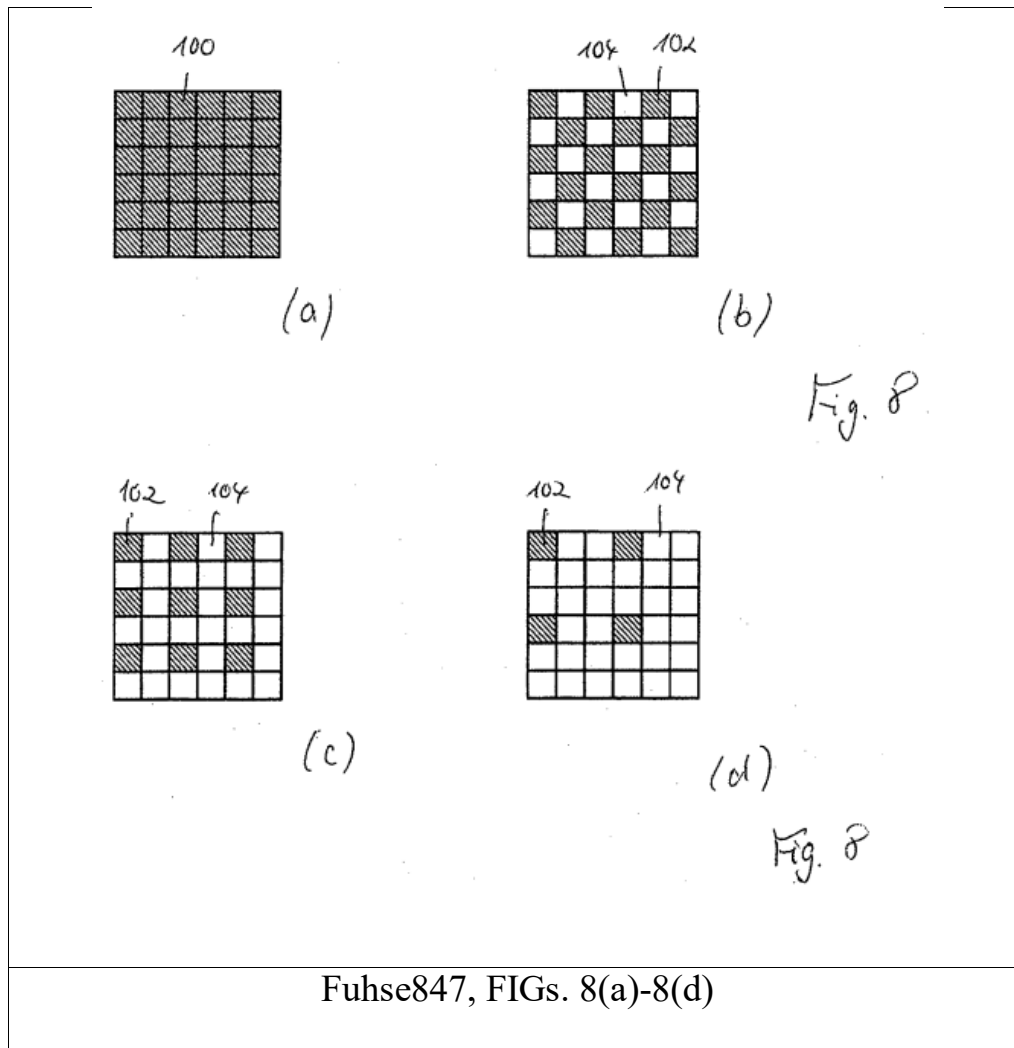
179. In my opinion, Fuhse847 in view of Rich teaches element [1b].

180. After defining each image points P_j corresponding to light spots in the two-dimensional image, Fuhse847 teaches **to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of the first object in the first image display plane.**

181. Fuhse847 teaches **an array of the micro mirrors** in the form of an arrangement of $n \times n$ micromirrors ("plurality of micromirrors") on the surface of the substrate. Fuhse847, pp. 14-15, 5, 7-8, 19-21 (describing the "checkerboard-like arrangement").

182. Figure 8, including Figures 8(a)-8(d), and supporting disclosure provides further detail of the **array of micro mirrors** in the form of "an arrangement

of $n \times n$ micromirrors 100, which are arranged next to one another without any distance between them in the surface of the security element.” Fuhse847, pp. 14-15, 5, 7-8, 19-21. This ordered arrangement of micromirrors 100 is **an array**.



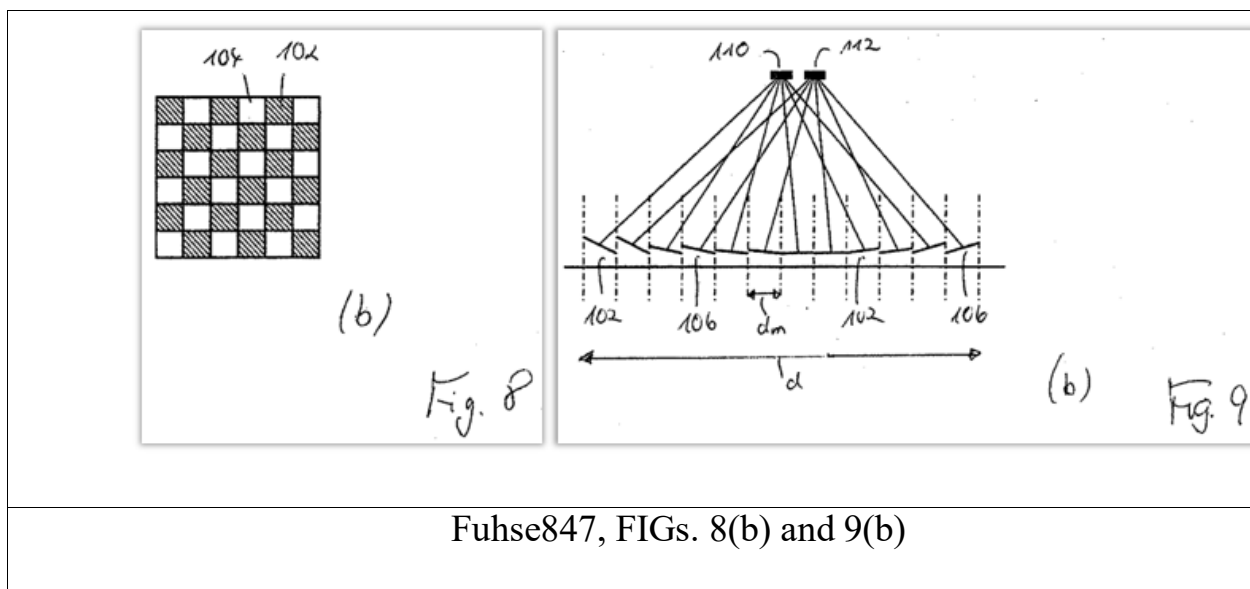
183. Fuhse847 teaches **to select a set of micro mirrors in Fushe847’s arrangement of micromirrors to display each of the pixels of the first object in the first image display plane.**

184. Fuhse847 discloses that **the array of micro mirrors includes for each of the pixels a different set of the micro mirrors**. Fuhse847, pp. 6, 9-10, 19-21. Fuhse847 explains that for every light spot in the image, “a plurality of optical elements is assigned to every light spot,” such that “groups of optical elements” “are each assigned to different light spots” (**to select a set of micro mirrors... to display each of the pixels of the first object in the first image display plane**). Fuhse847, p. 6. Fuhse847 does so by defining “a number of fine fields” “for every image point P_j ,” (**each of the pixels**),¹ and providing that the optical elements in those fine fields (**a set of the micro mirrors**) “contribute to producing the light spot that corresponds to image point P_j ” (**to display each of the pixels of the first object in the first image display plane**). Fuhse847, pp. 9-10, 27-28, cl. 26.

185. In the example of FIG. 8b, (shaded) micromirrors 102 form a set of **micro mirrors**, and (white) “fields 104 [] covered with micromirrors 106” form a second **set of micro mirrors**, and the sets are different because they comprise different micromirrors. Fuhse847, pp. 21-22. In other words, each micromirror is assigned to a single light spot. No micromirrors are shared with multiple light spots. Thus, each pixel has its own set of micromirrors.

¹ The term “each of the pixels” appears to antecedent basis, but I understand that issue is not to be determined in this Proceeding.

186. As shown in Figure 9(b), “[m]icromirrors 102 form a group of micromirrors, which are all assigned to the same light spot 110 and produce it together when illuminated,” while micromirrors 106 “serve to produce a light spot 112,” meaning the **display of each of the pixels of the first object in the first image display plane** is done by **select[ing] a separate set of micro mirrors in an array of the micro mirrors**. *Id.* Fuhse847 states that in the “[t]he number $n \times n$ of micromirrors is, for example, 10×10 ,” (totaling 100) meaning that in FIG. 8(b), each **set of micro mirrors** would have 50 micromirrors. Fuhse847, pp. 19-20.



187. Fuhse847 in view of Rich render obvious that this selection is done using **a processor of a computing device, executing code to provide an array design module**.

188. It is first noted that the single example of “a processor” in the ’863 patent is processor 610, and the single example of “an array design module” in the ’863 patent is “array design program 630,” both annotated in red below in Figure 6.

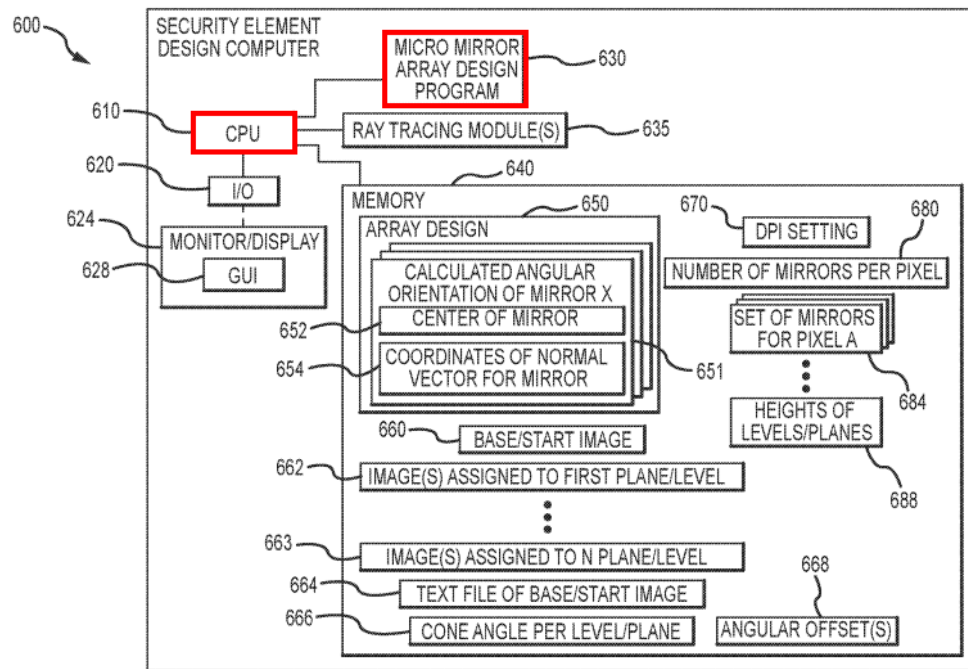


FIG.6

’863 Patent, 9:64-10:56, FIG. 6.

189. The processor 610 is a conventional processor that was well-known in the art before the relevant date. The tasks for CPU 610 could be performed by a typical CPU (i.e., central processor) that was ubiquitous and readily commercially available before the relevant date. The processor 610 has the task of executing instructions, such as of a computer program and input/output (I/O) operations, including accessing and managing memory to do so. ’863 Patent, 9:64-10:56, FIG.

6. These are the basic, conventional tasks that any programmable commercially available CPU would have provided before the relevant date.

190. The array design program 630 is a software program that is described in the '863 Patent in functional terms of the tasks that it executes on the generic processor 610. '863 Patent, 9:64-10:56, FIG. 6.

191. Likewise, in the claims of the '863 Patent, the **array design module** is described only in terms of the tasks it provides. For claims 1 and 7, the array design module (1) selects a set of micro mirrors for each pixel, and (2) determines the angular orientation of each micro mirror in each set. For claim 12, the array design module must define an array of micro mirrors.

192. As discussed, Fuhse847's "light spots" for each digital image are described in "a data set which describes the surface of the body." Fuhse847, p. 10. Fuhse847 further teaches that these data sets are in digital formats on a computer, such as 3D-CAD, or may be "stored on the computer in so-called point cloud format." Fuhse847, p. 10 (annotations added). A POSITA would have understood that operations using these data files, such as assigning micro mirrors to the light points and determining the angular orientation of those micro mirrors, would have likewise been performed on **a processor of a computing device by executing code** of software (such as **an array design module**).

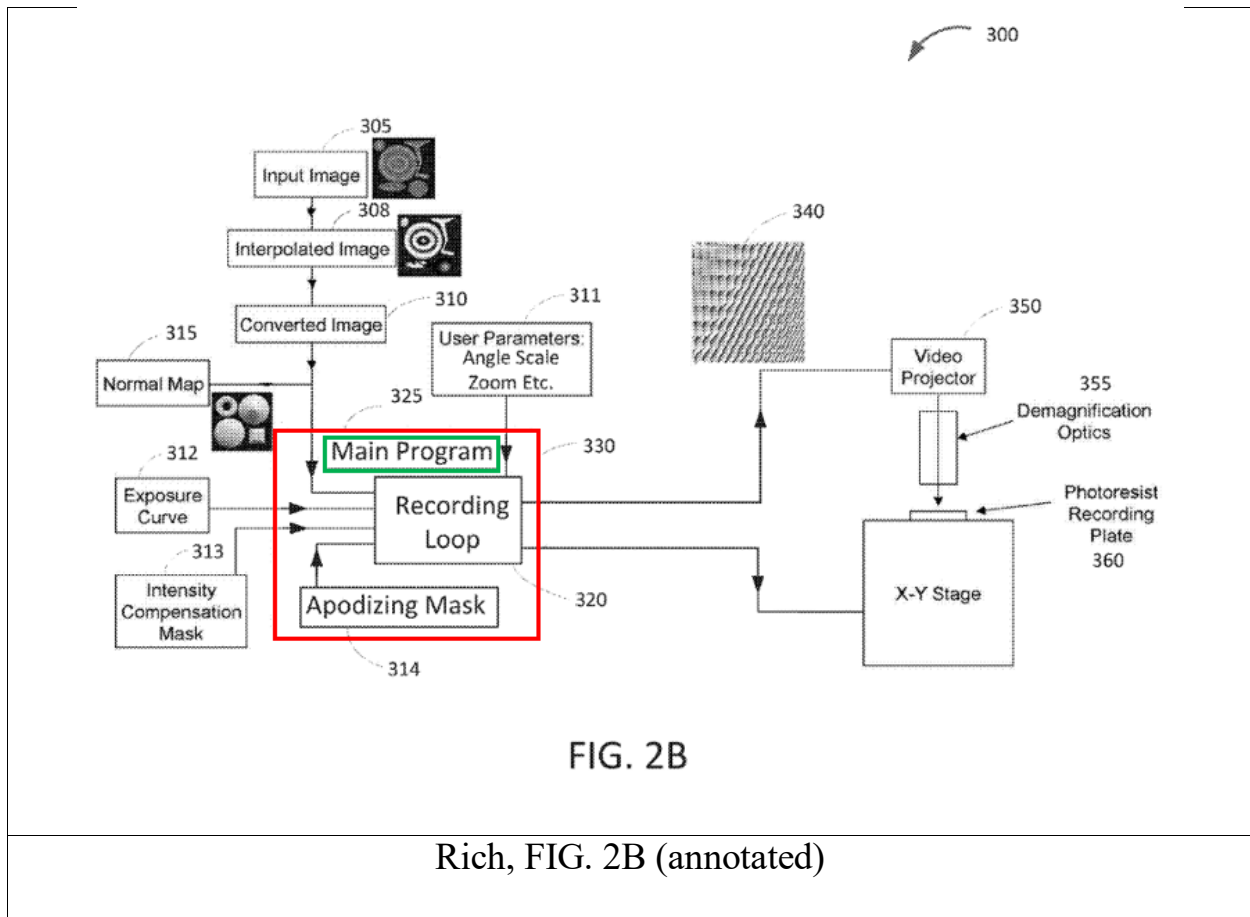
193. Fuhse847 further teaches “methods of concealment calculation, as known from 3D CAD such as ray tracing or Z-buffer methods” in order ensure that “each microelement (or micromirror or microprism) is only assigned to one spot on the body surface which is closest or most distant on the connecting straight line of microelement and body, depending from which side the light spot image is to be viewed.” Fuhse847, p. 11. Thus, Fuhse847 explicitly contemplates computer-implemented methods for selecting micro mirrors, including methods such as “3D CAD” that require a processor of a computing device that executes code.

194. Further, it would be counterintuitive, and very difficult (if not impossible for large numbers of mirrors), to manually select sets of micromirrors for each pixel in an image and compute the angular orientation of a micromirror to reflect light to that pixel (see [1.c]) without the aid of a computer program to do so.

195. Thus, while Fuhse847 teaches computerized data files that are used for selection of micro mirrors, and that selection of micro mirrors must be performed, Fuhse847 does not explicitly disclose a processor with software to do so.

196. However, Rich (EX1039) discloses such tasks are performed on **a processor of a computing device by executing code** of software (such as **an array design module**).

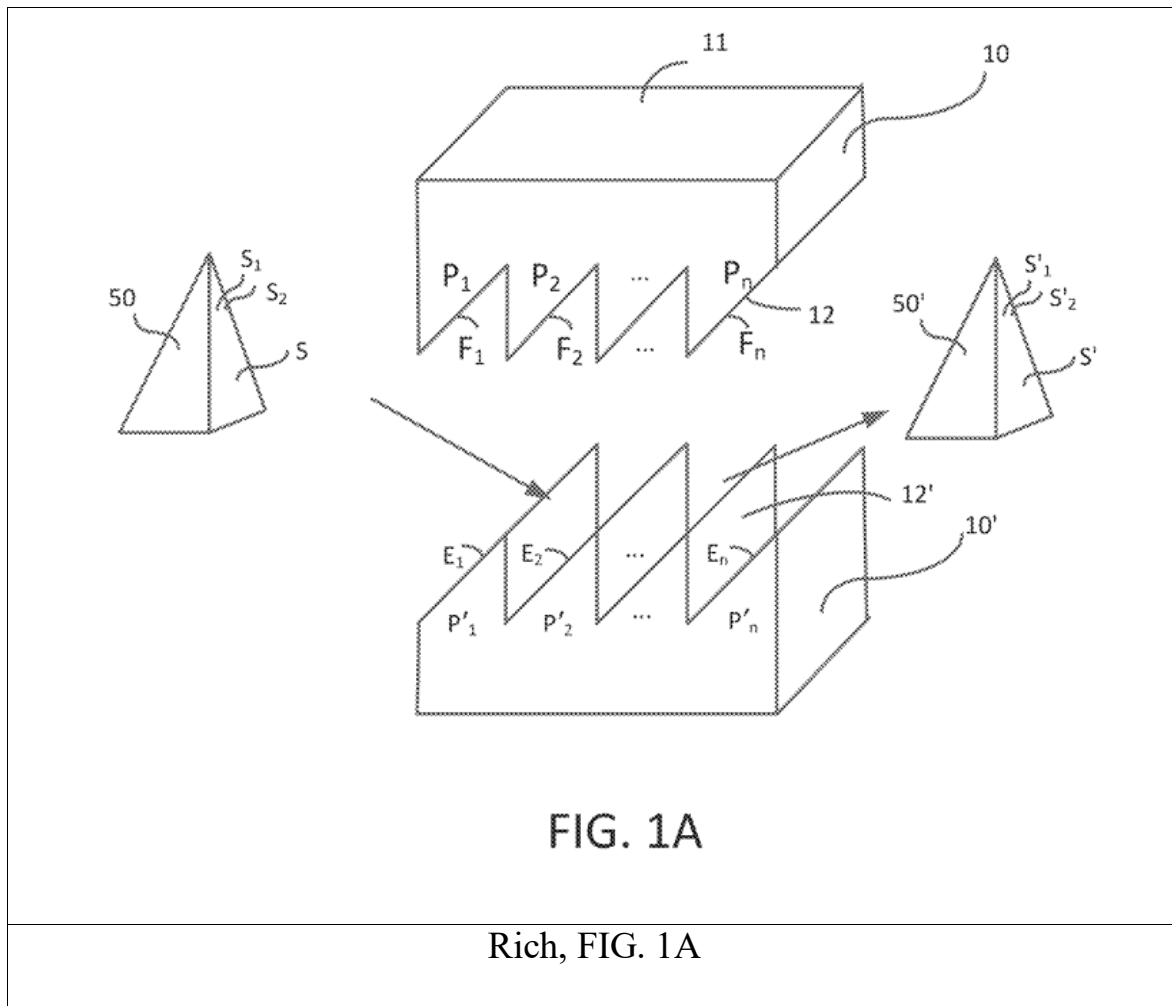
197. Rich discloses processor 330 (a **processor of a computing device**) running a main program 325 (**an array design module**). Processor 330 (shown in red) and main program 325 (shown in green) are shown below in Figure 2B of Rich.



198. Rich discloses teachings for FIG. 2B, which “illustrates an example method that can be used to manufacture the master 10 and also to determine the data file to be used to manufacture the master 10, *e.g.*, to determine the pattern of the features $F_1, F_2, \dots F_n$ on the surface 12 of the master 10.” Rich, 16:33-17:7. The “master” is the “shim” used to mass-produce the “optical products” (*e.g.*, on

currency) that “when illuminated, can reproduce an overt 3D image (*e.g.*, an image that appears 3D to the naked eye) of a 3D object. ’863 Patent, 1:16-23, 2:9-12.

199. Rich’s master and optical product are shown in Figure 1A: “FIG. 1A schematically illustrates an example master **10** for fabricating an optical product **10’**.” Rich, 5:20-35.



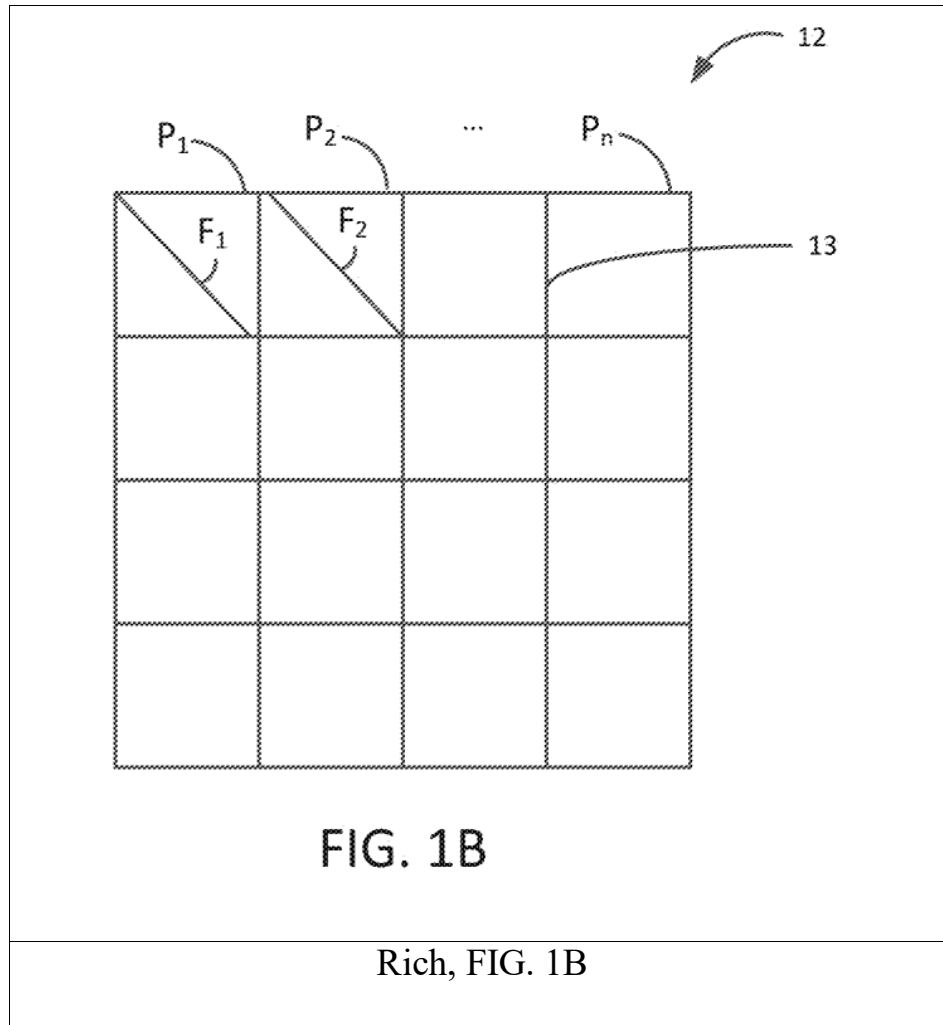
200. As Rich explains, Rich's master and corresponding optical product has arrays of micro mirrors with similar dimensions to that of Fuhse847 and the '863 patent:

“As shown in FIG. 1A, the second surface **12** can include a plurality of portions $P_1, P_2, \dots P_n$. Each portion P_n can correspond to a plurality of portions $P'_1, P'_2, \dots P'_n$ on the optical product **10'**. The plurality of portions $P'_1, P'_2, \dots P'_n$ on the optical product **10'** can also be referred to as a cell, pixel, or a tile. Each portion P'_n can have a length between 30 μm and 100 μm , between 35 μm and 55 μm , or between 40 μm and 50 μm . Each portion P'_n can have a width between 30 μm and 100 μm , between 35 μm and 55 μm , or between 40 μm and 50 μm . Accordingly, in various embodiments, the aspect ratio of each portion P'_n can be 1:1 or 1:1.1.”

Rich, 5:24-35. Rich further discloses that “the optical product 10' can include reflective material,” including “reflective metal such as aluminum, copper, or silver.” Rich, 6:1-15.

201. Further, each portion and feature are individually oriented with an orientation (“gradient (*e.g.*, slope)”) corresponding to the desired image. Rich, 5:36-54. With the proper inclinations of each mirror, “an optical product 10' fabricated using the example master 10 can be configured, when illuminated, to reproduce by reflected (or refracted) light, a 3D image 50'.” Rich, 5:47-54.

202. Rich's array of micro mirrors is further shown in FIG. 1B, which may have any number of rows and columns, but shows an example of 4x4.



Rich, 10:44-50.

203. It should be noted that the '863 Patent discloses that the computer methods likewise produce a master shim that is then used to mass-produce the end product security element:

“A number of manufacturing approaches may be used to fabricate an array of micro mirrors for attachment to or upon a surface of a substrate (such as currency, coins, product labels, and so on). In some embodiments, a photo resist process has been implemented by the inventors in creating security elements or devices as taught herein. As discussed earlier, the design program or software generates an output

file (as explained in more detail below). To form the micro mirrors according to this output file, a laser system is used to expose the photo resist material, usually on a quartz or lime glass master. The photo resist material is normally at least 25 microns thick. The laser or laser system may expose the material in steps such as in about 0.5μ steps. The exposure settings correspond to the amount of material that will be washed away and not hardened, and this exposure creates a “Z” axis or height of the feature. The resulting micro mirrors (which may be flat or may be concaved for better focus depending upon design) are made in the photo resist material. The photo resist is generally still light sensitive and will “melt” in white light. In some cases, the photo resist is chrome plated in house before processing. The photo resist is then placed in an electroforming tank. The resist is charged and attracts nickel (or other metallic) particles, and nickel is “grown” on the photo resist as a nickel “shim.” **This nickel shim can be “turned” as needed from negative to positive and back again for tooling. The nickel shim is then used in the cast and cure process to form the array of micro mirrors oriented as indicated by the output file of the design program or software.”**

’863 Patent, 16:1-29.

204. Rich’s computer method according to Figure 2B is reproduced below:

“FIG. 2B illustrates an example method that can be used to manufacture the master 10 and also to determine the data file to be used to manufacture the master 10, e.g., to determine the pattern of the features $F_1, F_2, \dots, F_n$ on the surface 12 of the master 10. Certain such embodiments can be advantageous as a 3D physical object and/or a 3D model utilizing physical dimensions of the 3D object (e.g., topographical calculations) are not required. For example, in the method 300 shown in FIG. 2B, the input image 305 can be a 2D input image (e.g., a 2D photograph of the 3D object) or 2D image converted from a 3D image. In some embodiments, the input image 305 can be converted into a 2D interpolated image 308 and produced as a 2D converted image 310. The 2D image of the 3D object can be translated into a gray scale image (e.g., a normal map 315 wherein black, white, and gray regions correlate to different heights of the 3D object). In the method 300 shown in FIG. 2B, the converted image 310 (or a normal map 315) is entered into

the recording loop 320 of the main program 325 of the processor 330 in accordance with certain embodiments described herein. Similar to the method 200 in FIG. 2A, other information, such as user parameters 311 (e.g., angle, scale, zoom, etc.), exposure compensation curve 312, intensity compensation mask 313, and apodizing mask 314 can also be entered into the recording loop 320. The processor 330 can produce a data file 340, e.g., a 2D data file, that is configured to describe the 3D image 50' of at least a part of the 3D object 50. In some embodiments, the intensities in the data file 340 can be assigned based on gray scale. For example, the data file 340 can comprise a plurality of portions. Each portion can correspond to one or more points on a surface S of the 3D object 50. Each portion can comprise features of intensity corresponding to non-holographic elements on the optical product 10'. A gradient in intensity can correlate to a gradient or an inclination of the surface S of the 3D object 50 at the one or more corresponding points. In addition, an orientation of the features can correlate to an orientation of the surface S of the 3D object 50 at the one or more corresponding points. This data file 340 can be used as a map to generate the pattern of features $F_1, F_2, \dots, F_n$ on the surface 12 of the master 10. An example data file is discussed with respect to FIG. 3A.”

Rich, 16:33-17:7.

205. As described, processor 330 (**a processor of a computing device**) running a main program 325 (**an array design module**) to take the input image file (describing the image), and use it “to determine the pattern of the features $F_1, F_2, \dots, F_n$ on the surface 12 of the master 10.” *Id.*

206. For the same reasons Fuhse847 teaches to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of the first object in the first image display plane, Fuhse847 teaches **to select a set of micro mirrors in an**

array of the micro mirrors to display each of the pixels... of the pixels of the second object in the second image display plane.

207. As explained in element [1a], Fuhse847 discloses that all its teachings apply to a **second image display plane**.

208. Fuhse847 in view of Rich therefore teaches element [1b].

iv. Claim 1, Element [1c]: *for each of the pixels, determining with the array design module an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors;*

209. In my opinion, Fuhse847 in view of Rich teaches element [1c].

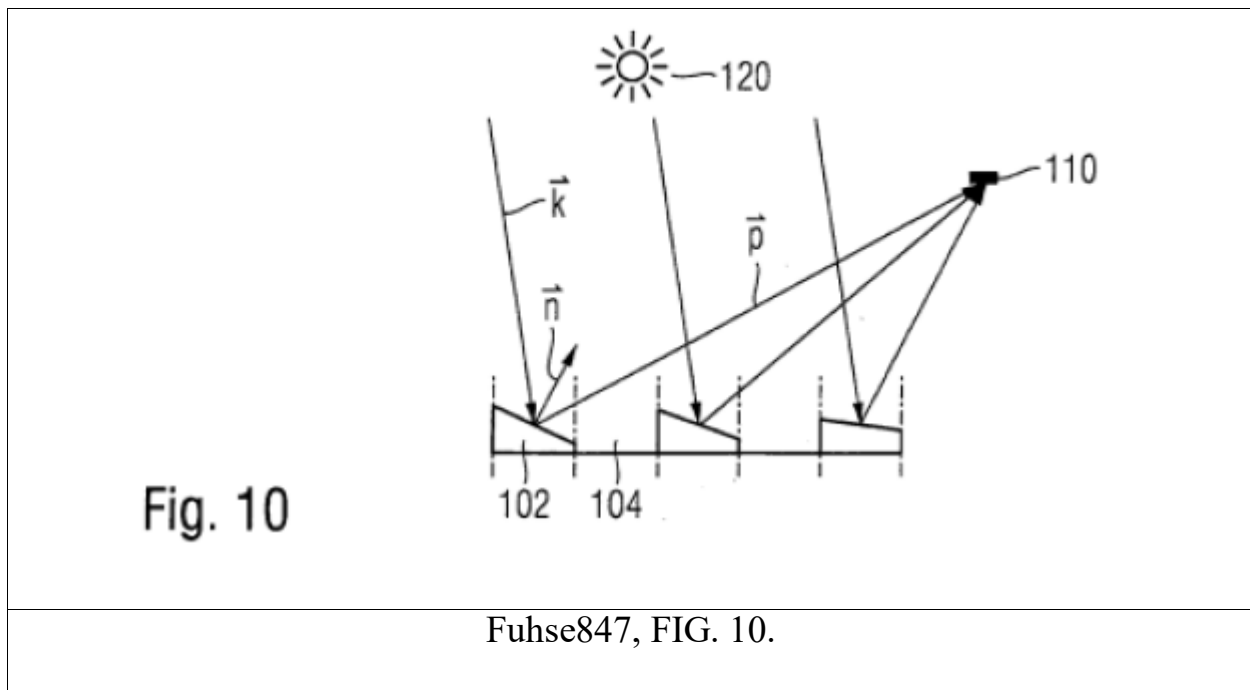
210. Fuhse847 teaches **for each of the pixels, determining ... an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors.**

211. Fuhse847 discloses how to calculate angular orientations of its micromirror surfaces with respect to Figure 10 and corresponding disclosures. Fuhse847, pp. 19-23 (“The calculation of the orientation of the flat mirror surfaces is explained below with reference to Fig. 10.”). In particular, Fuhse847 explains that “[t]he position of the mirror surfaces, i.e. the normal vector $\vec{n}$, is to be determined in such a way that the light incident from a specified direction $\vec{k}$ is reflected onto the focal point (x_0, y_0, z_0) for all micromirrors 102 assigned to light spot 110,” the following equations are used to define the normal vector $\vec{n}$ (**an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors**), incident light $\vec{k}$, and reflected light ray $\vec{p}$ **for each of the pixels**:

$$\vec{n} = \frac{\frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|}}{\left| \frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|} \right|}, \quad \vec{p} = \begin{pmatrix} x_0 - x \\ y_0 - y \\ z_0 \end{pmatrix}, \quad |\vec{p}| = \sqrt{(x_0 - x)^2 + (y_0 - y)^2 + z_0^2}$$

Fuhse847, pp. 21-22.

212. In other words, the normal vector $\vec{n}$ of the micromirrors such that reflected light ray $\vec{p}$ is directed towards the point (x_0, y_0, z_0) corresponding to one of the pixels. These vectors are shown in Figure 10:



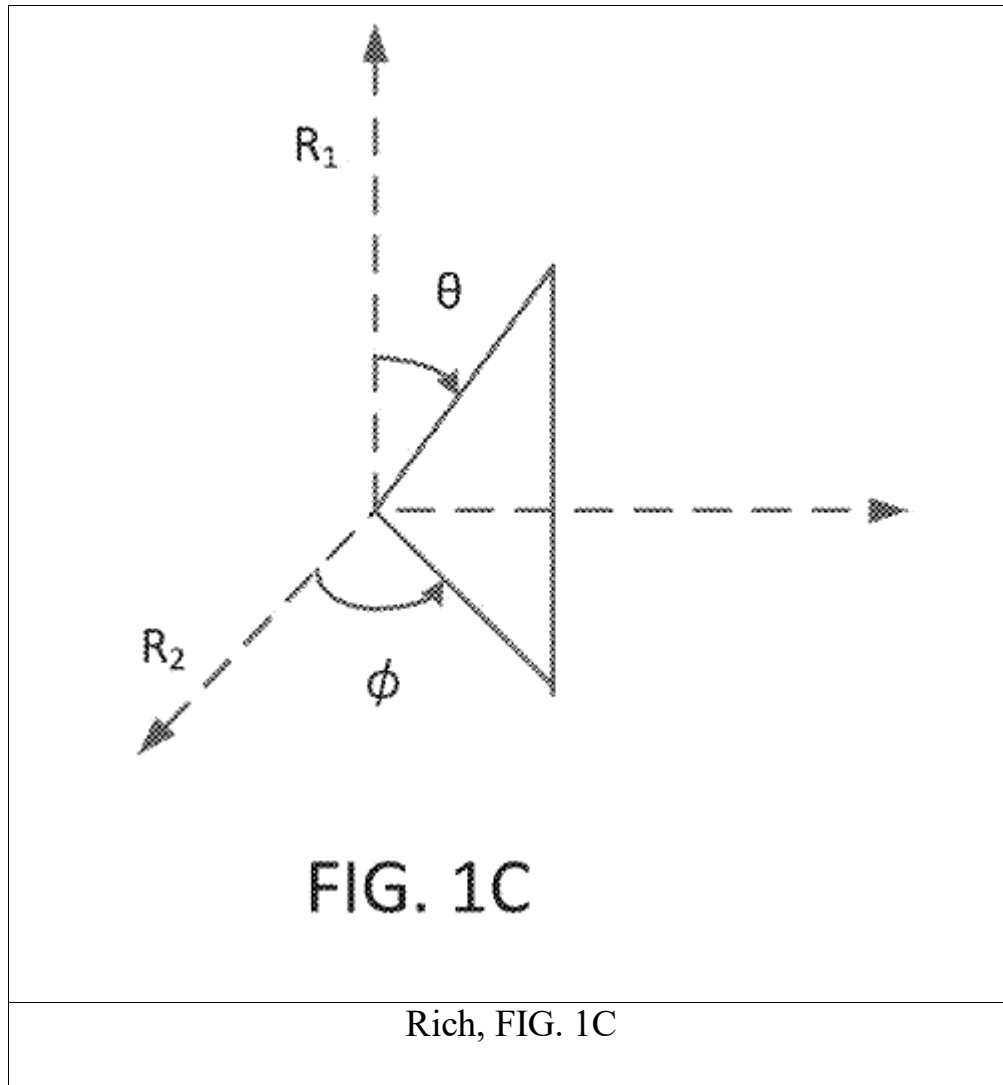
213. The '863 Patent explicitly contemplates that a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels, which is what is taught above by Fuhse847, is within the scope of the angular

orientation of each of the micro mirrors. *See* claim 2 (“2. The method of claim 1, wherein the angular orientation is defined by coordinates of a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels.”).

214. Fuhse847 in view of Rich render obvious that this determination is **with the array design module**.

215. Using the method of FIG. 2B of Rich, Rich’s processor 330 (**a processor of a computing device**) running a main program 325 (**an array design module**) computes the “orientation” of each micromirror. Rich, 16:33-17:7.

216. As shown in Figure 1C, and just as in the ’863 Patent and in Fuhse847, this orientation includes two rotation axes: an azimuth angle ϕ and a polar angle θ . Rich, 12:57-61, 13:18-44.



217. In the combined system of Fuhse847 and Rich, it would have been obvious for Rich's processor 330 (**a processor of a computing device**) running a main program 325 (**an array design module**) to compute the orientation calculations provided by Fuhse847.

218. Fuhse847 in view of Rich therefore teaches element [1c].

v. Claim 1, Element [1d]: *generating a design output file including the angular orientation and location*

coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors; and

219. In my opinion, Fuhse847 in view of Rich teaches element [1d].

220. Fuhse847 in view of Rich render obvious **generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors.**

221. Rich teaches generating a design output file in the form of a data file 340.

222. Data file 340 **includ[es]** the “orientation of the features” (**the angular orientation... for each of the micro mirrors in the selected sets of the micro mirrors**), as discussed above in element [1c].

223. Data file 340 **includ[es]** the **location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors.** As Rich explains, the data file includes the “plurality of portions,” and is “a map to generate the pattern of features F1, F2, ... Fn on the surface 12 of the master 10.” Rich, 16:57-17:7.

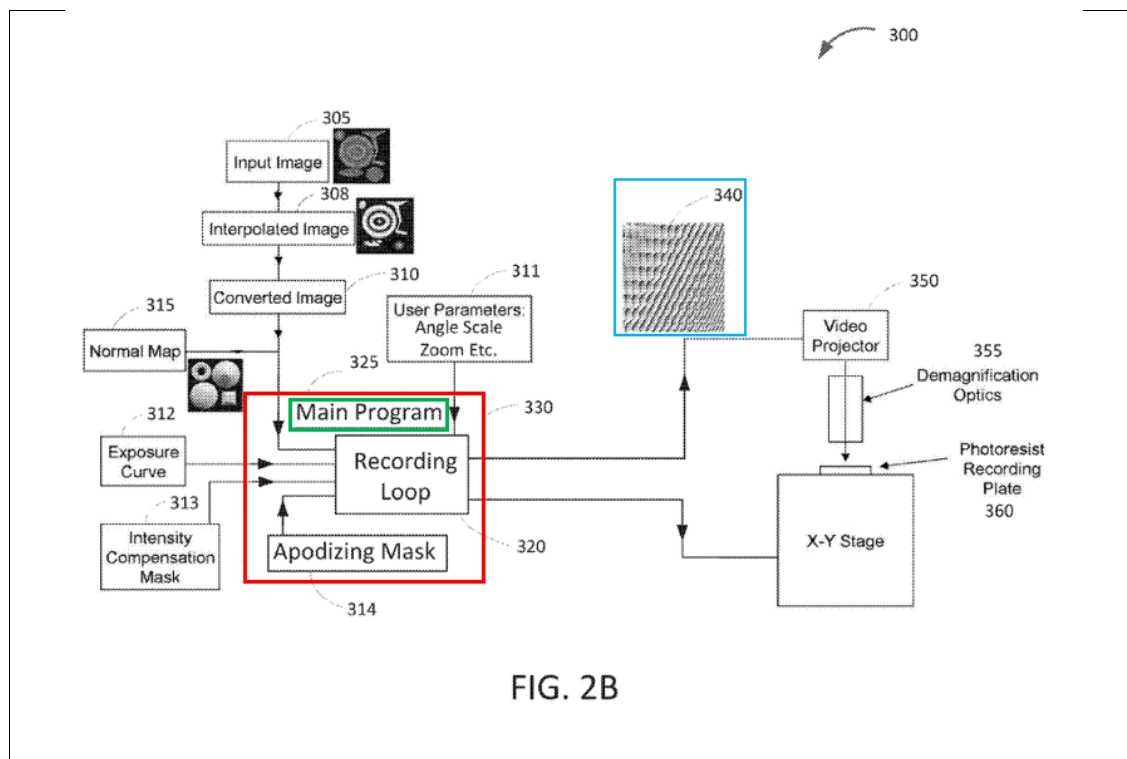
224. As Rich further explains, “[t]he data file can provide the pattern of the features F1, F2, ... Fn on the surface 12 of the master 10” (see 15:33-35), and “[t]he pixels of the data file 340 can also correspond to one or more portions P₁, P₂, ... P_n of the surface 12 of the master 10.” Rich, 17:15-17.

225. As Rich explains:

“The processor 330 can produce a data file 340, e.g., a 2D data file, that is configured to describe the 3D image 50' of at least a part of the 3D object 50. In some embodiments, the intensities in the data file 340 can be assigned based on gray scale. For example, **the data file 340 can comprise a plurality of portions**. Each portion can correspond to one or more points on a surface S of the 3D object 50. Each portion can comprise features of intensity corresponding to non-holographic elements on the optical product 10'. A gradient in intensity can correlate to a gradient or an inclination of the surface S of the 3D object 50 at the one or more corresponding points. In addition, an **orientation of the features** can correlate to an orientation of the surface S of the 3D object 50 at the one or more corresponding points. This data file 340 can be used as a map to generate the pattern of features $F_1, F_2, \dots, F_n$ on the surface 12 of the master 10. An example data file is discussed with respect to FIG. 3A.”

Rich, 16:57-17:7.

226. The generated data file 340 (a **design output file**) output file is shown below in blue:



Rich, FIG. 2B (annotated)

227. With respect to Figure 2B, Rich further shows “[a]n example data file is discussed with respect to FIG. 3A.” Rich, 17:6-7.

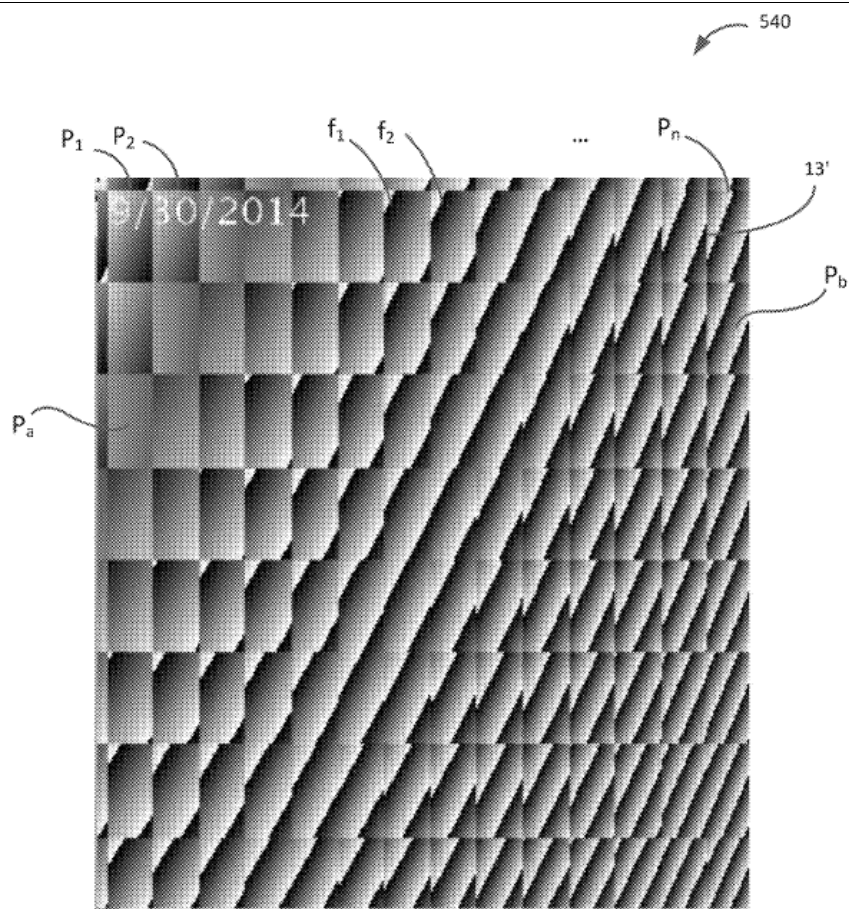


FIG. 3A

Rich, FIG. 3A

Rich, 17:6-7, 17:51-18:3.

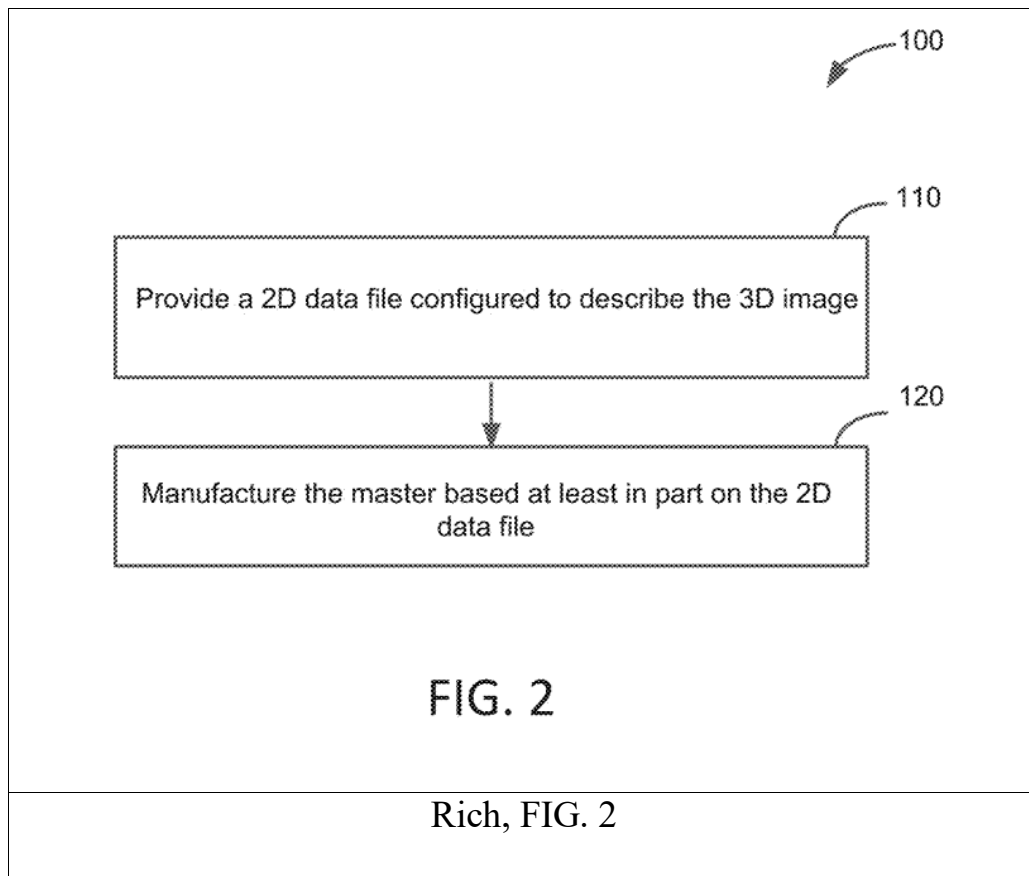
228. Fuhse847 in view of Rich therefore renders obvious element [1d].

vi. Claim 1, Element [1e]: *forming the array of the micro mirrors according to the design output file.*

229. In my opinion, Fuhse847 teaches element [1e].

230. Rich teaches **forming the array of the micro mirrors according to the design output file** because it teaches “manufacturing the master based at least in part on the 2D data file.” Rich, 2:38-40, 15:45-48.

231. In particular, the “data file 340 can be used... to generate the pattern of features F1, F2, ... Fn on the surface 12 of the master 10.” Rich, 17:4-7. This is summarized in Figure 2:



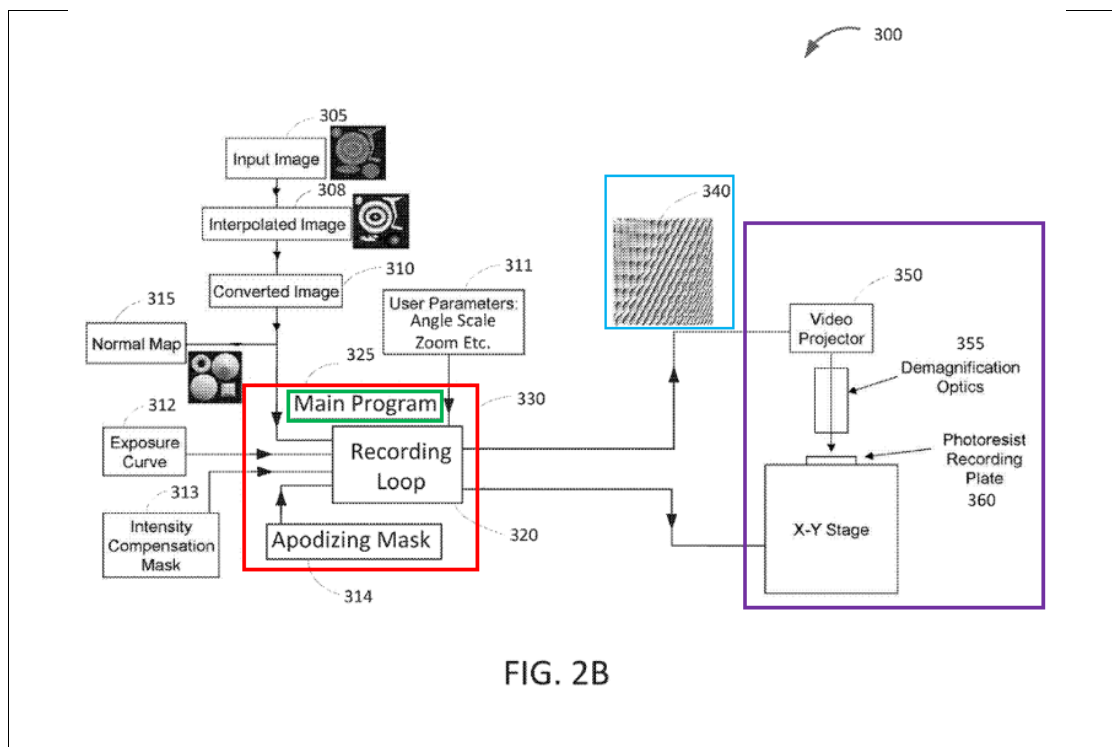
Rich, FIG. 2

232. Rich explains to perform this as follows:

“Similar to method 200 in FIG. 2A, a digital micromirror device (DMD) video projector 350 can be used along with the photoresist recording plate 360, each receiving the inputted information from the recording loop 320. The plurality of micromirrors in the DMD video projector 350 in certain embodiments can correspond to the pixels of the data file 240. **The pixels of the data file 340 can also correspond to one or more portions $P_1, P_2, \dots P_n$ of the surface 12 of the master 10 in some embodiments.** As shown in FIG. 2B, the demagnification optics 355 can be used to produce the pattern of features $F_1, F_2, \dots F_n$ in a light sensitive material, e.g., a photoresist, on the resist recording plate 360. In some embodiments, the resist can be used as the surface 12 of the master 10. As disclosed herein, other techniques, such as electron beam lithography on electron sensitive material and ion beam lithography on ion sensitive material can also be used.”

Rich, 18:8-24 (annotated).

233. This is shown in Figure 2B, with the forming of the micro mirrors (shown in purple) according to the data file (shown in blue):



234. As discussed above, just like Rich, the '863 Patent teaches that the computer-implemented process is used to create the master shim, which is then used to mass-produce security element end-product. *See* '863 Patent, 16:1-29.

235. To the extent that **the array of the micro mirrors** in the limitation **forming the array of the micro mirrors according to the design output file** means the security element end-product, then Rich teaches that in the same way as the '863 Patent.

236. In other words, because “the master 10 can be used to fabricate an optical product 10’,” Rich teaches **forming the array of the micro mirrors** (of end product optical product 10’) **according to the design output file** because the data file is used to produce the master, and the master is used to produce **the array of the micro mirrors** of end product optical product 10’.

237. Fuhse847 therefore teaches element [1e].

b) Claim 2: *The method of claim 1, wherein the angular orientation is defined by coordinates of a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels.*

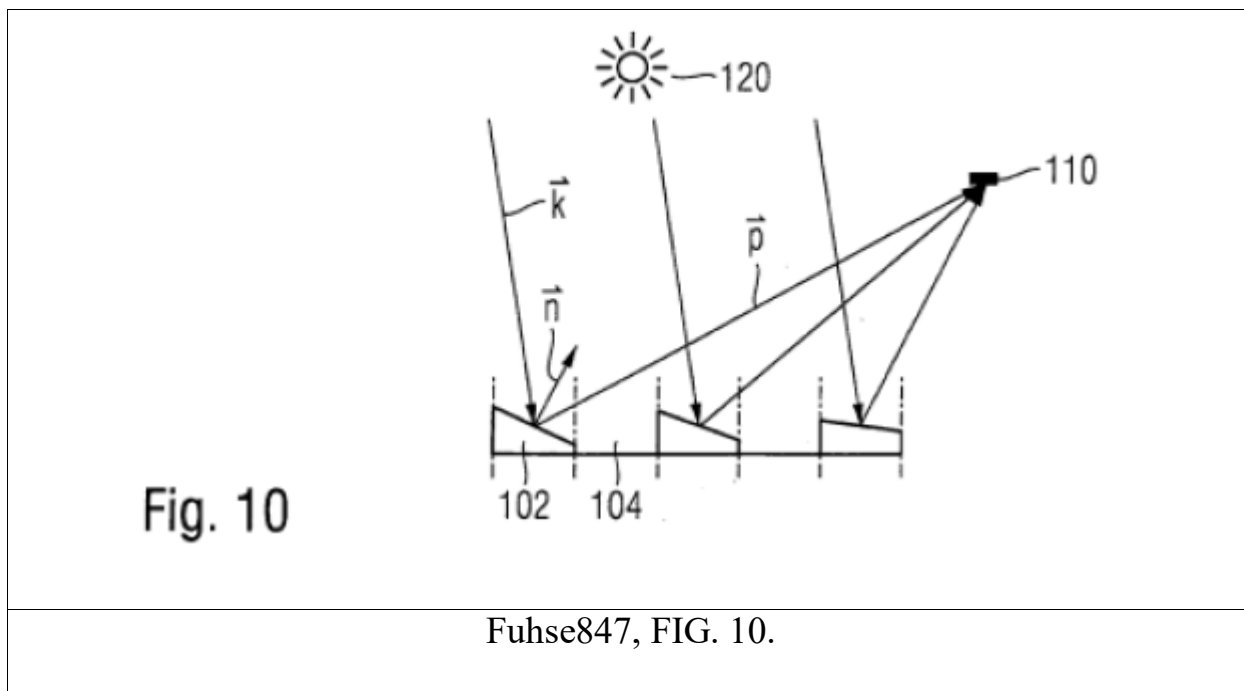
238. In my opinion, Fuhse847 renders obvious this claim. *See, supra*, Section X.A.2.a.iv ([1c]).

239. Fuhse847 discloses how to calculate angular orientations of its micromirror surfaces with respect to Figure 10 and corresponding disclosures. Fuhse847, pp. 21-23, 19 (“The calculation of the orientation of the flat mirror surfaces is explained below with reference to Fig. 10.”). In particular, Fuhse847 explains that “[t]he position of the mirror surfaces [**a reflective surface of each of the micro mirrors**], i.e. the normal vector $\vec{n}$ [**coordinates of a normal vector**], is to be determined in such a way that the light incident from a specified direction $\vec{k}$ is reflected onto the focal point (x_0, y_0, z_0) for all micromirrors 102 assigned to light spot 110 [**directing light to one of the pixels**],” the following equations are used to define the normal vector $\vec{n}$, incident light $\vec{k}$, and reflected light ray $\vec{p}$ for each of the pixels:

$$\vec{n} = \frac{\frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|}}{\left| \frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|} \right|}, \quad \vec{p} = \begin{pmatrix} x_0 - x \\ y_0 - y \\ z_0 \end{pmatrix}, \quad |\vec{p}| = \sqrt{(x_0 - x)^2 + (y_0 - y)^2 + z_0^2}$$

Fuhse847, pp. 21-22.

240. In other words, the normal vector $\vec{n}$ of the micromirrors such that reflected light ray $\vec{p}$ is directed towards the point (x_0, y_0, z_0) corresponding to one of the pixels. Fuhse847, pp. 21-22. These vectors are shown in Figure 10:



- c) **Claim 4:** *The method of claim 3, wherein the cone has an apex coinciding with coordinates of one of the pixels on the first or second image display planes.*

241. In my opinion, Fuhse847 renders obvious this claim.

242. Fuhse847 teaches that “every image point P_j ,” (every **pixel**, including **one of the pixels on the first or second image display planes**) **coinciding with coordinates of** a “cone originating from” or “emanating from” the image point (**an apex of the cone**). Fuhse847, pp. 9-10, 28. Each pixel is at “the intersection” of the emanating cone, which defines the apex. As Fuhse847 explains:

- for every image point P_j , a sphere of influence E_j is determined by an intersection of the aperture **cone originating from** the image point with the xy plane,

Fuhse847, pp. 9-10.

First, a desired three-dimensional motif with image points P_j and height values Z_j is defined above the xy plane, with image points corresponding to the light spots created by illumination. For a normal viewing distance of around 30 cm, the image point spacing should be in the range of 0.1 to 0.5 mm. Furthermore, the image points P_j are assigned a brightness I_j between 0% and 100%. Then the image points are assigned aperture cones that have an aperture ratio > 0.2 , for example an aperture ratio of 0.4. For each pixel P_j , the intersection of the opening **cone emanating from** the image point with the xy plane defines a catchment region E_j to the image point P_j .

Fuhse847, p. 28.

d) Claim 5: *The method of claim 1, wherein the angular orientations are calculated based on heights of the first and second image display.*

243. In my opinion, Fuhse847 renders obvious this claim.

244. As discussed, Fuhse847 discloses how to calculate angular orientations of its micromirror surfaces with respect to Figure 10 and corresponding disclosures.

Fuhse847, pp. 21-23, 19.

245. In these calculations, (x_0, y_0, z_0) “denotes the position of” every light spot, meaning z_0 is the height of the image display plane for each pixel (including **heights of the first and second image display**). Fuhse847, pp. 21-22.

246. As discussed, **the angular orientations are calculated** based on the normal vector $\vec{n}$ for all micromirrors assigned to the light spot 110:

$$\vec{n} = \frac{\frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|}}{\left| \frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|} \right|}, \quad \vec{p} = \begin{pmatrix} x_0 - x \\ y_0 - y \\ z_0 \end{pmatrix}, \quad |\vec{p}| = \sqrt{(x_0 - x)^2 + (y_0 - y)^2 + z_0^2}$$

Fuhse847, pp. 21-22.

247. As can be seen in the equations, the normal vector $\vec{n}$ is **calculated based on $\vec{p}$ and $|\vec{p}|$** , which both are both **calculated based on z_0** . Fuhse847, pp. 21-22.

e) **Claim 6: The method of claim 1, wherein the angular orientations are calculated to provide a predefined angular offset of at least 10 degrees between the first and second image display planes.**

248. In my opinion, Fuhse847 renders obvious this claim.

249. Fuhse847 teaches that “different images become visible to the viewer from different directions.” Fuhse847, pp. 25, 7. As Fuhse847 explains:

“When **tilted to the side**, the security element should show an image change from a light-spot image A to a light-spot image B. First, the required optical elements that produce the light-spot images when illuminated are determined for both light-spot images. As described in connection with Figs. 8 to 10, each light spot is assigned a plurality of optical elements, here a plurality of micromirrors.”

Fuhse847, p. 25.

250. In other words, light-spot image A (in **the first image display plane**) is viewable from a certain angle, and an “image change” to light-spot image B (in **the second image display plane**) occurs when “tilted to the side.” As discussed under element [1c] (*see, supra*, Section X.A.2.a.iv ([1c])), the **angular orientations are calculated** to reflect light to the assigned pixel (forming part of light-spot image A or B).

251. Fuhse847 further teaches a **predefined angular offset** in the two viewing angles by providing the ability “to separate the light-spot images of a changing image.” Fuhse847, p. 5. For example, Fuhse847 teaches “the size of the visibility range can be set as desired,” including between “three light-spot images A, B, C to change when tilted vertically.” Fuhse847, p. 26. When chosen such that light-spot image A (in **the first image display plane**) is viewable from a certain angle (**a first viewing angle**), and light-spot image B (in **the second image display plane**) is viewable from another certain angle, with a third image viewable at an angle between those images, the **predefined angular offset** would be understood to be at **least 10 degrees**. At least 10 degrees would be needed to be provided to the third image in most applications.

252. Further, before the relevant time, micro mirror devices had the known advantage of providing a large separation between images compared to other types of optical security devices known in the art. *See* EX1042 (Micromanufacturing and

Nanotechnology, Chapter 7 (Micromanufacturing for Document Security: Optically Variable Device)), pp. 164 (“A particular advantage of the micromirror OVD concept relates to the relatively large angular separation between channels (sometimes of the order of 120 degrees).”). This would have been a known advantage that would be recognizable to a POSITA, as small angular differences suffered from loss of separation upon crumpling of the banknote. *Id.*

f) Claim 12

253. In my opinion, Fuhse847 teaches claim 12, as detailed below.

i. Claim 12, Element [12Pre]: *A method of fabricating a security element useful on paper and coin currency and on product labels, comprising:*

254. In my opinion, Fuhse847 renders obvious the limitation. *See, supra*, Section X.A.2.a.i [1Pre] (“A method of fabricating a security element, comprising:”).

255. In my opinion, the preamble simply states what the claim is useful for. In fact, the preamble explicitly purports to describe what the preamble is “useful on.”

256. Also, none of the terms in the preamble are later provided in the claim body, so the preamble does not complete the structure of the claim body.

257. In my opinion, to the extent the preamble is limiting, Fuhse847 teaches the preamble. Fuhse847, pp. 4-5, 11, FIG. 1. *See, supra*, Section X.A.2.a.i [1Pre] (“A method of fabricating a security element, comprising:”).

258. Fuhse847 further teaches that the security element is **useful on paper and coin currency and on product labels**.

259. The depiction element has “security applications” for a “data carrier,” and “[t]he data carrier can in particular be a value document,” such as a “paper banknote” (**paper... currency**). Fuhse847, 11, 4-5, FIG. 1.

260. Coin currency and product labels are also “data carriers” because they carry data related to the currency or product.

261. Based on Fuhse847’s teachings that the depiction element would be useful for data carriers such as currency, a POSITA would have found it obvious to recognize that the depiction element would be useful for coin currency and product labels.

262. It was known in the art to apply depiction elements to coin currency and product labels. Ex. 1007 (Jordan), Abstract, ¶¶0013, 0002-04, 0113-14, 0124-25, 0154, 0159, 0174-77. For example, optical depiction elements were included on the surface of Australian coins by 2001. Ex. 1030, p. 6 (citing Exs. 1031-32); Ex. 1031, p. 2; Ex. 1032, p. 1032, pp. 1-2.

ii. Claim 12, Element [12a]: *with a processor of a computing device, executing code to provide an*

array design module configured to define an array of micro mirrors to be formed on a surface of a substrate;

263. In my opinion, Fuhse847 in view of Rich renders obvious the limitation. *See, supra*, Section X.A.2.a.iii ([1b]) (“with a processor of a computing device, executing code to provide an array design module that operates to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of the first object in the first image display plane and to display each of the pixels of the second object in the second image display plane;”). Further, claim 12 additionally recites an “array of micro mirrors... formed on the surface of the substrate.” In my opinion, it would have been obvious to combine the embodiments of Fuhse847. *See, supra*, Section X.A.1.

264. Fuhse847 teaches **a substrate**, such as substrate 22, shown annotated in blue in the below reproduction of Figure 2. Fuhse847, Abstract, 4, 9, 13-14, 24-25.

265. The surface of the substrate defines a “xy plane” or “substrate plane.” Fuhse847, pp. 28, 24-25. In Fuhse847’s coordinate system, this surface corresponds to $z=0$. Fuhse847, pp. 24, 28.

266. Fuhse847’s substrate has “a surface region” (**on a surface of the substrate**) “in which a plurality of optical elements are arranged.” *See* Fuhse847, Abstract, 4, 9, 13-14, 24-25. The optical elements may be “plurality of

micromirrors” (**an array of micro mirrors**) “distributed over a certain surface region of substrate 22” (**on a surface of the substrate**), as shown in Figure 2.

Fuhse847, pp. 14, 5, 7-8, 19-21.

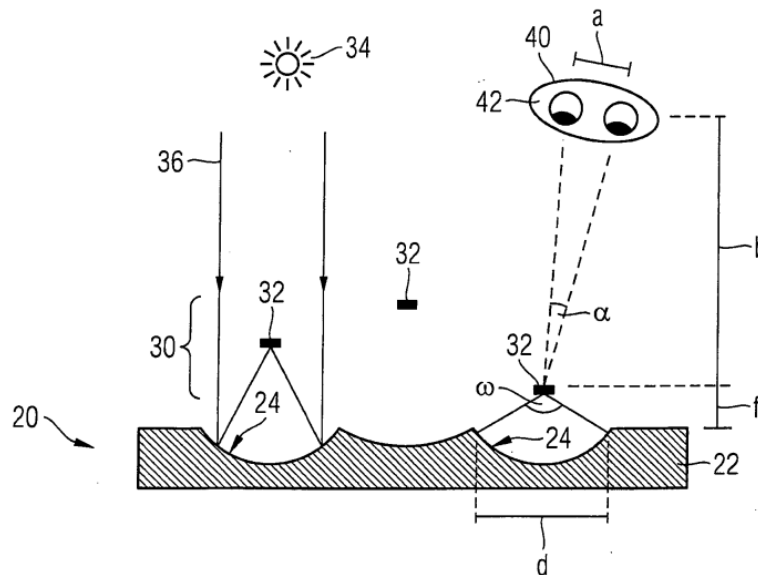
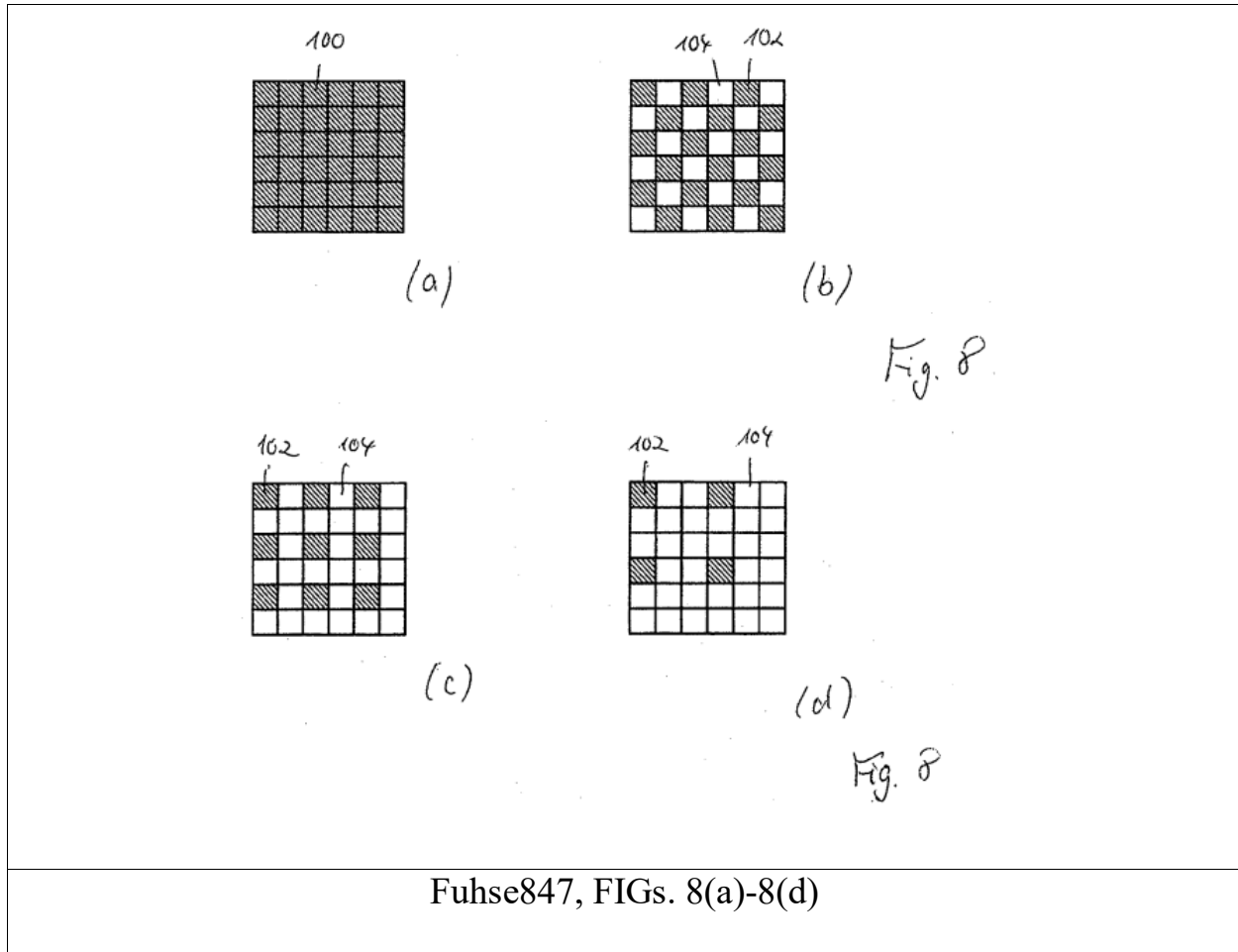


Fig. 2

267. Figure 8, including Figures 8(a)-8(d), and supporting disclosure provides further detail of the **array of micro mirrors** in the form of “an arrangement of $n \times n$ micromirrors 100, which are arranged next to one another without any distance between them in the surface of the security element.” Fuhse847, pp. 14, 5, 7-8, 19-21 (describing a “checkerboard-like arrangement”). Specifically, the curved mirrors of Figure 2 are “replaced by” the plurality of flat micromirrors 100 because they are “easier to calculate and produce.” Fuhse847, p. 19. This ordered arrangement of micromirrors 100 is **an array**. As I previously discussed, it would

have been obvious to combine the embodiments of Fuhse847. *See, supra*, Section X.A.1.



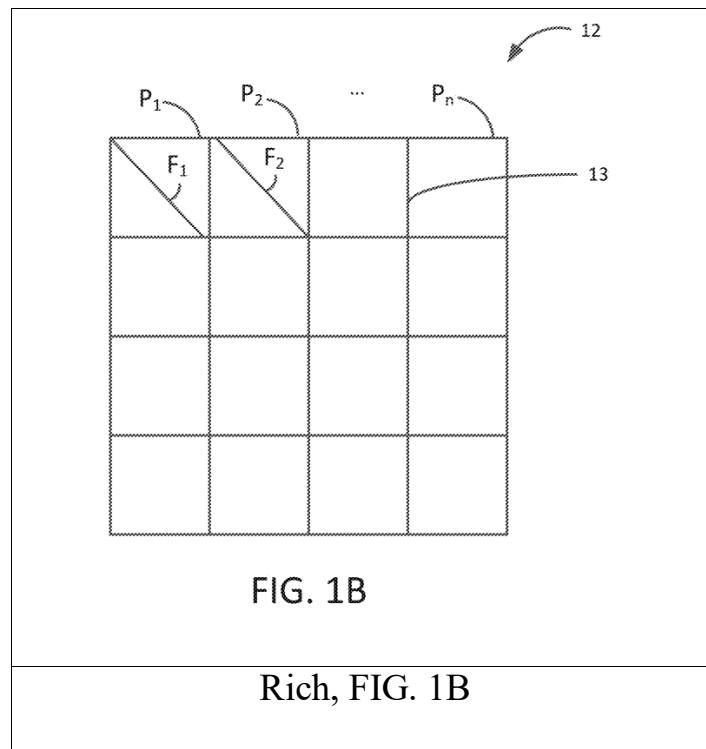
268. As discussed in Ground 1, element [1b], Rich teaches **a processor of a computing device, executing code to provide an array design module**. *See, supra*, Section X.A.2.a.iii ([1b])

269. Rich also teaches an **array of micro mirrors**. As Rich explains, Rich's master and corresponding optical product have arrays of micro mirrors with similar dimensions to that of Fuhse847 and the '863 patent:

“As shown in FIG. 1A, the second surface **12** can include a plurality of portions $P_1, P_2, \dots P_n$. Each portion P_n can correspond to a plurality of portions $P'_1, P'_2, \dots P'_n$ on the optical product **10'**. The plurality of portions $P'_1, P'_2, \dots P'_n$ on the optical product **10'** can also be referred to as a cell, pixel, or a tile. Each portion P'_n can have a length between 30 μm and 100 μm , between 35 μm and 55 μm , or between 40 μm and 50 μm . Each portion P'_n can have a width between 30 μm and 100 μm , between 35 μm and 55 μm , or between 40 μm and 50 μm . Accordingly, in various embodiments, the aspect ratio of each portion P'_n can be 1:1 or 1:1.1.”

Rich, 5:24-35. Rich further discloses that “the optical product **10'** can include reflective material,” including “reflective metal such as aluminum, copper, or silver.” Rich, 6:1-15.

270. Rich’s array of micro mirrors is further shown in FIG. 1B, which may have any number of rows and columns, but shows an example of 4x4.



Rich, 10:44-50.

271. It would have been obvious from Fuhse⁸⁴⁷ in view of Rich that Rich's **processor of a computing device, executing code to provide an array design module** would **define** the array of micro mirrors to be formed on a surface of a substrate.

272. Rich explains that the array is defined, explaining that "[t]he number of cells is not particularly limited and can depend on factors such as size and resolution of the image to be reproduced." Rich, 10:37-39. Accordingly, in the previously discussed method of FIG. 2B of Rich (see Ground 1, element [1b], performed by the **processor of a computing device, executing code to provide an array design module**), array is **define[d]** through the process of receiving input images and translating them into data files that are a "map" for the lithographic tools to produce the array of micro mirrors. *See* Rich, 16:33-17:7, as reproduced below:

"FIG. 2B illustrates an example method that can be used to manufacture the master 10 and also to determine the data file to be used to manufacture the master 10, e.g., to determine the pattern of the features $F_1, F_2, \dots F_n$ on the surface 12 of the master 10. Certain such embodiments can be advantageous as a 3D physical object and/or a 3D model utilizing physical dimensions of the 3D object (e.g., topographical calculations) are not required. For example, in the method 300 shown in FIG. 2B, the input image 305 can be a 2D input image (e.g., a 2D photograph of the 3D object) or 2D image converted from a 3D image. **In some embodiments, the input image 305 can be converted into a 2D interpolated image 308 and produced as a 2D converted image 310. The 2D image of the 3D object can be translated into a gray scale image (e.g., a normal map 315 wherein black, white, and gray regions correlate to**

different heights of the 3D object). In the method 300 shown in FIG. 2B, the converted image 310 (or a normal map 315) is entered into the recording loop 320 of the main program 325 of the processor 330 in accordance with certain embodiments described herein. Similar to the method 200 in FIG. 2A, other information, such as user parameters 311 (e.g., angle, scale, zoom, etc.), exposure compensation curve 312, intensity compensation mask 313, and apodizing mask 314 can also be entered into the recording loop 320. The processor 330 can produce a data file 340, e.g., a 2D data file, that is configured to describe the 3D image 50' of at least a part of the 3D object 50. In some embodiments, the intensities in the data file 340 can be assigned based on gray scale. For example, the data file 340 can comprise a plurality of portions. Each portion can correspond to one or more points on a surface S of the 3D object 50. Each portion can comprise features of intensity corresponding to non-holographic elements on the optical product 10'. A gradient in intensity can correlate to a gradient or an inclination of the surface S of the 3D object 50 at the one or more corresponding points. In addition, an orientation of the features can correlate to an orientation of the surface S of the 3D object 50 at the one or more corresponding points. **This data file 340 can be used as a map to generate the pattern of features $F_1, F_2, \dots, F_n$ on the surface 12 of the master 10.** An example data file is discussed with respect to FIG. 3A."

iii. Claim 12, Element [12b]: *generating a design output file including an angular orientation and location coordinates in the array for each of the micro mirrors; and*

273. In my opinion, Fuhse847 renders obvious the limitation. *See, supra*, Section X.A.2.a.v [1d] ("generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors; and").

iv. Claim 12, Element [12c]: *forming the array of micro mirrors according to the design output file,*

274. In my opinion, Fuhse847 renders obvious the limitation. *See, supra*, Section X.A.2.a.vi [1e] (“forming the array of the micro mirrors according to the design output file”).

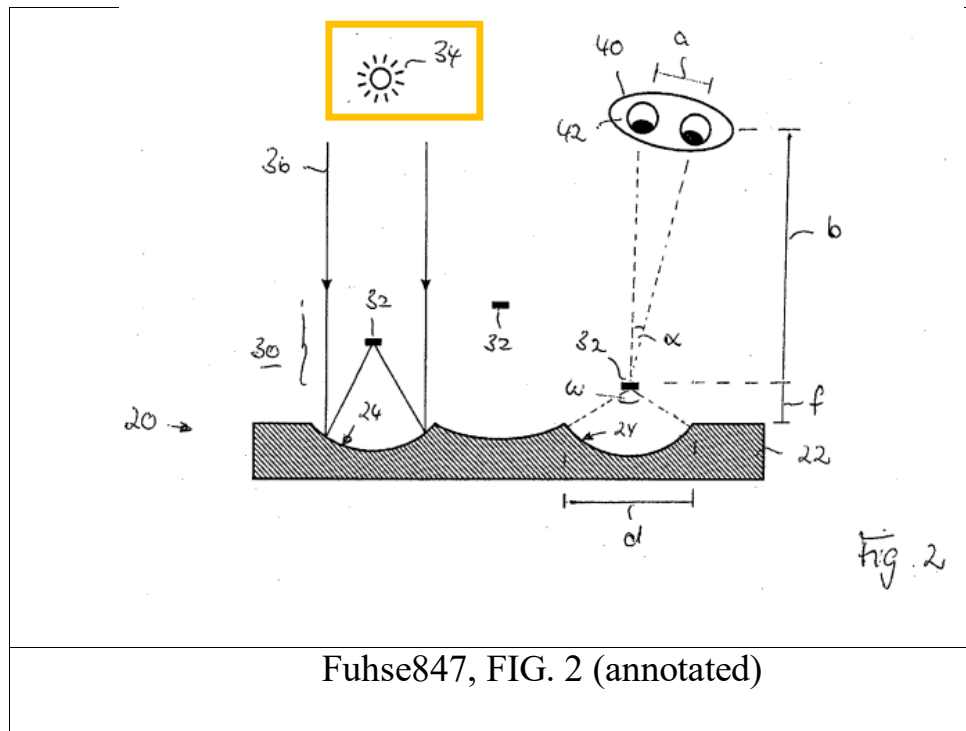
v. Claim 12, Element [12.d]: *wherein the array of micro mirrors is configured, when formed on the surface of the substrate, for receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate,*

vi. Claim 12, Element [12.e]: *wherein the image comprises a plurality of pixels, and*

275. In my opinion, Fuhse847 renders obvious these limitations ([12d] and [12.e]). Further, claim 12 additionally recites an “array of micro mirrors... formed on the surface of the substrate.” In my opinion, it would have been obvious to combine the embodiments of Fuhse847. *See, supra*, Section X.A.1.

276. The micromirrors shown in Figure 8 **receiv[e] ambient light** because they are “illuminated” in the same manner as the lenses and mirrors described in Fuhse847. Fuhse847, pp. 18-20. Fuhse847 discloses that the illumination is with **ambient light** such as “sunlight or a ceiling lamp,” that is **receiv[ed]** by the **array of micro mirrors when formed on the surface of the substrate**. Fuhse847, pp. 13-14 (“When illuminated, for example by sunlight or a ceiling lamp, security element 12 produces a three-dimensional light-spot image for a viewer from a

plurality of light spots, each of which appears to a viewer to float above or below the level of security element 12.”). For example, Fuhse847 discloses illumination by “distant light source 34,” depicted in Figure 2 as sunlight:



Fuhse847, pp. 14-15, *see also* p. 8 (distinguishing “normal illumination” “visible to the naked eye” with “directed illumination with laser light”).

277. As I discussed in the Technology Background, sunlight and light from a ceiling lamp are ambient because they are understood to generally illuminate space. *See, supra*, Section V.B.3. Fuhse847 distinguishes “normal illumination” “visible to the naked eye” (i.e., ambient light) with “directed illumination with laser light.” Fuhse847, p. 8.

278. Fuhse847 teaches that in response to illumination, a light-spot image (**displaying an image which comprises a plurality of pixels**) is produced that floats (with all light spots of the light spot image at the “same height”, meaning they are in a plane). Fuhse847, pp. 26 (describing “a two-dimensional motif in the light-spot image, in which all image points are at the same height”), 8. That image in the plane is above the surface region of the substrate (**a distance apart from the surface of the substrate**).

279. The image is **in a plane**. *First*, Fuhse847 states that the image may be two-dimensional, and a POSITA would understand that a floating two-dimensional image in space defines that it is in a plane based on Fuhse847’s teaching. Fuhse847 teaches that all the light spots may be at the “same floating height” or “a certain height above or below the substrate surface.” Fuhse847, pp. 16, 5. *Second*, Fuhse847 teaches that arbitrary three-dimensional images may be produced. Fuhse847, pp. 4-5, 9-10. A POSITA would understand that planed images are within this teaching because a two-dimensional plane is a three-dimensional space with one dimension fixed. For example, when the height (z-dimension) is fixed for an image, the image is defined in the x-y plane at that height z_0 (where z_0 denotes the distance from the plane in the z-direction).

280. Fuhse847 teaches that “upon illumination” (**in response**) “to produce... a light-spot image composed of a plurality of light spots,” (**displaying an image...**

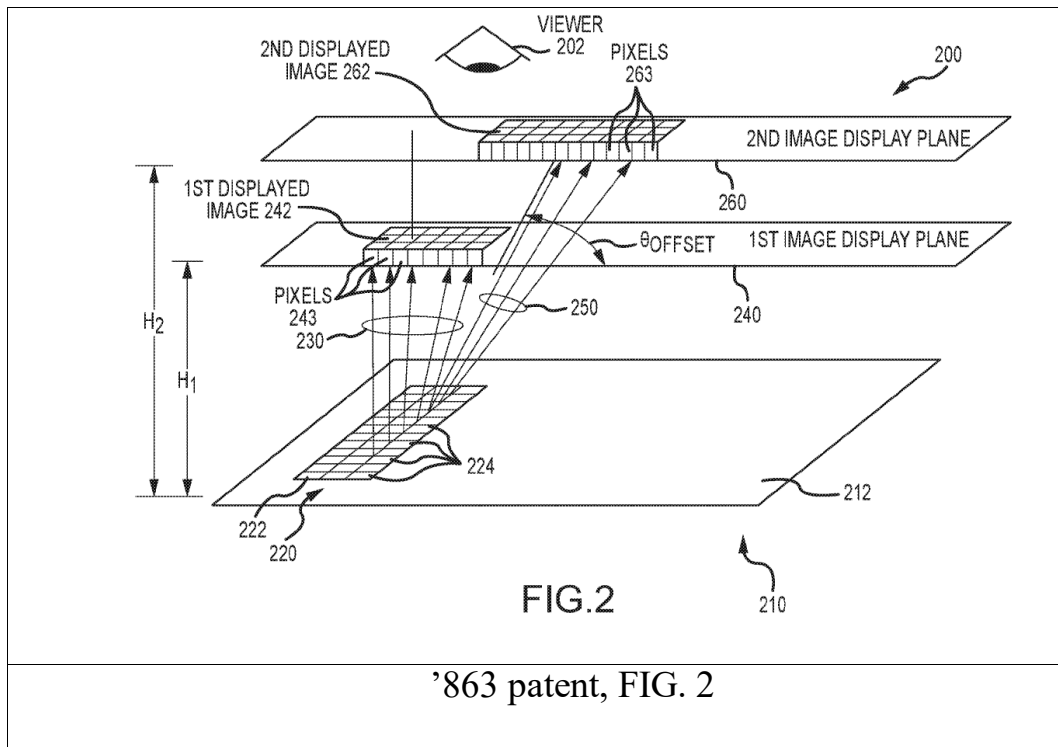
wherein the image comprises a plurality of pixels) “that for a viewer appear floating above or below the surface region” **(in a plane spaced a distance apart from the surface of the substrate).** Fuhse847, pp. 4-5, 9-10, 13-14, 19, 28.

281. The production of a light-spot image composed of a plurality of light spots is **in response** to the illumination. The micromirrors are passive components that produce the light-spot image by reflecting the incident illumination in a pre-determined manner. In other words, the micromirrors produce the light-spot image when there is incident illumination to reflect, and do not produce the light spot image when there is no incident illumination to reflect.

282. The plurality of light spots (**a plurality of pixels**) are the units that form the light-spot image (**the image**). A POSITA would know that overlapping beams reflected by the micromirrors create the light spots. These light spots make up the pixels (picture elements) of the displayed image. This is also how the '863 patent describes “pixels.” For example, with respect to FIG. 2, the '863 patent describes that pixels 243 are what makes up the image 242:

“To this end, a first number of the micro mirrors 224 may be configured to provide sets of pixel-providing micro mirrors that reflect ambient light as shown with arrows 230 to “write” or display **a first displayed image 242 made up of a plurality of pixels 243** (with each of these pixels 243 associated with one of the sets of pixel-providing micro mirrors 224).”

'863 patent, 7:42-48 (emphasis added).



283. Fuhse847 teaches that while “a truly three-dimensional” **image** can be formed by using light spots (**pixels**) of “different floating heights above and/or below the substrate surface,” alternatively, “all light spots [**a plurality of pixels**] in the light-spot image [may] have the same floating height,” (forming **a plane spaced a distance apart from the surface of the substrate**) which provides a two-dimensional image “that floats at a certain height above or below the substrate surface.” Fuhse847, p. 16.

284. Fuhse847 teaches that any arbitrary “desired three-dimensional motif having image points P_j and height values Z_j above an xy plane” may be “specified,”

meaning that providing image points P_j of all the same height values Z_j above the surface of the substrate results in **displaying an image in a plane spaced a distance apart from the surface of the substrate**. Fuhse847, pp. 9-10, 28, cl. 26. Fuhse847 interchangeably refers to image point P_j (**pixel**) and its corresponding light spot as “pixel P_j .” Fuhse847, pp. 28. The “xy plane” is understood to be **the surface of the substrate** because it is the plane that is divided into fields that are “covered with” the optical elements (micromirrors) which are **on a surface of the substrate**, as required by element [12a] (*see* element [12a]). Fuhse847, pp. 9-10, 28.

285. A two-dimensional image in a plane is simply a three-dimensional image with a small or zero thickness. For example, the surface of the substrate defines a “xy plane” with $z=0$. Fuhse847, pp. 28, 24-25. By teaching any arbitrary three-dimensional image in space (i.e., x, y, z space) can be constructed of light points, it is obvious that a two-dimensional image can be constructed by simply fixing the height (z) values of the pixels, provided the x-y plane is the plane of the surface of the substrate.

286. While providing a two-dimensional image in a plane is obvious based on teaching an arbitrary three-dimensional image, Fuhse847 *explicitly* teaches that a two-dimensional image may be formed by fixing the height (z) values of the pixels:

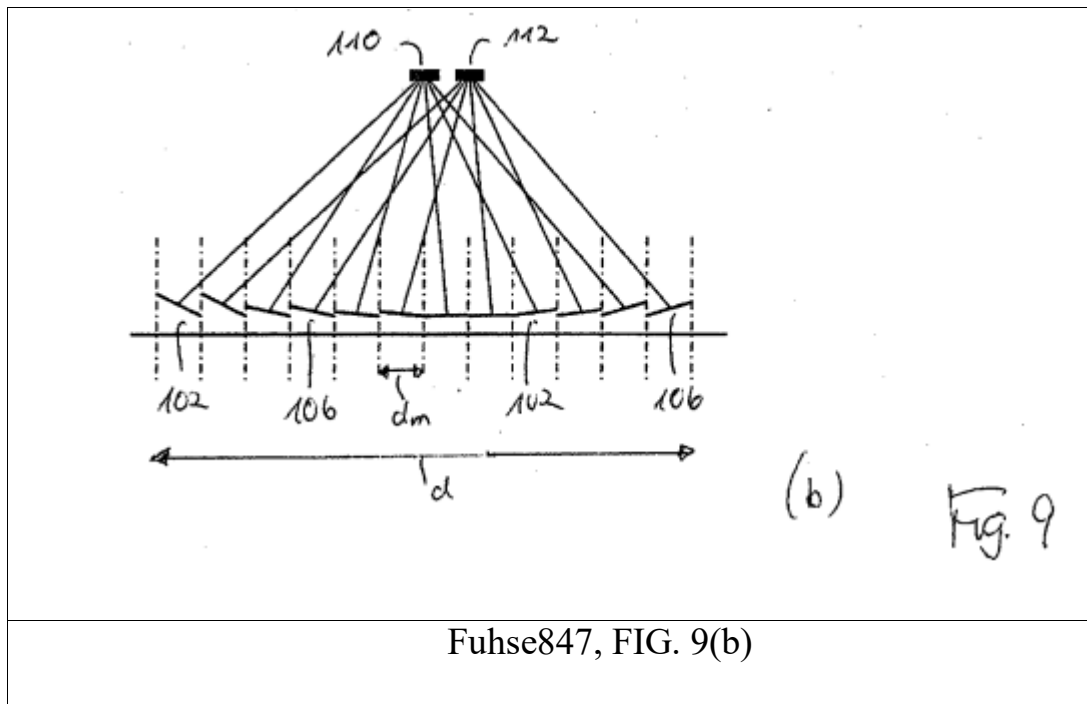
“If the convex mirrors of a security element have several different focal lengths, i.e. if the light spots of the light-spot image have several different floating heights above and/or below the substrate surface, a truly three-dimensional motif is created. In some configurations,

however, it may also be advisable to design all convex mirrors with the same focal length, so that **all light spots in the light-spot image have the same floating height**. In this way, a backdrop motif is created that floats at a certain height above or below the substrate surface.”

Fuhse847, p. 16, 5 (emphasis added). In fact, Fuhse847 refers to the resulting image as “a two-dimensional motif,” such as “a font or a logo.” Fuhse847, pp. 5, 7, 26.

287. For the given fixed height of the two-dimensional motif (for example, $z = z_1$), the image is **in a plane** defined by (x, y, z_1) .

288. For example, Figure 9(b) shows “two closely adjacent light spots” 110 and 112 (two pixels) formed at the same height:



Fuhse847, pp. 13, 20-21.

289. Accordingly, Fuhse847 renders obvious elements [12.d] and [12.e].

- vii. **Claim 12, Element [12.f]: wherein the array of micro mirrors includes for each of the pixels a different set of the micro mirrors each having a reflective surface oriented, in a fixed manner, with a body of each of the micro mirrors rotated about at least one of first and second rotation axes extending through the body, to reflect the ambient light toward a point on the plane corresponding to one of the pixels.**

290. In my opinion, Fuhse847 renders obvious this limitation.

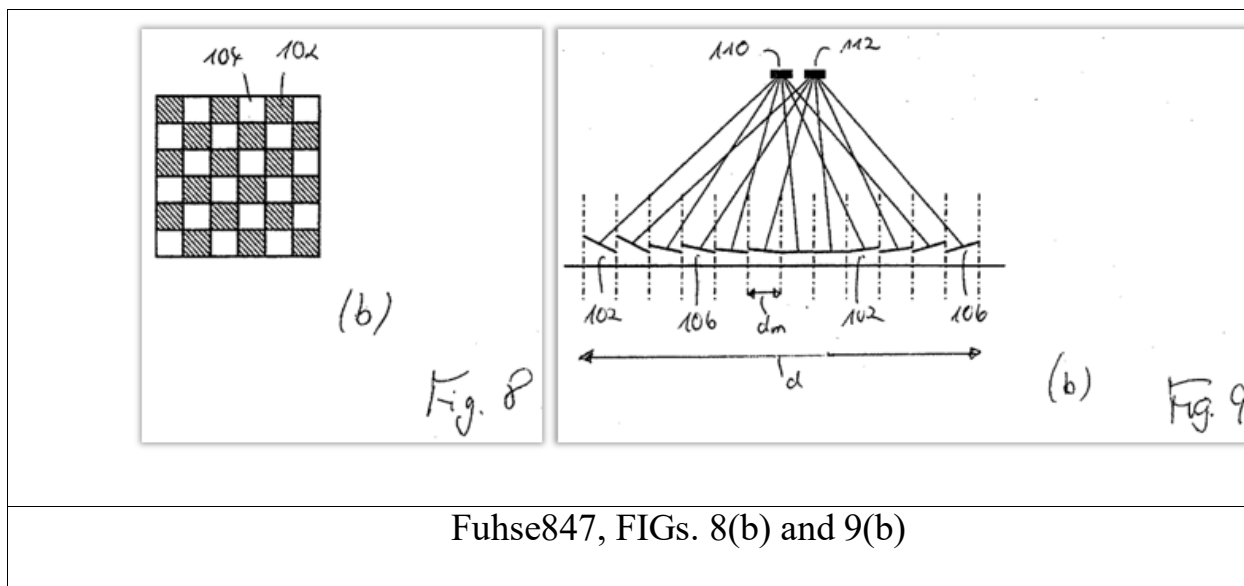
291. Fuhse847 describes an assignment system to assign micromirrors to light spots (**pixels**) in which each pixel is assigned a “group” of micromirrors, such that each micromirror is assigned to at most one pixel. Figure 10 and its descriptions teach how to properly orient each micromirror to reflect light to its assigned pixel. The micromirrors are fixed in the xy-plane (i.e., **the substrate surface plane**), and each of the x and y axes are rotation axes by which the bodies of the micromirrors are oriented to properly reflect light to the assigned pixel.

292. Fuhse847 discloses that **the array of micro mirrors includes for each of the pixels a different set of the micro mirrors**. Fuhse847, pp. 6, 9-10, 19-21. Fuhse847 explains that “a plurality of optical elements is assigned to every light spot” (**for each of the pixels a different set of the micro mirrors**), such that “groups of optical elements” “are each assigned to different light spots.” Fuhse847, p. 6 (emphasis added). Fuhse847 does so by defining “a number of fine fields” “for every image point P_j ,” (**each of the pixels**), and providing that the optical elements

in those fine fields (**a different set of the micro mirrors**) “contribute to producing the light spot that corresponds to image point P_j .” Fuhse847, pp. 9-10, 28, cl. 26.

293. In the example of FIG. 8b, (shaded) micromirrors 102 form a set **of micro mirrors**, and (white) “fields 104 [] covered with micromirrors 106” form a second **set of micro mirrors**, and the sets are different because they comprise different micromirrors. Fuhse847, pp. 20-21. In other words, each micromirror is assigned to a single light spot. No micromirrors are shared with multiple light spots. Thus, the set of micromirrors for each light spot contains a unique set of micromirrors.

294. As shown in Figure 9(b), “[m]icromirrors 102 form a group of micromirrors, which are all assigned to the same light spot 110 and produce it together when illuminated,” while micromirrors 106 “serve to produce a light spot 112,” meaning a **different set of the micro mirrors is assigned for each of the pixels**. *Id.* Fuhse847 states that in the “[t]he number $n \times n$ of micromirrors is, for example, 10×10 ,” (totaling 100) meaning that in FIG. 8(b), each **set of micro mirrors** would have 50 micromirrors. Fuhse847, pp. 19-20.



295. Fuhse847 discloses that **the micro mirrors each having a reflective surface oriented... to reflect the ambient light toward a point on the plane corresponding to one of the pixels.** Fuhse847 discloses that its micromirrors may be “purely reflective.” Fuhse847, pp. 4-5, 9-10, 14-15. In particular, Fuhse847 discloses that “the flat mirror surfaces of the micromirrors” “reflect[]” incident light **(the micro mirrors each having a reflective surface).** Fuhse847, pp. 21-22. For each of the pixels, the micromirror surfaces reflect incident light **(reflect the ambient light)**, such as light source 120, **towards** the point (x_0, y_0, z_0) , which “denotes the position of light spot 110” **(a point on the plane corresponding to one of the pixels).** Fuhse847, pp. 21-22.

296. Fuhse847 discloses that such orientation is **in a fixed manner with a body of each of the micro mirrors rotated about at least one of first and second**

rotation axes extending through the body. Fuhse847, pp. 21-23. As an initial matter, Fuhse847's orientation of all its mirrors is **in a fixed manner** because each one has one permanent orientation (normal vector $\vec{n}$, as discussed below is fixed). Micromirrors for security elements on, for example, currency, are generally manufactured with a particular orientation to produce a particular image, and generally are not variably controlled.

297. Fuhse847 further teaches that its micromirrors are produced by embossing a lacquer layer and providing a metallized coating on top to increase reflectivity. Fuhse847, pp. 8-9. The structure of the micromirrors (including the orientation of the mirrored surface) would be **fixed** upon embossing and metallization.

298. Fuhse847 refers to “a display device with a control device” to display different images “very quickly” “depending on the control,” such that “[t]he display device can [] be used as a 3D display for a wide variety of applications.” Fuhse847, p. 11. The “wide variety of applications” are separate, additional applications to provide a 3-D display for electronics, not the applications discussed in this declaration (*e.g.*, micromirror arrays for banknotes, etc.). An electronically controlled display to provide a “continuous sequence of images” would not be suitable for Fuhse847's micromirror arrays for banknotes.

299. The term “fixed manner” was introduced during prosecution of the parent '294 patent to distinguish Raber, which is in the electronic arts and discloses using variable focal length to “sequentially display a slice of an image on differing image planes.” '294 FH, pp. 464/765, 479-80 (“Applicant’s invention that involves orienting sets of micro mirrors in a fixed manner (i.e., a part of mirror fabrication)”).

300. Fuhse847 discloses how to calculate orientations of its flat micromirror surfaces with respect to Figure 10 and corresponding disclosures. *Id.* In particular, Fuhse847 explains that “[t]he position of the mirror surfaces, i.e. the normal vector $\vec{n}$, is to be determined in such a way that the light incident from a specified direction $\vec{k}$ is reflected onto the focal point (x_0, y_0, z_0) for all micromirrors 102 assigned to light spot 110,” the following equations are used to define the normal vector $\vec{n}$, incident light $\vec{k}$, and reflected light ray $\vec{p}$:

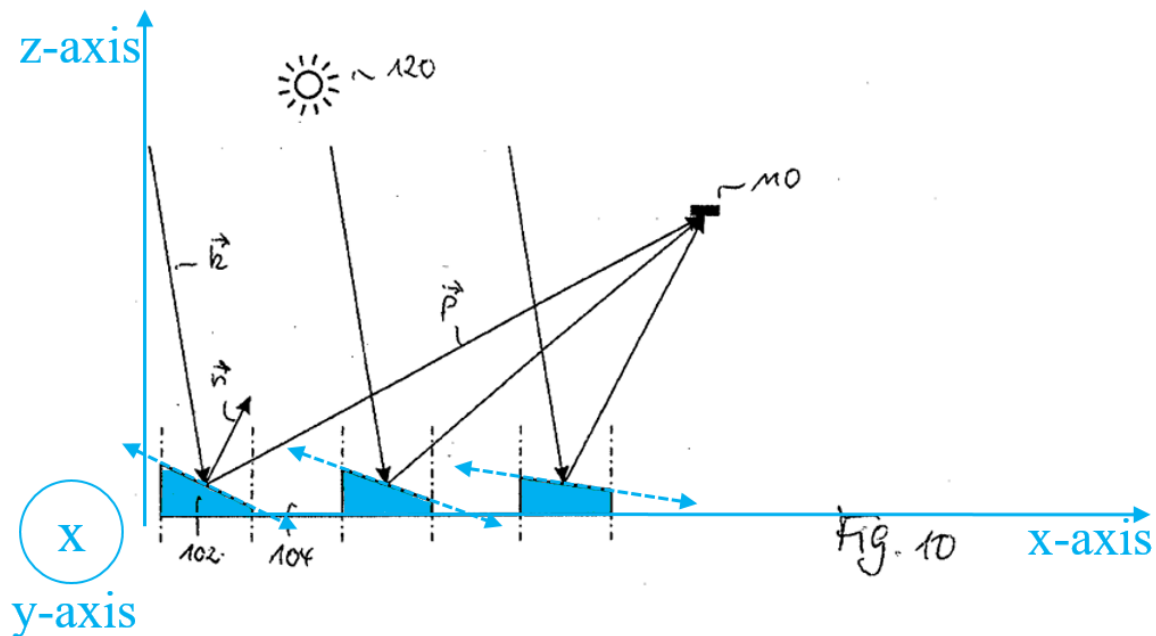
$$\vec{n} = \frac{\frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|}}{\left| \frac{\vec{p}}{|\vec{p}|} - \frac{\vec{k}}{|\vec{k}|} \right|}, \quad \vec{p} = \begin{pmatrix} x_0 - x \\ y_0 - y \\ z_0 \end{pmatrix}, \quad |\vec{p}| = \sqrt{(x_0 - x)^2 + (y_0 - y)^2 + z_0^2}$$

Fuhse847, pp. 21-22. These vectors are shown in Figure 10.

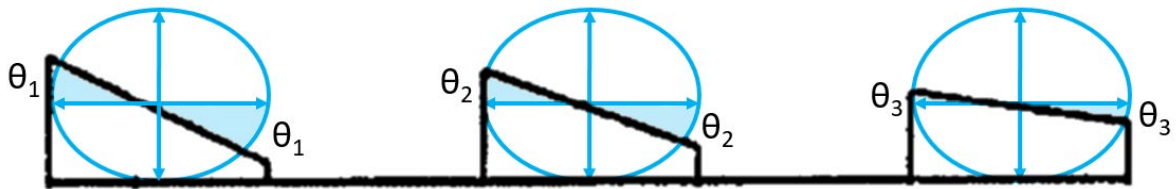
301. The x and y axes are **first and second rotation axes**, such that **a body of each of the micro mirrors rotated about at least one of first and second rotation axes extending through the body** in order to align the normal vector $\vec{n}$ of the micromirrors such that reflected light ray $\vec{p}$ is directed towards the point $(x_0, y_0,$

z0) corresponding to one of the pixels. In the '863 Patent, the **first and second rotation axes** are likewise the x and y axes. See '863 Patent, FIG. 1 (“1ST ROTATION AXIS (Y-AXIS)” and “2ND ROTATION AXIS (X-AXIS)).”

302. As shown in annotated Figure 10 below, a **body of each of the micro mirrors** has been **rotated about at least one of first and second rotation axes extending through the body**. Assuming the axes shown in annotated Figure 10 below, with the x axis extending along the horizontal, the z axis extending along the vertical, and the y axis extending perpendicular to the page, the below micromirrors have been rotated about **y rotation axis**, which **extend[s]** through the y - length of the micromirror **body**.



303. I have further annotated FIG. 10 below show the rotation of each mirror about the y rotation axis. As can be seen, each mirror has been rotated by a particular angle (i.e., θ_1 , θ_2 , θ_3) in order to reflect light to the coordinates of light spot 110.



304. Accordingly, Fuhse847 renders obvious element [12.f].

- g) **Claim 13:** *The method of claim 12, wherein a voxel is created at each of the point on the plane via intersection of two or more beams of the reflected ambient light, and wherein each of the created voxels produces an effect of a point source of light floating above the surface of the substrate in the plane.*

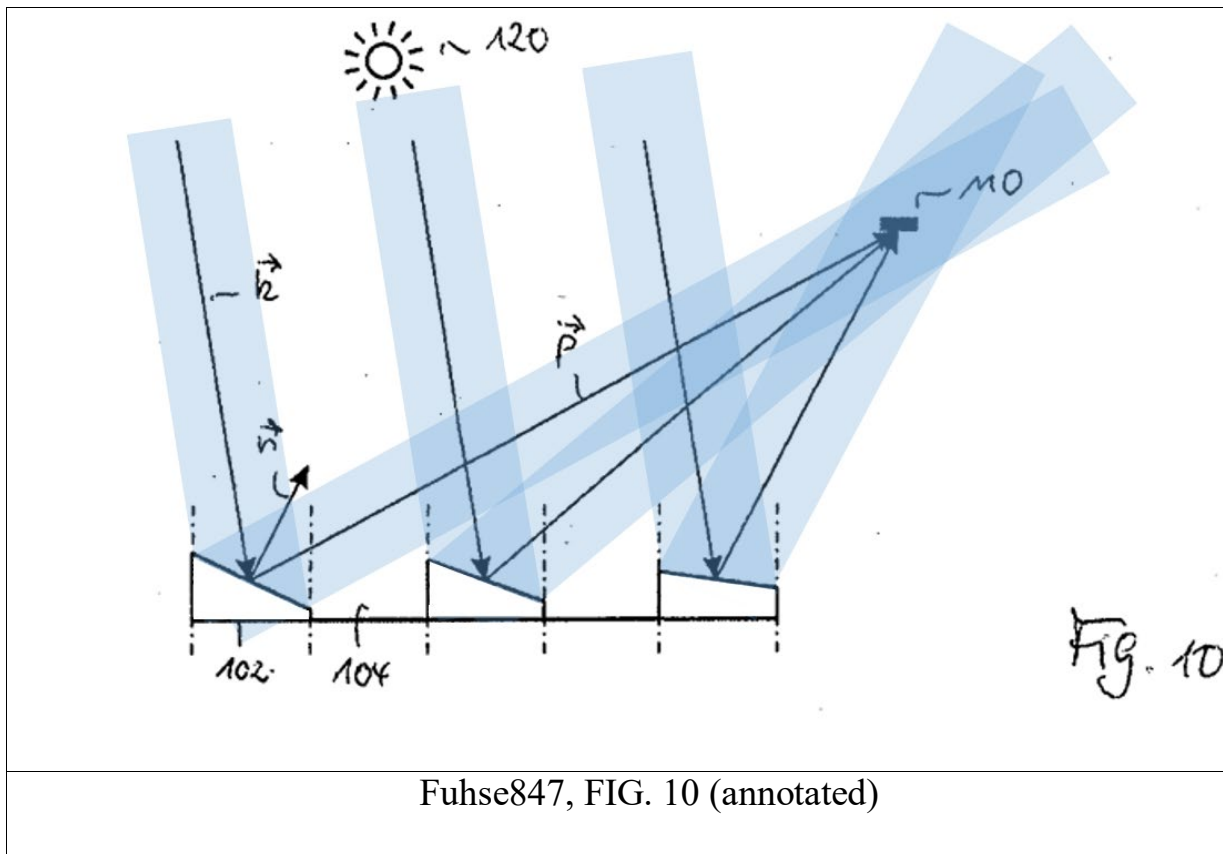
305. In my opinion, Fuhse847 renders obvious this claim. Fuhse847, pp. 21-22, FIG. 9-10.

306. The '863 patent does not use the term "voxel." Patent Owner introduced this element this term during prosecution of the parent '294 Patent in response to the Examiner's rejection based on Raber. '294 FH p. 411. As Applicant explained in its response, Raber teaches to "sequentially display 2D images onto differing image planes to provide 3D" television images. FH p. 422. Applicant's discussion appears to treat "voxels" as synonymous with "pixels," referring numerous times to "voxels/pixels" in its response. See FH pp. 421-22.

307. While '863 patent does not use the term “voxel,” voxels generally have a volume. This understanding agrees with what Fuhse847 teaches.

308. As discussed with respect to element [12.f], for each of the pixels, a light spot at point (x_0, y_0, z_0) is a **point on the plane corresponding to one of the pixels**. Fuhse847, pp. 21-22. In other words, each light spot is defined in three-dimensional space (i.e., x, y, z coordinates), which is the center-point of **a voxel is created at each of the points on the plane**. *Id.*

309. For example, with respect to light spot 110 shown in Figure 10, the rays shown are chief rays that depict the center rays of light for each optical element, which is very common in micro-optic design. *See* Section V.B.2. Ambient light reflects from the entire surface of the mirrors and forms reflected beams of light, not just the rays aimed at the center point, as I have depicted below with respect to Figure 10:

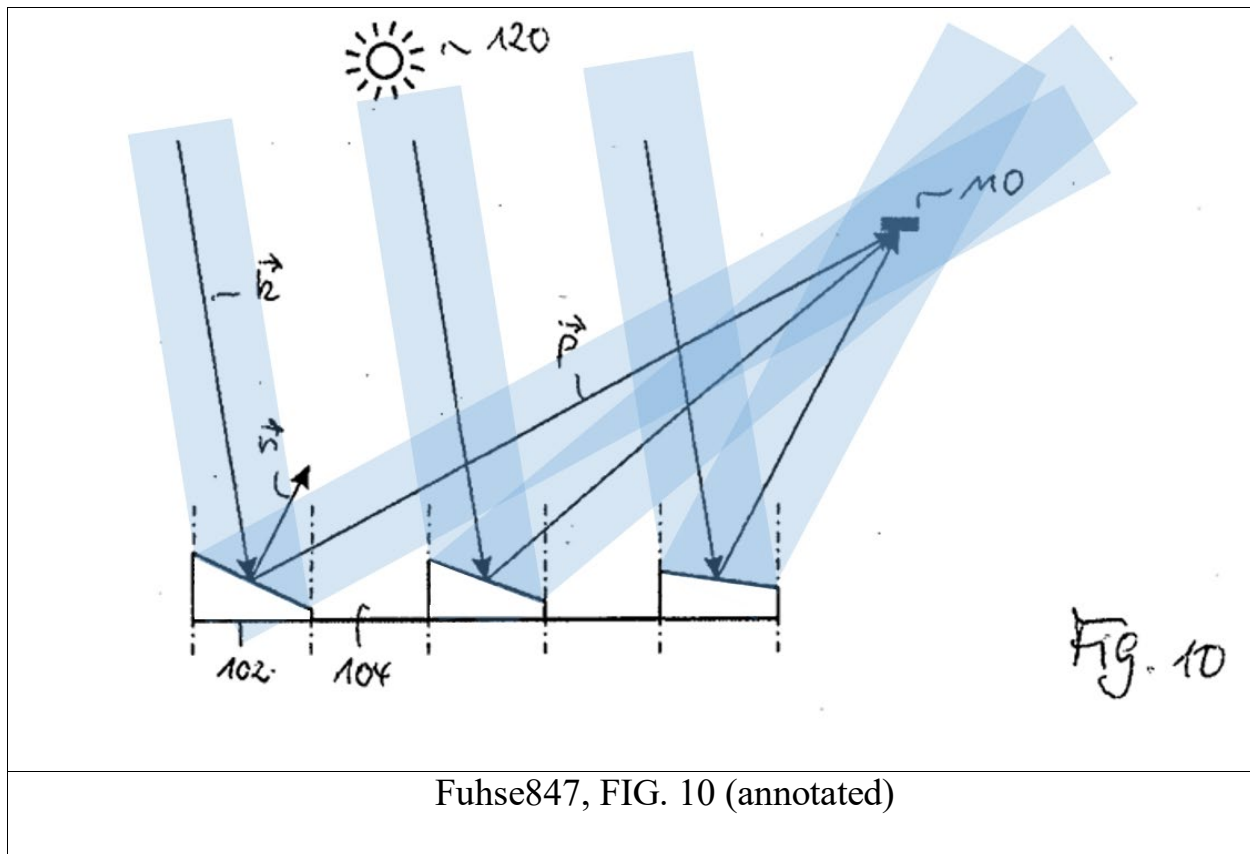


Fuhse847, FIG. 10 (annotated)

310. As can be seen above, the volume of the voxel is set by the superposition of the beams from each micromirror in the set, with the center of the voxel being the coordinates of the point (x_0, y_0, z_0) where all the chief rays intersect. As more micromirrors are added to the set for a given pixel, the pixel becomes brighter and more defined.

311. The beam size reflected from each mirror depends on the size of the mirror, so the size of the voxel ultimately depends on the size of the mirrors and the number of mirrors in the set. See Ex. 1029, p. 359 (discussing the resolution of micromirror based devices is determined by the dimensions of the micromirrors).

312. As shown in Figures 9-10, Fuhse847 creates a voxel via intersection of two or **more beams of the reflected ambient light**. As discussed for element [12.f], the reflected ambient light for each micromirror is given by “reflected light ray” of direction vector $\vec{p}$, as shown in Figure 10, which is the chief ray for each mirror. The three reflected beams in Figure 10 are reproduced below:



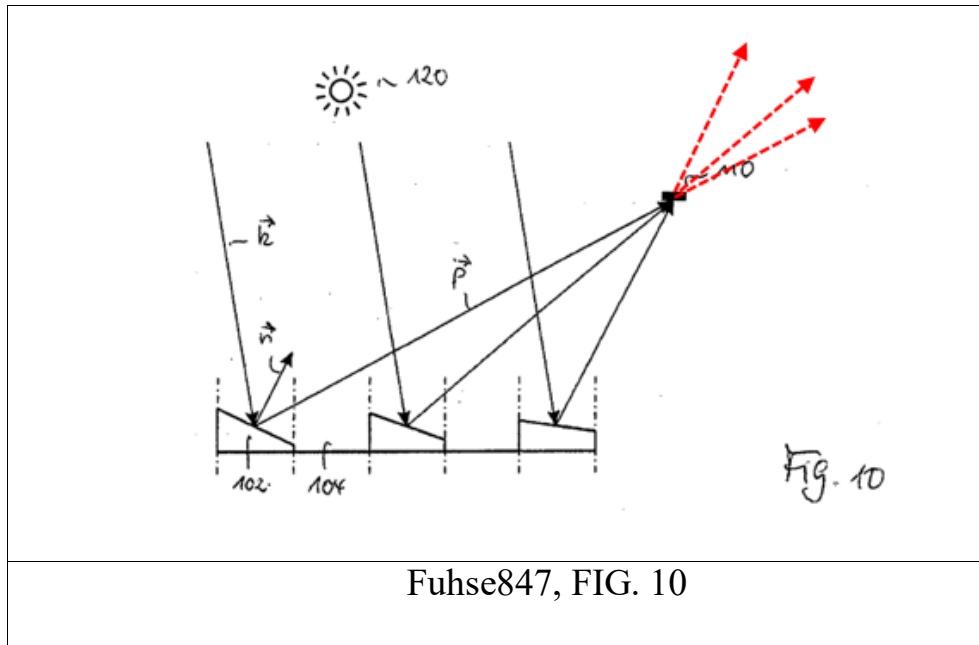
Fuhse847, pp. 21-22.

313. Each “reflected light ray” (i.e., the chief ray in each image) represents the center of each **beam[] of the reflected ambient light**. Because each pixel is required to be formed with a “set of micro mirrors” (as required by [12.f]), the voxel

would include **two or more beams**. As shown in Figures 9-10, each point (x_0 , y_0 , z_0) (**a point on the plane corresponding to one of the pixels**) is the center-point of each voxel.

314. Fuhse847 teaches that its “light-spot image composed of a plurality of light spots” (**each of the created voxels**) “for a viewer appear floating above... the surface region” in the form of a specified motif (**produces an effect of a point source of light floating above the surface of the substrate in the plane**). Fuhse847, pp. 4-5, 9, 0058-59, 14-16, 19-20, cl. 1. The image in the plane “floats at a certain height above... the substrate surface” because “all light spots in the light-spot image have the same floating height.” Fuhse847, p. 16.

315. Reflected light rays do not terminate at the light spot, but continue unchanged in their ray path, as illustrated below in annotated Figure 10 below. It is a fundamental principle of ray optics that a light ray will continue in its path until it is disturbed. Indeed, the rays must continue in their ray paths to be viewed by the viewer. As such, the voxel’s **effect of a point source** is evident from Fuhse847’s Figure 10.



316. Each voxel is centered at a “point.”

317. Further, the '863 Patent teaches that “the resulting effect is a point source of light” when the “mirrors (which are in the base of the cone) are aimed or targeted (or ‘oriented’) toward the cone apex (image’s pixel).” '863 Patent, 6:7-13. In other words, **voxels produce[] an effect of a point source of light** at least when a cone can be described in which the voxel is the cone’s apex and the micro mirrors are within the base of the cone. Likewise, Fuhse847 teaches a “cone” can be described “originating from the image point” and including all the micromirrors within the base of the cone (*i.e.*, “sphere of influence E_j ”). Fuhse847, pp. 9-10, 28, cl. 26.

318. Accordingly, Fuhse847 renders obvious element claim 13.

h) Claim 14: *The method of claim 12, wherein each of the different sets concurrently reflect the ambient light to concurrently generate the plurality of pixels.*

319. In my opinion, Fuhse847 renders obvious this claim.

320. Fuhse847's **array of micro mirrors receiving ambient light** is an array of micromirrors arranged on a banknote, for example, that receive the same ambient light that is the same for all micromirrors (*e.g.*, sunlight in FIGs. 2, 10).

321. Fuhse847 relies on **ambient light** that is incident on all micromirrors, not focused light that is only incident on particular micromirrors at a given time. *See* Section (Technology Background), V.B.3. The '863 patent also discusses that certain mirrors are aimed at the same point in space to create the image pixels (*see* '863 patent, 2:39-54). In other words, all the micromirrors in Fuhse847's depiction element receive ambient light **concurrently**.

322. Likewise, Fuhse847's micromirrors reflect light **concurrently**. Fuhse847's micromirrors are passive reflectors, such that **each of the different sets concurrently reflect the ambient light to concurrently generate the plurality of pixels** whenever incident light is incident upon them. Accordingly, the ambient light is incident on the array of micromirrors, and thus **each of the different sets will concurrently reflect the ambient light** in the manner discussed in element [12.f]. *See* element [12.f].

323. Further, each of the different sets **concurrently generate the plurality of pixels** in the manner discussed in element [12f]. *See* element [12f]. As discussed in element [12.f], the micromirrors in each set have a **reflective surface oriented, in a fixed manner ... to reflect the ambient light toward a point on the plane corresponding to one of the pixels**. Because the micromirrors concurrently reflect the ambient light, and are properly oriented in a fixed position, the micromirrors concurrently reflect light to their respective pixels to concurrently generate them. Thus, as long as the micromirrors are properly oriented or aimed to generate their respective pixels, the incidence of ambient light will generate concurrent reflections, which will concurrently generate the plurality of pixels.

324. It should be noted that the '863 patent does not use the term “concurrent” (or “simultaneous” or similar terms), and does not even discuss the concept of concurrent operation of sets of micromirrors.² This claim limitation was

² Any argument that “angular offset viewing” (*see* '863 patent, 5:28-38) doesn't satisfy this limitation should be rejected because that involves whether an image is visible to a viewer from a certain angle, not whether the micromirrors are reflecting ambient light. Even in that case, ambient light would still be reflected by the micromirrors to create all the images, regardless of whether or not there is a viewer to view them.

introduced during prosecution of the parent '294 patent in response to a non-final rejection based on a reference (U.S. Pat. App. Publ. No. 2005/0057812 ("Raber")) in the electronic arts that was "useful in providing a 3D television" and used optical elements that displayed images "in succession with one another." '294 FH, 420-22, 411. As Patent Owner stated, that electronic device was "very different technologies" compared with a currency security device. *Id.*

325. In passive micro-optic security elements such as Fuhse847, *concurrent* reflection and generation of pixels is trivially met by any array of passive micromirrors that operate based on reflecting ambient light.

326. Accordingly, Fuhse847 renders obvious element claim 13

B. Ground 2: Fuhse847 and Rich in view of Fuhse925 Renders Obvious Claims 3 and 6-14

327. In my opinion, Fuhse847 and Rich in view of Fuhse925 render obvious claims 3 and 6-14 of the '863 patent.

1. Combined Teachings of Fuhse847 and Rich in view of Fuhse925

a) Motivation to Combine

328. In my opinion, it is obvious to apply the teachings of Fuhse925 to Fuhse847. Fuhse847 and Fuhse925 both relate to security elements for data carriers (e.g., banknotes, etc.) with arrays of optical elements that are arranged to produce, upon illumination, three-dimensional motifs, and thus are in the same field. Fuhse847, Abstract; Fuhse925, Abstract.

329. One reviewing Fuhse847 would have looked to Fuhse925. Fuhse847 describes the proper orientation (i.e., to produce the light spot in the correct location in three-dimensional space) of its micromirrors in the surface plane (i.e., x-y axes) by a normal vector n of its reflective surface. Fuhse847, pp. 21-22. While it is only a matter of elementary mathematics to understand how much to rotate the mirror surface in the x and y axes to achieve the normal vector n (as is shown in Fuhse847, FIGs. 9-10), it is not expressed in explicit detail. Fuhse925, however, *does* provide that explicit detail. Fuhse925 further teaches that the normal surface N can be broken down into two “inclination components” that represent the inclination angle (i.e., how much the mirror surface should be rotated or tilted) of the mirror in each respective axis. Fuhse925, 7:33-63. It would therefore have been obvious to examine how mirror surface orientations are achieved when reviewing Fuhse847.

330. Fuhse925 provides explicit detail for implementing what Fuhse847 teaches, namely a micromirror with a desired surface normal $\vec{n}$. As Fuhse925 explains, $N_{\parallel}$ and $N_{\perp}$ are the “mirror slope” in each of the x and y axes (the claimed first and second rotation axes), such that the body of each of the micro mirrors [is] rotated about the x-axis extending through the body by an amount of $N_{\parallel}$, and the body of each of the micro mirrors [is] rotated about the y-axis extending through the body by an amount of $N_{\perp}$ to achieve the proper orientation of the micromirrors. Fuhse925, 7:33-63. Whereas Fuhse847 discloses a desired surface normal for each

micromirror and shows the properly angled mirrors (*see* FIGs. 9-10), Fuhse925 provides further explicit detail for how to implement the properly oriented mirrors using “inclination components,” thus, it would have been obvious to combine Fuhse847 and Fuhse925.

331. Additionally, using Fuhse925’s teachings regarding inclination components in Fuhse847’s system would have involved using a known technique to improve Fuhse847 in a known way, without unpredictable results, and would thus also have been obvious under.

b) Reasonable Expectation of Success

332. In my opinion, a POSITA would have had a reasonable expectation of success in implementing the combination of Fuhse847 and Fuhse925. As a POSITA would have recognized, the structures of Fuhse847 and Fuhse925 are similar and compatible.

333. For example, Fuhse847 teaches that its micromirrors may “for example, have a dimension of $50\ \mu\text{m} \times 50\ \mu\text{m}$ and can be formed with a flat mirror surface.” Fuhse847, pp. 21-22. Fuhse925’s facets are “micromirrors” with “the dimensions... between $20\ \mu\text{m}$ and $300\ \mu\text{m}$, preferably between $50\ \mu\text{m}$ and $200\ \mu\text{m}$.” Fuhse925, 5:36-38, 7:43-48. Fuhse provides almost identical teachings regarding how the micromirrors in Fuhse847 and Fuhse925 should be made, further showing the compatibility in their teachings. *Compare* Fuhse847, pp. 8-9 (“the optical elements

are designed as embossed structures in an embossing lacquer layer... preferably provided with a reflection-increasing coating,” “[i]n particular, a full-surface or gridded metallization”) *with* Fuhse935, 5:4-8 (“the planar facets are cast in an embossing lacquer layer and preferably provided with a reflection-increasing coating, especially a metalization”). Thus, the teachings in Fuhse925 regarding proper orientation of micromirrors would have been incorporated into Fuhse847 with no difficulty.

334. As discussed in Ground 1 (see X.A.1.b), the art was relatively predictable in the relevant timeframe (2015). *Id.* Thus, a POSITA would have been able to implement the obviousness modifications in this ground without difficulty. *Id.*

335. The required mathematics regarding surface orientations (see V.C) would have been well within the skill of a POSITA, as that knowledge is integral to OVD operation. Given the mature state of the art, it would be routine and predictable for a POSITA to implement the system of Fuhse847 teachings according the surface inclination teachings of Fuhse925 in 2015.

2. Application to the Challenged Claims

336. In my opinion, Fuhse847 and Rich in view of Fuhse925 teaches the limitations of claims 3 and 6-14. The mapping below provides my analysis on a limitation-by-limitation basis, with relevant citations to the teachings.

- a) **Claim 3: The method of claim 1 wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of micro mirrors.**

337. In my opinion, Fuhse847 in view of Fuhse925 renders obvious this claim.

338. Fuhse847 teaches that “every image point P_j ,” corresponds to a “cone originating from” or “emanating from” the image point (an apex of **a cone**). Fuhse847, pp. 9-10, 28. Further, “a sphere of influence E_j [**a base of the cone**] is determined by an intersection of the aperture cone originating from the image point with the xy plane” (**on a surface containing the array of micro mirrors**). *Id.* The “xy plane” is understood to be the **surface of the substrate** because it is the plane that is divided into fields that are “covered with” the optical elements (micromirrors) which are the surface of the substrate. Fuhse847, pp. 4, 9-10, 27-28.

339. In Fuhse847, all of the micromirrors that “contribute to producing the light spot that corresponds to image point P_j ” are selected from fields in the xy plane that are “in the sphere of influence E_j of the image point P_j ” (**a plurality of the micro mirrors located in a base of a cone**). Fuhse847, pp. 9-10, 27-28.

340. Fuhse925 teaches that the orientation vector N of each reflective facet 30 is defined by two inclination components – a normal component $N_{\perp}$ and a non-vanishing parallel component $N_{\parallel}$ – whereby the non-vanishing component $N_{\parallel}$ varies irregularly in the spreading range, especially according to a random distribution or

a pseudorandom distribution. *See* Fuhse925 at 3:3-16, 9:1-31, 11:14-27. Because the non-vanishing component $N_{\parallel}$ is one inclination component of the orientation vector N of each reflective facet 30, the randomness of the non-vanishing component $N_{\parallel}$ would result in a randomness of the orientation vector N of each reflective facet 30 on the surface of the substrate. It therefore follows that the randomness of the orientation vector N of each reflective facet 30 is the result of a random pattern of the reflective facets 30. *Id.*

341. Each facet 30 is coated with a reflective coating thereby forming micro mirrors arranged in a random pattern. As the facets 30 are arranged in according to a random distribution or a pseudorandom distribution, a POSITA would understand that making a selection of a subset of micromirrors from the plurality of micromirrors formed on the facets 30 would make for a **random selection**. *Id.*

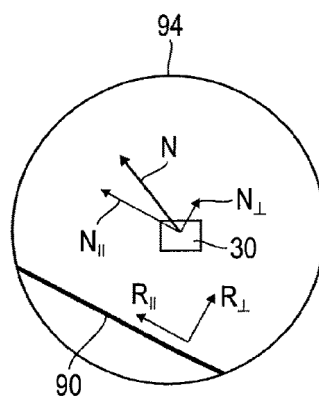


Fig. 7(b)

Fuhse925, FIG. 7(b).

342. Further, Fuhse925 discloses the that “additional parallel component $N_{\parallel}$ ensures that a viewer still sees the line 16 floating at the depth T even if he tilts the security element upward or downward about the x-axis by a certain angle within the second angle range.” *Id.*, 9:27-31. A POSITA would understand that the random arrangement of facets 30 is such that an image of line 16 floating at depth T is visible to the observer.

343. Accordingly, Fuhse847 in view of Fuhse925 teaches claim 3.

b) Claim 6: *The method of claim 1, wherein the angular orientations are calculated to provide a predefined angular offset of at least 10 degrees between the first and second image display planes.*

344. In my opinion, Fuhse847 in view of Fuhse925 renders obvious this claim.

345. As discussed in Ground 1, claim 6, Fuhse847 renders obvious this claims. *See, supra*, Section X.A.2.e. (Ground 1, claim 6).

346. If it is argued that Fushe847 does not satisfy the claim, Fushe847 in combination with Fushe925 does, and a POSITA would have been motivated to combine them with reasonable expectation of success. *See, supra*, Sections X.B.1.a (Ground 2, Motivation to Combine) and X.B.1.b (Ground 2, Reasonable Expectation of Success).

347. To the extent that Fushe847 does not provide express detail of a predefined angular offset of at least 10 degrees, Fushe925 does such as seen in Figs.

6(a)-(b) below. Fuhse925, Figs. 6(a)-(b); 6:26-27 (“FIGS. 6(a) and 6(b) illustrations of the effect achieved by reducing the spreading range for two viewing directions”).

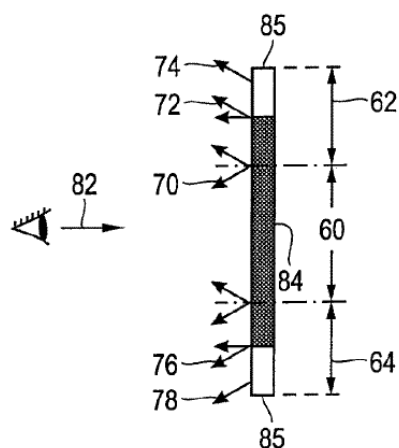


Fig. 6(a)

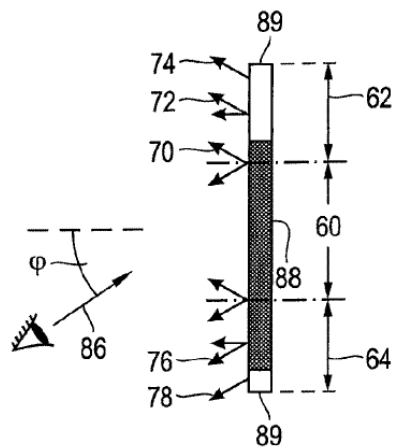


Fig. 6(b)

348. Fuhse925 describes what happens when viewing each image from different angles as be seen in Figures 6(a) and 6(b). “In the perpendicular view 82 shown in FIG. 6(a) (corresponding to a viewing angle $\varphi=0^\circ$), the viewer sees that portion 84 of the line 16 in which the spreading range includes the angle $\varphi=0^\circ$.” Fuhse925, 9:66-10:2. “In the view 86, shown in FIG. 6(b), obliquely from below at an angle $\varphi=-10^\circ$, the viewer sees that portion 88 of the line 16 in which the spreading range includes the angle $\varphi=-10^\circ$.” Fuhse925, 10:9-12.

349. The difference in the two viewing angles ($\varphi=0^\circ$ and $\varphi=-10^\circ$) is 10° , which is a **predefined angular offset of at least 10 degrees**.

350. Accordingly, a POSITA would understand that the image and the second image have viewing angles and an offset between them.

351. Further, as discussed Section X.A.2.e (claim 6), micromirror devices had the known benefit of providing a large separation between images compared to other types of optical security devices known in the art, which solves the known problem of loss of image separation due to crumpling of the banknote.. *See* EX1042, p. 164.

c) Claim 7

352. In my opinion, Fuhse847 teaches claim 7, as detailed below.

i. Claim 7, Element [7Pre]: *A method of fabricating a security element, comprising:*

353. In my opinion, Fuhse847 renders obvious the limitation. *See, supra*, Section X.A.2.a.i ([1Pre]) (“A method of fabricating a security element, comprising”).

ii. Claim 7, Element [7a]: *with a processor of a computing device, executing code to provide an array design module configured to select a set of micro mirrors in an array of the micro mirrors to display pixels of a first object in a first image display plane and to display pixels of a second object in a second image display plane spaced apart from the first image display plane;*

354. In my opinion, Fuhse847 renders obvious this limitation. *See, supra*, Sections X.A.2.a.ii ([1a]) and X.A.2.a.iii ([1b]) (“with a processor of a computing device, executing code to provide an array design module that operates to select a set of micro mirrors in an array of the micro mirrors to display each of the pixels of

the first object in the first image display plane and to display each of the pixels of the second object in the second image display plane;”)

355. The second image display plane is **spaced apart from the first image display plane**. *See, supra*, Sections X.A.2.a.ii ([1a]) (explaining the two image planes are in the foreground and background of each other).

356. As discussed, Fuhse847 also teaches that the two images may be in different planes. Fuhse847 teaches that two images to be in the “foreground” and “background” of each other. Fuhse847, p. 26. A POSITA would have understood that for two images to be in the foreground and background of each other, they are **spaced apart** from each other. This is accomplished by selecting the image points P_j of the **second image display plane** to have a height values Z_j that are different from height values Z_j of the **first image display plane**. *See, supra*, Section X.A.2.a.v ([12d]); Fuhse847, pp. 9-10, 27-28, cl. 26.

iii. Claim 7, Element [7b]: *for each of the pixels, determining, with the array design module, an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors;*

357. In my opinion, Fuhse847 renders obvious this limitation. *See, supra*, Section X.A.2.a.iv ([1c]) (“for each of the pixels, determining with the array design module an angular orientation of each of the micro mirrors in the selected sets of the micro mirrors;”).

iv. Claim 7, Element [7c]: *generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors,*

358. In my opinion, Fuhse847 renders obvious this limitation. *See, supra*, Section X.A.2.a.v ([1d]) (“generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors; and”).

v. Claim 7, Element [7d]: *wherein each of the sets of micro mirrors are selected randomly from a plurality of the micro mirrors located in a base of a cone on a surface containing the array of the micro mirrors; and,*

359. In my opinion, Fuhse847 teaches element [7d]. *See, supra*, Section X.B.2.a (Ground 2, claim 3).

vi. Claim 7, Element [7e]: *forming the array of the micro mirrors according to the design output file.*

360. In my opinion, Fuhse847 renders obvious this limitation. *See, supra*, Section X.A.2.a.vi ([1e]) (“forming the array of the micro mirrors according to the design output file”).

d) Claim 8: *The method of claim 7, wherein the cone has an apex coinciding with coordinates of one of the pixels on the first or second image display planes.*

361. In my opinion, Fuhse847 renders obvious this claim. *See, supra*, Section X.A.2.c (claim 4).

- e) **Claim 9:** *The method of claim 7, wherein the angular orientation is defined by coordinates of a normal vector from a reflective surface of each of the micro mirrors directing light to one of the pixels.*

362. In my opinion, Fuhse847 renders obvious this claim. *See, supra*, Section X.A.2.b (claim 2).

- f) **Claim 10:** *The method of claim 7, wherein the angular orientations are calculated based on heights of the first and second image display.*

363. In my opinion, Fuhse847 renders obvious this claim. *See, supra*, Section X.A.2.d (claim 5).

- g) **Claim 11:** *The method of claim 7, wherein the angular orientations are calculated to provide a predefined angular offset of at least 10 degrees between the first and second image display planes.*

364. In my opinion, Fuhse847 renders obvious this claim. *See, supra*, Section X.A.2.e (claim 6).

h) Claim 12

365. In my opinion, Fuhse847 teaches claim 12, as detailed below.

- i. **Claim 12, Element [12Pre]:** *A method of fabricating a security element useful on paper and coin currency and on product labels, comprising:*

366. In my opinion, Fuhse847 renders obvious the limitation. *See, supra*, Section X.A.2.a.i [1Pre] (“A method of fabricating a security element, comprising:”).

367. In my opinion, the preamble simply states what the claim is useful for. In fact, the preamble explicitly purports to describe what the preamble is “useful on.”

368. Also, none of the terms in the preamble are later provided in the claim body, so the preamble does not complete the structure of the claim body.

369. In my opinion, to the extent the preamble is limiting, Fuhse847 teaches the preamble. Fuhse847, pp. 4-5, 11, FIG. 1. *See, supra*, Section X.A.2.a.i [1Pre] (“A method of fabricating a security element, comprising:”).

370. Fuhse847 further teaches that the security element is **useful on paper and coin currency and on product labels**.

371. The depiction element has “security applications” for a “data carrier,” and “[t]he data carrier can in particular be a value document,” such as a “paper banknote” (**paper... currency**). Fuhse847, pp. 11, 4-5, FIG. 1.

372. Coin currency and product labels are also “data carriers” because they carry data related to the currency or product.

373. Based on Fuhse847’s teachings that the depiction element would be useful for data carriers such as currency, a POSITA would have found it obvious to recognize that the depiction element would be useful for coin currency and product labels.

374. It was known in the art to apply depiction elements to coin currency and product labels. Ex. 1009 (Jordan), Abstract, ¶¶0013, 0002-04, 0113-14, 0124-25, 0154, 0159, 0174-77. For example, optical depiction elements were included on the surface of Australian coins by 2001. Ex. 1030, p. 6 (citing Exs. 1031-32); Ex. 1031, p. 2; Ex. 1032, p. 1032, pp. 1-2.

ii. Claim 12, Element [12a]: *with a processor of a computing device, executing code to provide an array design module configured to define an array of micro mirrors to be formed on a surface of a substrate;*

375. In my opinion, Fuhse847 renders obvious the limitation. *See, supra*, Section X.A.2.f.ii (Ground 1, Section [12.a]).

iii. Claim 12, Element [12b]: *generating a design output file including an angular orientation and location coordinates in the array for each of the micro mirrors; and*

376. In my opinion, Fuhse847 renders obvious the limitation. *See, supra*, Section X.A.2.a.v ([1d]) (“generating a design output file including the angular orientation and location coordinates in the array for each of the micro mirrors in the selected sets of the micro mirrors; and”).

iv. Claim 12, Element [12c]: *forming the array of micro mirrors according to the design output file,*

377. In my opinion, Fuhse847 renders obvious the limitation. *See, supra*, Section X.A.2.a.vi [1e] (“forming the array of the micro mirrors according to the design output file”).

v. Claim 12, Element [12.d]: *wherein the array of micro mirrors is configured, when formed on the surface of the substrate, for receiving ambient light and, in response, displaying an image in a plane spaced a distance apart from the surface of the substrate,*

vii. Claim 12, Element [12.e]: *wherein the image comprises a plurality of pixels, and*

378. In my opinion, Fuhse847 renders obvious these limitations ([12.d] and [12.e]). *See, supra*, Section X.A.2.a.v, vi (Ground 1, elements [12.d], [12.e]).

vi. Claim 12, Element [12.f]: *wherein the array of micro mirrors includes for each of the pixels a different set of the micro mirrors each having a reflective surface oriented, in a fixed manner, with a body of each of the micro mirrors rotated about at least one of first and second rotation axes extending through the body, to reflect the ambient light toward a point on the plane corresponding to one of the pixels.*

379. In addition, Fuhse847 in view of Fuhse925 renders obvious element with respect to the term **micro mirrors each having a reflective surface oriented, in a fixed manner with a body of each of the micro mirrors rotated about at least one of first and second rotation axes extending through the body.** Fuhse847, pp. 4-6, 9-10, 14-15, 19-23, FIGs. 8b, 9b, and 10; Fuhse925, 6:63-7:18, 7:33-63.

380. Fuhse847 discloses that the micromirrors each have a normal vector $\vec{n}$ of its reflective surface defined in the x and y axes, and it is a matter of elementary

mathematics to understand how to rotate the surface in the x and y axis to achieve that normal vector $\vec{n}$. However, to the extent it would not, Fuhse925's additional teachings would.

381. Like Fuhse847, Fuhse925 teaches a security element (for currency, for example) using arrays of reflective micromirrors to create three-dimensional images appearing to float above the security element. Fuhse925, 6:63-7:18, 7:33-48. Also, like Fuhse847, each micromirror is taught to have a normal vector – “slope N” – that defines the overall surface orientation of the micromirror. Fuhse925, 7:55-58.

382. Fuhse925 further teaches that the normal surface N can be broken down into two “inclination components” that represent the inclination angle of the mirror in each respective axis. Fuhse925, 7:33-63. Fuhse925 explains:

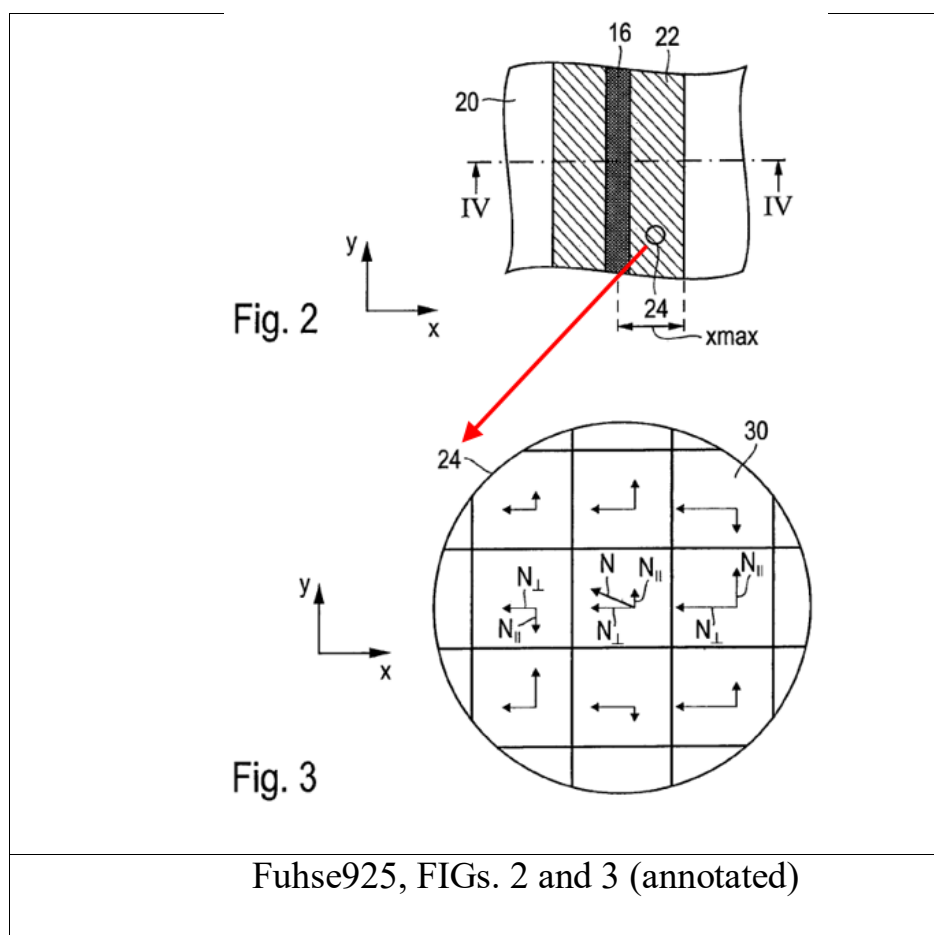
“As shown in the detailed section **24** in FIG. 3, the depiction region **22** is provided with a plurality of reflective, planar facets **30** that have, for example, a base area of $15\ \mu\text{m} \times 15\ \mu\text{m}$ and a maximum height of a few micrometers. Each of the planar facets **30** is especially characterized by **an inclination angle against the plane** of the areal motif region **20**, which inclination angle has, as **inclination components**, a **parallel component $N_{\parallel}$ parallel to the line 16 (y-direction in FIGS. 2 and 3)** and a **normal component $N_{\perp}$ perpendicular to the line 16 (x-direction in FIGS. 2 and 3)**.

The ray-optically effective reflective facets 30 constitute small inclined micromirrors that direct incident light in a reflection direction given by the condition “angle of incidence equals angle of reflection”. Within the scope of this description, the arrangement of the reflective facets **30** is thus also referred to as a micromirror arrangement.

Particularly the mirror slope or the facet slope in the respective direction can be calculated from the two inclination components $N_{\parallel}$ and $N_{\perp}$. For illustration, in the top view in FIG. 3, the inclination components of the facets **30** are marked as vectors whose direction indicates the direction of rising mirror level and whose absolute value indicates the slope in the respective direction. The inclination components $N_{\parallel}$ and $N_{\perp}$ yield, as usual, the total slope N of a facet **30**, which is additionally marked for the middle facet in FIG. 3.”

Fuhse925, 7:33-58.

383. Fuhse925 Figures 2 and 3, referenced in the passage above, are reproduced below:



384. Fuhse925, 7:33-58. As Fuhse925 explains, $N_{\parallel}$ and $N_{\perp}$ are the “mirror slope” in each of the x and y axes (**first and second rotation axes**), such that the **body of each of the micro mirrors [is] rotated about the x-axis extending through the body by an amount of $N_{\parallel}$, and the body of each of the micro mirrors [is] rotated about the y-axis extending through the body by an amount of $N_{\perp}$ to achieve the proper orientation of the micromirrors.**

385. Fuhse925 also clarifies that the micromirrors are oriented **in a fixed manner**. Fuhse925 further explains that its reflective planar facets 30 are “characterized by an inclination angle.” Fuhse925, 7:37-42, claim 1. The planar facets 30 are “characterized” by this single “inclination angle” because they are manufactured to provide that angle to achieve a desired reflection

386. Accordingly, Fuhse847 in view of Fuhse925 renders obvious element [12.f].

- i) ***Claim 13: The method of claim 12, wherein a voxel is created at each of the point on the plane via intersection of two or more beams of the reflected ambient light, and wherein each of the created voxels produces an effect of a point source of light floating above the surface of the substrate in the plane.***

387. In my opinion, Fuhse847 renders obvious this claim. *See, supra*, Section X.A.2.g (Ground 1, claim 13).

- j) **Claim 14: *The method of claim 12, wherein each of the different sets concurrently reflect the ambient light to concurrently generate the plurality of pixels.***

388. In my opinion, Fuhse847 renders obvious this claim. *See, supra*, Section X.A.2.h (Ground 1, claim 14).

C. Ground 3: Fuhse847 and Rich (Ground 1) in view of Sauvage-Vincent Renders Obvious Claims 15-18

389. In my opinion, Fuhse847 and Rich in view of Sauvage-Vincent render obvious claims 15-18 of the '863 patent. The positions for claims 1 and 6 are the same as the inclusion of Sauvage-Vincent does not affect those positions.

1. Combined Teachings of Fuhse847 and Rich in view of Sauvage-Vincent

a) Motivation to Combine

390. It is my opinion that a POSITA would have found it obvious to apply the teachings of Sauvage-Vincent to Fuhse847. Fuhse847 and Sauvage-Vincent both relate to security elements for data carriers (*e.g.*, banknotes, etc.) with arrays of optical elements that are arranged to produce, upon illumination, images, and thus are in the same field. Fuhse847, Abstract; Sauvage-Vincent, Abstract.

391. It is also my opinion that a POSITA would have looked to Sauvage-Vincent when reviewing Fuhse847. Fuhse847 teaches that its “optical elements are designed as embossed structures in an embossing lacquer layer.” Fuhse847, pp. 8-9, 16. While a POSITA would understand that embossed structures are produced using a tool, it is not expressed in explicit detail how the embossing is performed.

Sauvage-Vincent teaches what Fuhse847 does not explicitly disclose, namely, that a “die” or “master” may provide a “stamping operation” to produce the microstructure pattern of the desired optical elements. EX1033, ¶¶71, 73, 43, Abstract. It would therefore have been obvious for a POSITA to examine how embossed structures are produced when reviewing Fuhse847.

392. Sauvage-Vincent provides explicit detail for implementing what Fuhse847 teaches, namely a method for producing embossed structures for reflective micromirrors in security elements.

393. As Sauvage-Vincent explains, a “stamping operation is performed from the die to transfer the microstructure onto a film and structure the layer of dielectric material 101,” such as a film of polymer material. EX1033, ¶¶71, 73, 43, Abstract. This “stamping may be done by hot pressing of the dielectric material (‘hot embossing’) or by molding then cross-linking (‘UV casting’).” *Id.*

394. Whereas Fuhse847 discloses embossed structures in an embossing lacquer layer, Sauvage-Vincent provides further explicit detail for how to produce the properly oriented embossed micromirrors using a die, thus, it would have been obvious for a POSITA to combine Fuhse847 and Sauvage-Vincent.

395. Additionally, using Sauvage-Vincent’s teachings regarding die tools in Fuhse847’s system would have involved using a known technique to improve

Fuhse847 in a known way, without unpredictable results, and would thus also have been obvious.

b) Reasonable Expectation of Success

396. It is my opinion that a POSITA would have had a reasonable expectation of success in implementing the combination of Fuhse847 and Sauvage-Vincent. Here, the art was relatively predictable in the relevant timeframe (2015). A POSITA would have been able to implement the obviousness modifications in this ground without difficulty.

397. The art related fabrication of OVDs, including techniques such as using “dies” or “masters” for embossing and casting polymer substrates had been highly developed and known to work for decades. As I discussed in Section V.D (Technology Background, Fabrication Methodologies), decades before the relevant date, it was well-known to fabricate arrays of optical elements, including micro mirror arrays, for use in OVDs. These techniques generally relied on the properties of polymers, such as thermoplastics, that has already been developed to a commercially mature stage decades earlier.

398. By the 1980’s there were numerous thermoplastics and fabrication techniques that would be suitable to fabricate the mirco-mirror arrays described in both Fuhse847 and the ’863 Patent. Section V.D. Although prior art to the ’863 Patent, the fabrication techniques discussed in Fuhse847 and Sauvage-Vincent were

not new at the time of their filing, and nothing in the structures described by Fuhse847 require anything more than traditional fabrication techniques for optical micro-structures that were well-known and known to work by the 1980's.

2. Application to the Challenged Claims

399. In my opinion, Fuhse847 and Rich in view of Sauvage-Vincent teaches the limitations of claim 15-18. The mapping below provides my analysis on a limitation-by-limitation basis, with relevant citations to the teachings of Fuhse847 and Sauvage-Vincent.

a) Claim 15: *The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by casting the micro mirrors with a mirror tool in contact with the surface of the substrate.*

400. In my opinion, Fuhse847 in view of Sauvage-Vincent renders obvious this claim.

401. It is my opinion that the references for each of Grounds 1-4, and additionally Sauvage-Vincent, discloses and/or suggests these limitations.

402. Fuhse847 teaches that its “optical elements are designed [**the forming the array of micro mirrors comprises**] as embossed structures in an embossing lacquer layer.” Fuhse847, pp. 8-9, 16. Embossing is a well-known fabrication technique that involves using an embossing tool to stamp designs (i.e., “embossed structures” formed from the relief pattern of the stamp) into a substrate (such as “an embossing lacquer layer”). It is my opinion that a POSITA would have understood

that in order to form “embossed structures,” an embossing tool must have stamped the embossing lacquer layer (**casting the micro mirrors with a mirror tool in contact with the surface of the substrate**). However, it is not explicitly disclosed in Fuhse847.

403. Sauvage-Vincent teaches what Fuhse847 does not explicitly disclose, namely, that a nickel “die” or “master” (**a mirror tool**) may provide an “embossed layer” relief structure of the desired optical elements:

“The security components as described previously can be produced as follows. The optical structures (undulations) of the different areas are recorded by photolithography or electron beam lithography on a photosensitive support or “photoresist”. A galvanoplasty step is used to transfer these optical structures into a resistant material, for example based on nickel, to produce the die or “master”. A stamping operation is performed from the die to transfer the microstructure onto a film and structure the layer of dielectric material 101 (FIG. 1 A), typically a stamping lacquer a few microns thick borne by a 12 μm to 50 μm film of polymer material, for example of PET (polyethylene terephthalate). The stamping may be done by hot pressing of the dielectric material (“hot embossing”) or by molding then cross-linking (“UV casting”). The refractive index of the layer formed by the stamping lacquer is typically 1.58. The duly embossed layer is then metalized.”

EX1033, ¶71, ¶¶73, 43, Abstract. For example, as shown in Figure 1A, Sauvage-Vincent teaches that its “optical structures” are formed by the stamping operation as applied to “dielectric material 101 (FIG. 1A), “typically a stamping lacquer a few microns thick borne by a 12 μm to 50 μm film of polymer material, for example of PET (polyethylene terephthalate)” that forms part of the **substrate**. (*Id.*).

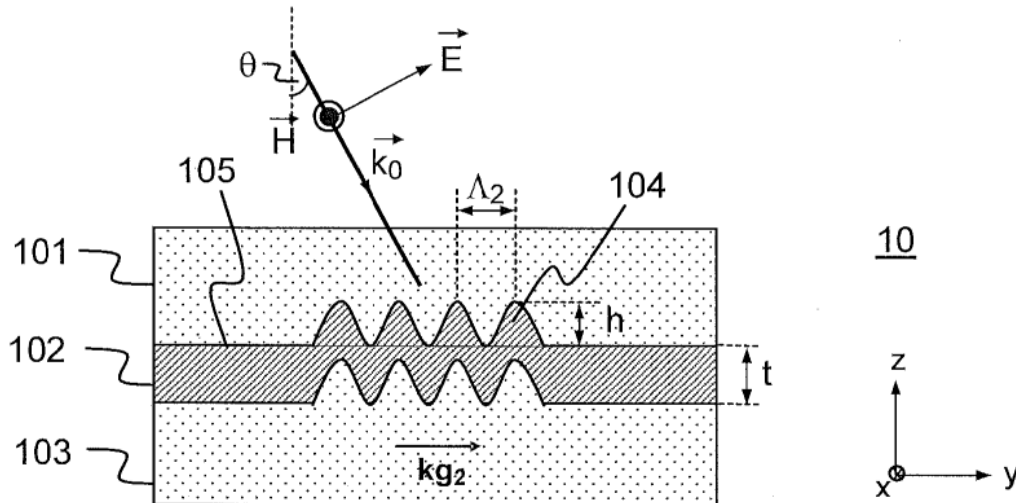


FIG.1A

404. The **casting the micro mirrors** occurs when “stamping operation is performed from the die to transfer the microstructure onto a film and structure the layer of dielectric material 101” (**a mirror tool in contact with the surface of the substrate**). EX1033, ¶¶71, FIG. 1A. In particular, this “stamping may be done ... by molding then cross-linking (“UV **casting**”).” *Id.* (emphasis added). As another example, dielectric material 101 may be stamped by “hot pressing” or “hot embossing,” which is another form of **casting**.

“A stamping operation is performed from the die to transfer the microstructure onto a film and structure the layer of dielectric material 101 (FIG. 1A), typically a stamping lacquer a few microns thick borne by a 12 μm to 50 μm film of polymer material, for example of PET (polyethylene terephthalate). The stamping may be done by hot pressing of the dielectric material (“hot embossing”) or by molding then cross-linking (“UV casting”).”

EX1033, ¶71.

405. While Sauvage-Vincent deals primarily with the casting of diffractive optical elements, this technique may be applied equally to periodic non-diffractive optical elements, such as arrays of micro-mirrors.

b) Claim 16: *The method of claim 15, wherein the substrate provided in the providing step comprises a clear, energy-cured polymer.*

406. In my opinion, Fuhse⁸⁴⁷ in view of Sauvage-Vincent renders obvious this claim.

407. Sauvage-Vincent's substrate includes "dielectric material 101 (FIG. 1 A)," which is "typically a stamping lacquer a few microns thick borne by a 12 μm to 50 μm film of **polymer** material," (**polymer**) "for example of PET (polyethylene terephthalate)," which is **a clear, energy-cured polymer**. EX1033, ¶¶71, FIG. 1A.

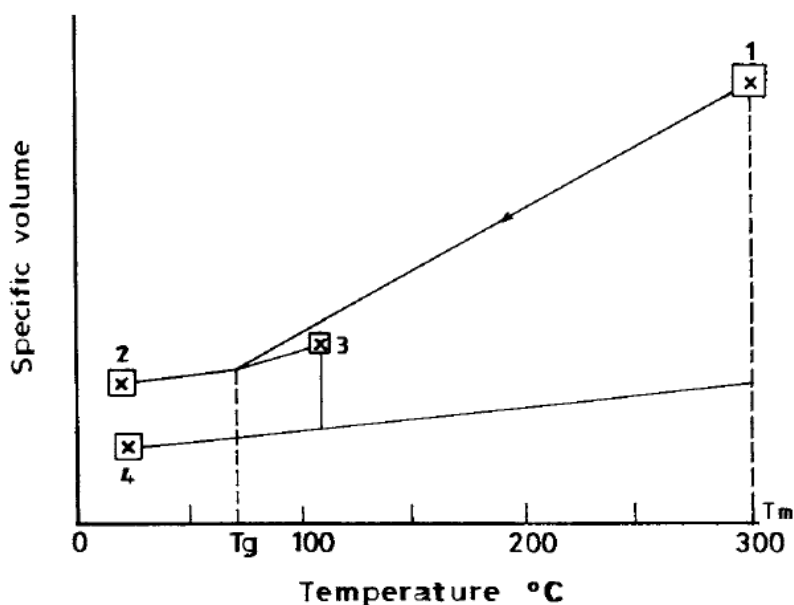
408. Further, layer 101 is **clear** because it is "transparent in said observation spectral band," and is also referred to as a "transparent layer 101." EX1033, Abstract, ¶¶0009, 0030, 0073, FIG. 1A.

409. The dielectric material 101 is an **energy-cured** polymer under two separate examples. First, the transparent dielectric material 101 may be "UV cast[ed]" that is formed when it is molded by the die, meaning that UV **energy cure[s] the** dielectric material. EX1033, ¶71.

410. Second, dielectric material 101 may be stamped by "hot pressing" or "hot embossing," (i.e., the polymer structures are formed when the die presses

against it at elevated temperature) which provides the **energy** for the layer to be **cured**. EX1033, ¶71.

411. Further, polyethylene terephthalate (PET) was a very common transparent, thermoplastic polymer resin of the polyester family before the relevant date. Amorphous PET, which would result from an energy-cured process, is fully transparent. As explained in *Polymer Science and Technology*, when “Poly(ethylene terephthalate) is cooled rapidly from 300°C (state 1) to room temperature (state 2). The resulting material is rigid and perfectly transparent.”



See EX1029 (*Polymer Science and Technology*, Ebewele, 1st Edition (2000)), p. 103.

- c) **Claim 17: The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by metallization of surfaces of the micro**

mirrors, wherein the metallization applies a layer of aluminum, gold, or silver to form reflective surfaces.

412. In my opinion, Fuhse847 in view of Sauvage-Vincent renders obvious this claim.

413. Fuhse847 teaches that the forming the array of micro mirrors includes providing “the embossed structures ... a reflection-increasing coating[] [and] [i]n particular, **a full-surface or gridded metallization**” (**metallization of surfaces of the micro mirrors**). Fuhse847, pp. 8-9.

414. The “full-surface or gridded metallization” is “a reflection-increasing coating” of the micromirrors, meaning it is provided **to form reflective surfaces**. Layers of aluminum, gold, and silver are three of the most common materials to use for highly reflective surfaces of micromirrors, however, it is not explicitly disclosed in Fuhse847.

415. Sauvage-Vincent likewise teaches that the forming desired optical elements includes that a “metallization” (**metallization**). EX1033, ¶71. This “metallization is done in a vacuum, for example, one of the following metals: **silver, aluminum, gold**” (**a layer of aluminum, gold, or silver to form reflective surfaces**). (*Id.*).

d) **Claim 18: *The method of claim 17, wherein the forming the array of micro mirrors includes, prior to the metallization of the surfaces of the micro mirrors, embossing the surface of the substrate to form the***

surfaces of the micro mirrors and wherein the surface of the substrate includes an embossable coating or layer.

416. In my opinion, Fuhse847 in view of Sauvage-Vincent renders obvious this claim.

417. As discussed in claim 15, Fuhse847 teaches that its “optical elements are designed [**the forming the array of micro mirrors comprises**] as embossed structures in an embossing lacquer layer,” which renders obvious **embossing the surface of the substrate to form the surfaces of the micro mirrors and wherein the surface of the substrate includes an embossable coating or layer**. Fuhse847, pp. 8-9, 16. Fuhse847 further teaches that “the embossed structures” are provided with a “metallization,” meaning the embossing must have come **prior to the metallization of the surfaces of the micro mirrors**. Fuhse847, pp. 8-9.

418. Sauvage-Vincent further teaches a nickel “die” or “master” may create the microstructures by “hot pressing of the dielectric material (‘hot embossing’)” (**embossing the surface of the substrate to form the surfaces of the micro mirrors**). EX1033, ¶71. This process results in an “embossed layer” (**an embossable... layer**). *Id.* As shown in FIGs. 1A and 7A, the dielectric material 101 is part of the **surface of the substrate**, and **the surface of the substrate includes** the dielectric material 101. EX1033, ¶73 (noting layers 71 and 73 in FIG. 7A are to be removed upon transfer).

419. The embossing is **prior to the metallization of the surfaces of the micro mirrors** because “[t]he duly embossed layer is **then** metalized,” meaning the embossing occurred before the metallization. EX1033, ¶71 (emphasis added).

D. Ground 4: Fuhse847, Rich, and Fuhse925 (Ground 2) in view of Sauvage-Vincent Renders Obvious Claims 15-18

420. In my opinion, Fuhse847, Rich, and Fuhse925 (Ground 2) in view of Sauvage-Vincent render obvious claims 15-18 of the ’863 patent.

1. Combined Teachings of Fuhse847, Rich, and Fuhse925 in view of Sauvage-Vincent

a) Motivation to Combine

421. *See, supra*, Section X.A.2.a. X.C.1.a (Ground 3, Motivation to Combine). The presence of Fuhse925 in the combination does not affect the motivation to combine discussed in Ground 3.

b) Reasonable Expectation of Success

422. *See, supra*, Section X.C.1.b (Ground 3, Reasonable Expectation of Success). The presence of Fuhse925 in the combination does not affect the reasonable expectation of success discussed in Ground 3.

2. Application to the Challenged Claims

423. In my opinion, Fuhse847, Rich, and Fuhse925 (Ground 2) in view of Sauvage-Vincent teaches the limitations of claims 15-18. The mapping below provides my analysis on a limitation-by-limitation basis, with relevant citations to the teachings.

- a) **Claim 15:** *The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by casting the micro mirrors with a mirror tool in contact with the surface of the substrate.*

424. In my opinion, Fuhse847 in view of Sauvage-Vincent renders obvious this claim. *See, supra*, Section X.C.2.a (Ground 3, claim 15).

- b) **Claim 16:** *The method of claim 15, wherein the substrate provided in the providing step comprises a clear, energy-cured polymer.*

425. In my opinion, Fuhse847 in view of Sauvage-Vincent renders obvious this claim. *See, supra*, Section X.C.2.b (Ground 3, claim 16).

- c) **Claim 17:** *The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by metallization of surfaces of the micro mirrors, wherein the metallization applies a layer of aluminum, gold, or silver to form reflective surfaces.*

426. In my opinion, Fuhse847 in view of Sauvage-Vincent renders obvious this claim. *See, supra*, Section X.C.2.c (Ground 3, claim 17).

- d) **Claim 18:** *The method of claim 17, wherein the forming the array of micro mirrors includes, prior to the metallization of the surfaces of the micro mirrors, embossing the surface of the substrate to form the surfaces of the micro mirrors and wherein the surface of the substrate includes an embossable coating or layer.*

427. In my opinion, Fuhse847 in view of Sauvage-Vincent renders obvious this claim. *See, supra*, Section X.C.2.d (Ground 3, claim 18).

E. Ground 5: Fuhse847 and Rich (Ground 1) in view of Morford Renders Obvious Claims 19-20

428. In my opinion, Fuhse847 and Rich in view of Morford render obvious claims 19-20 of the '863 patent.

1. Combined Teachings of Fuhse847, Rich, and Fuhse925 in view of Morford

a) Motivation to Combine

429. It is my opinion that a POSITA would have found it obvious to apply the teachings of Morford to Fuhse847. Fuhse847 relates to micro-optic components, and Morford relates to materials for use in micro-optics components, and thus are in the same field. Fuhse847, Abstract; Morford, Abstract.

430. It is also my opinion that a POSITA would have looked to Morford when reviewing Fuhse847. Fuhse847 teaches that its micromirrors are “embedded in a surrounding material or provided with a protective layer,” but does not specify what material to use for the protective layer. Fuhse847, p. 23, FIG. 12. However, Morford does.

431. Morford teaches that “a UV-curable high refractive index material” may be used as an optical material. Morford, p. 1. As shown in Figure 2 of Morford, this material has a refractive index of above 1.61 over the entire visible spectrum. Morford, p. 4. As further shown in Figure 4, the UV varnish is highly transparent over the visible range and suitable as a protective layer in Fuhse847. Morford, p. 5.

432. While Fuhse847 teaches that the protective layer usually has “a refractive index of approximately $n = 1.5$ ” (see Fuhse847, p. 23), Morford teaches

that “[i]ncreasing the refractive index of the organic materials and utilizing a UV curing mechanism hold several advantages, including minimal shrinkage during curing, the ability to cure at room temperature, no emission of by-products, and more efficient devices.” Morford, p. 1. A POSITA would have been motivated to select Morford’s “UV-curable high refractive index material” when selecting what material to use for its protective layer.

433. Additionally, using Morford’s teachings regarding UV-curable materials in Fuhse847’s system would have involved using a known technique to improve Fuhse847 in a known way, without unpredictable results, and would thus also have been obvious.

b) Reasonable Expectation of Success

434. It is my opinion that a POSITA would have had a reasonable expectation of success in implementing the combination of Fuhse847 and Morford. Here, the art was relatively predictable in the relevant timeframe (2015). A POSITA would have been able to implement the obviousness modifications in this ground without difficulty.

435. Protective layers are relatively simple and were well known and well-characterized well before the relevant date. Section V.D.4, ¶¶59-60. It would have been routine to apply the protective later described by Morford to the system of Fuhse847. A POSITA would have been familiar with protective layers and how to

implement them. Fuhse847 is a system that is already adapted to use a protective layer, and little to no modification would be required to accommodate the particular protective layer described by Morford.

436. Protective layers provided by companies like Brewer Science (the provider of the varnish in Morford) are particularly developed for integration into optical micro-device fabrication, and Morford particularly explains the ease with which such materials may be adapted to such products. See EX1024, p. 1 (“To fully realize the materials’ potential, Brewer Science has been developing processes and machines to provide enabling solutions for device manufacturing.”).

2. Application to the Challenged Claims

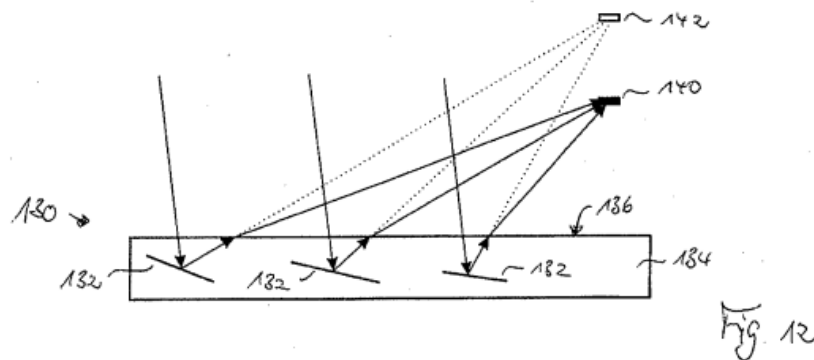
437. In my opinion, Fuhse847, Rich, and Fuhse925 (Ground 2) in view of Morford teaches the limitations of claims 19-20. The mapping below provides my analysis on a limitation-by-limitation basis, with relevant citations to the teachings.

- a) Claim 19: *The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by filling in recessed surfaces associated with the micro mirrors with a filler comprising at least one of an ultraviolet (UV) varnish, an e-beam solvent, and a water-based varnish.***

438. In my opinion, Fuhse847 in view of Morford renders obvious this claim.

439. As shown in Figure 12, Fuhse847 teaches that its micromirrors are “embedded in a surrounding material or provided with a protective layer” (**a filler**).

Fuhse847, pp. 23. As discussed under claim 2, the micromirrors are “embossed structures,” and would be understood to include **recessed surfaces** as a result of the embossing. Fuhse847, pp. 8-9, 16. A POSITA would have understood that by “surrounding” or “embedding” the micromirrors with the protective layer, the **recessed surfaces** would be **fill[ed] in**.



440. Fuhse847 teaches that the protective layer usually has “a refractive index of approximately $n = 1.5$.” Fuhse847, pp. 23. A POSITA would have understood that “approximately” 1.5 includes 1.55, so Fuhse847 teaches that **the filler has a refractive index of at least 1.55**.

441. Fuhse847 does not explicitly disclose the material of the protective layer, but the use of **an ultraviolet (UV) varnish** was known in the art, for example, by Morford. Morford teaches that “a UV-curable high refractive index material” may be used as an optical material. Morford, p. 1. As shown in Figure 2 of Morford, this material has a refractive index of above 1.61 over the entire visible spectrum. Morford, p. 4.

442. Morford's material is a varnish. A varnish is a resin that is applied to a surface to form a hard, typically transparent, film or coating. Morford's material is a "resin solution" that is "applied on various substrates using spin coating to create the films," and is a varnish. Morford, 2-3. As further shown in Figure 4, the UV varnish is highly transparent over the visible range and suitable as a filler in Fuhse847. Morford, p. 5.

b) Claim 20: *The method of claim 19, wherein the filler has a refractive index of at least 1.55, whereby at least a portion of the received ambient light at extreme angles is reflected to sharpen the displayed image.*

443. In my opinion, Fuhse847 in view of Morford renders obvious this claim.

444. As shown in Figure 2 of Morford, this material has a refractive index of above 1.61 over the entire visible spectrum. Morford, p. 4. As further shown in Figure 4, the UV varnish is highly transparent over the visible range and suitable as a filler in Fuhse847. Morford, p. 5.

445. The '863 Patent's only teaching with respect to **whereby at least a portion of the received ambient light at extreme angles is reflected to sharpen the displayed image** is that it is a direct result of providing a material with an index of at least 1.55. *See* '863 Patent, 17:43-47. Thus, because Morford provides an index of over 1.55, it would cause **at least a portion of the received ambient light at extreme angles to be reflected to sharpen the displayed image.**

F. Ground 6: Fuhse847, Rich, and Fuhse925 (Ground 2) in view of Morford Renders Obvious Claims 19-20

446. In my opinion, Fuhse847, Rich, and Fuhse925 (Ground 2) in view of Morford render obvious claims 19-20 of the '863 patent.

1. Combined Teachings of Fuhse847, Rich, and Fuhse925 in view of Morford

a) Motivation to Combine

447. *See, supra*, Section X.E.1.a (Ground 5, Motivation to Combine). The presence of Fuhse925 in the combination does not affect the motivation to combine discussed in Ground 5.

b) Reasonable Expectation of Success

448. *See, supra*, Section X.E.1.b (Ground 5, Reasonable Expectation of Success). The presence of Fuhse925 in the combination does not affect the reasonable expectation of success discussed in Ground 5.

2. Application to the Challenged Claims

449. In my opinion, Fuhse847, Rich, and Fuhse925 (Ground 2) in view of Morford teaches the limitations of claims 19-20. The mapping below provides my analysis on a limitation-by-limitation basis, with relevant citations to the teachings.

a) Claim 19: *The method of claim 12, further comprising providing the substrate and forming the array of micro mirrors by filling in recessed surfaces associated with the micro mirrors with a filler comprising at least one of*

an ultraviolet (UV) varnish, an e-beam solvent, and a water-based varnish.

450. In my opinion, Fuhse847 in view of Morford renders obvious this claim. *See, supra*, Section X.E.2.a (Ground 5, claim 19).

b) Claim 20: *The method of claim 19, wherein the filler has a refractive index of at least 1.55, whereby at least a portion of the received ambient light at extreme angles is reflected to sharpen the displayed image.*

451. In my opinion, Fuhse847 in view of Morford renders obvious this claim. *See, supra*, Section X.E.2.b (Ground 5, claim 20).

XI. SECONDARY CONSIDERATIONS

452. Having reviewed the evidence of record, I am not aware of any secondary considerations that would suggest non-obviousness of the challenged claims. Indeed, as discussed above, the claimed subject matter appears to be well-known micromirror design features that would have been obvious to combine at the time of the alleged invention. To the extent Patent Owner identifies evidence of secondary considerations at a later point in the proceeding, I reserve the right to offer my opinions to address it at that time.

XII. CONCLUSION

453. For the foregoing reasons, I am of the opinion that claims 1-20 of the '863 patent would have been obvious based on the prior art cited herein.

I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: _____ May 1, 2014 _____

Respectfully Submitted



Prof. Lambertus Hesselink, Ph.D.