

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. 10,317,691
IPR No. 2024-00837

DECLARATION OF LAMBERTUS HESSELINK, PH.D.

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CHALLENGED CLAIMS

Claim 1	
1Pre	A visual display assembly useful as a security element on paper and coin currency and on product labels, comprising:
1a	a substrate; and on a surface of the substrate, an array of micro mirrors receiving ambient light and,
1b	in response, displaying a plurality of images in a plane spaced a distance apart from the surface of the substrate, wherein each of the images comprises a plurality of pixels,
1c	wherein the array of micro mirrors includes, for each of the pixels of each of the images, a set of 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,
1d	wherein each of the sets of the micro mirrors providing the pixels for each of the differing ones of the images has a differing cone angle offset, wherein the cone angle offset is defined based upon a relative position of a cone axis for a cone of rays projected by the sets of the micro mirrors through each of the pixels,
1e	wherein the cone has a cone angle in the range of 10 to 45 degrees,
1f	wherein the cone angle offsets are selected whereby the cones do not overlap at a predefined height above the substrate, whereby only one of the images is observable at a time by a viewer,
1g	wherein each of the sets of the micro mirrors includes at least two of the micro mirrors,
1h	wherein the reflected ambient light from the at least two of the micro mirrors intersects at the point corresponding to the one of the pixels,
1i	wherein the point on the plane corresponds to an apex of a cone and the at least two of the micro mirrors are located within a base of the cone coplanar with the surface of the substrate, and
1j	wherein each of the micro mirrors in each of the sets for the micro mirrors is selected randomly from available micro mirrors in the base of the cone coplanar with the surface of the substrate, whereby each of the sets of the micro mirrors is arranged in a random pattern.

Claim 3	
3	The assembly of claim 1, wherein the micro mirrors are configured to display the images in at least two colors and wherein at least one of ink, plasmonic resonance, and dielectric coating is used to configure the micro mirrors to display the image with the colors.
Claim 4	
4	The assembly of claim 1, wherein the images comprise two or more frames of an animated clip, whereby a viewer observes animation when viewing two or more of the images associated with the two or more frames.
Claim 5	
5	The assembly of claim 4, wherein the animation is in both the X axis and in the Y axis.
Claim 6	
6Pre	A visual display assembly useful as a security element on paper and coin currency and on product labels, comprising:
6a	a substrate; and on a surface of the substrate, a plurality of micro mirrors receiving light and,
6b	in response, displaying a plurality of images in a plane a distance away from the surface of the substrate,
6c	wherein the plurality of micro mirrors includes, for each of displayed pixel of each of the images, a number of the micro mirrors each having a reflective surface oriented, in a rigid manner, to reflect the ambient light toward a point on the plane corresponding to one of the pixels,
6d	wherein each of the sets of the micro mirrors providing the pixels for each of the differing ones of the images has a differing cone angle offset, wherein the cone angle offset is defined based upon a relative position of a cone axis for a cone of rays projected through each of the pixels,
6e	wherein each of the numbers of the micro mirrors includes at least two of the micro mirrors,
6f	wherein the reflected ambient light from the at least two of the micro mirrors intersects at the point corresponding to the one of the pixels,
6g	wherein the point on the plane corresponds to an apex of a cone and the at least two of the micro mirrors are located within a base of the cone coplanar with the surface of the substrate, and

6h	wherein each of the micro mirrors in each of the sets for the micro mirrors is selected randomly from available micro mirrors in the base of the cone coplanar with the surface of the substrate, whereby each of the sets of the micro mirrors is arranged in a random pattern.
Claim 7	
7	The assembly of claim 6, wherein the cone has a cone angle in the range of 10 to 45 degrees and wherein the cone angle offsets are selected whereby the cones do not overlap at a predefined height above the substrate.
Claim 9	
9	The assembly of claim 6, wherein the micro mirrors are configured to display the images in at least two colors and wherein at least one of ink, plasmonic resonance, and dielectric coating is used to configure the micro mirrors to display the image with the colors.
Claim 10	
10	The assembly of claim 6, wherein the images comprise two or more frames of an animated clip, whereby a viewer observes animation when viewing two or more of the images associated with the two or more frames.
Claim 11	
11	The assembly of claim 10, wherein the animation is in both the X axis and in the Y axis.
Claim 12	
12Pre	A visual display assembly useful as a security element on paper and coin currency and on product labels, comprising:
12a	a substrate; and on a surface of the substrate, an array of micro mirrors receiving light and,
12b	in response, displaying images; wherein each of the images comprises a plurality of pixels,
12c	wherein the array of micro mirrors includes, for each of the pixels of the images, a set of the micro mirrors each having a reflective surface oriented to reflect received light toward a point on a plane corresponding to one of the pixels,

12d	wherein each of the sets of the micro mirrors providing the pixels for each of the images has a differing cone angle offset,
12e	wherein each of the sets of the micro mirrors includes at least two of the micro mirrors,
12f	wherein the reflected received light from the at least two of the micro mirrors intersects at the point corresponding to the one of the pixels,
12g	wherein the point on the plane corresponds to an apex of a cone and the at least two of the micro mirrors are located within a base of the cone coplanar with the surface of the substrate,
12h	wherein the images comprise two or more frames of an animated clip, whereby a viewer observes animation when viewing two or more of the images associated with the two or more frames,
12i	wherein the animation is in both the X axis and in the Y axis, and
12j	wherein each of the micro mirrors in each of the sets for the micro mirrors is selected randomly from available micro mirrors in the base of the cone coplanar with the surface of the substrate, whereby each of the sets of the micro mirrors is arranged in a random pattern.
Claim 13	
13	The assembly of claim 12, wherein the micro mirrors are configured to display the images in at least two colors and wherein at least one of ink, plasmonic resonance, and dielectric coating is used to configure the micro mirrors to display the image with the colors.

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. 10,317,691 (the “’691 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.

III. LEGAL UNDERSTANDING

11. I understand that issues such as invalidity and claim construction are analyzed based on certain legal standards. Counsel for Petitioner has 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

12. 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.

13. 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

14. 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

15. 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.

16. 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.

17. 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.

18. 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.

19. 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.

20. 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

21. For purposes of this declaration, I have been asked to analyze claims 1, 3-7, and 9-13 (“Challenged Claims”) of the ’691 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, 4-7, and 10-12	Fuhse262, Fuhse925
2	1, 4-7, and 10-12	Fuhse262, Fuhse925, Jordan
3	3, 9, 13	Fuhse262, Fuhse925, Fuhse172
4	3, 9, 13	Fuhse262, Fuhse925, Jordan, Fuhse172

V. TECHNICAL BACKGROUND

A. Optical Security Features

1. Historical Background

22. 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.

23. 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, or otherwise.

24. 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.*

25. By the late 1980’s OVDs with arrays and feature sizes on the order as those contemplated in the ’691 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 Pixelgram™. 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 Exelgram™. 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.

26. 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.

27. 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

28. 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.

29. 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. Dynamically changeable micromirror arrays have also been used in optical projectors since at least the 1990s.

30. 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 often covered by an optically transparent medium that is flat and smooth.

31. In the early 2000s, over a decade before the '691 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 '691 Patent's earliest possible priority date).

32. 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.”

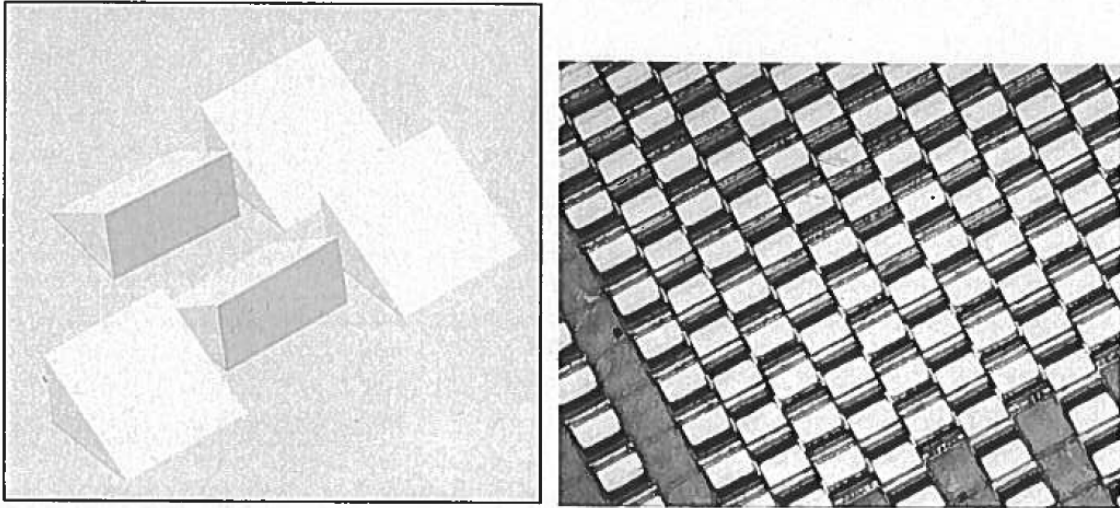


Figure 10. Optical micrograph of an experimental micro-mirror structure. Rows of micro-mirrors of opposing slopes can be seen here. In this particular case, each micro-mirror has a dimension of $30 \times 30 \mu\text{m}$.

EX1026, p. 26, FIG. 10.

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

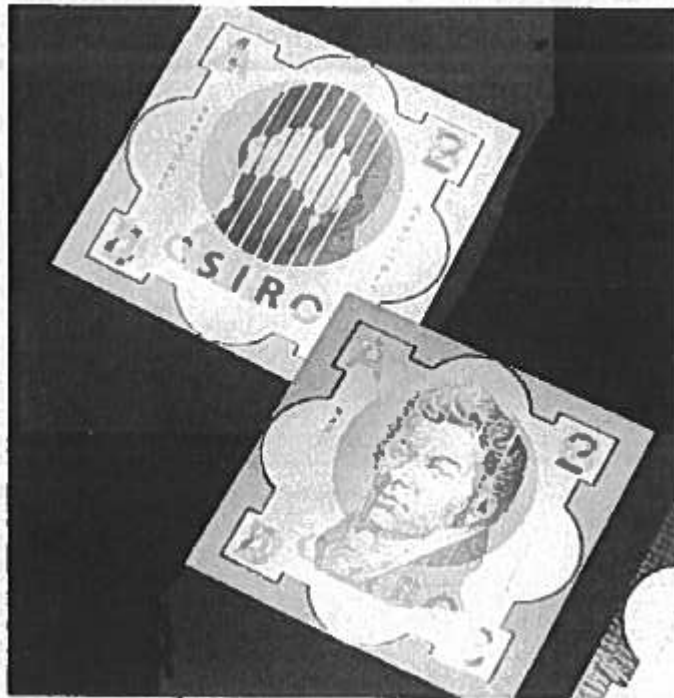


Figure. 12. Images of an experimental micro-mirror optically variable device at two angles of view showing the corresponding images embedded into each channel. Micro-mirrors of opposite slope have been used to reflect the two images into two different viewing directions.

EX1026, p. 26, FIG. 12.

B. Ray Optics

1. The Ray Model

34. 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:

35. **(1)** Rays in a uniform medium (i.e. a medium that consists of one material only, such as air having the same properties everywhere, also referred to as a homogeneous and isotropic medium) 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*”).

36. **(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 sin 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).

37. **(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*”).

38. 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.”

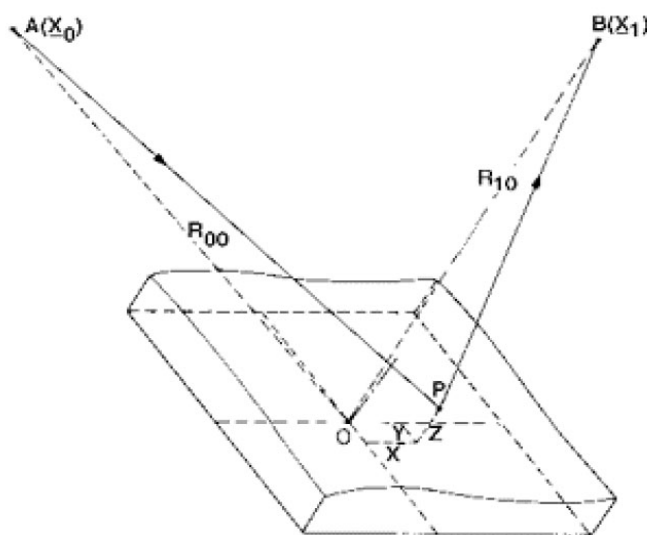


Figure 2. Pixel optical geometry

39. Additionally, CODEV and Zemax are examples of 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

40. Ray propagation is often visualized by drawing cartoons referred to as ray diagrams. Ray diagrams visualize the ray paths resulting from 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.*

41. 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.

42. 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.

3. Chief Ray

43. 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.

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

4. Ambient Light

45. 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

46. 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.

VI. THE '691 PATENT

47. In this section, I provide an overview of the '691 patent, a summary of the prosecution history, and a listing of the challenged claims.

A. Overview

48. The '691 patent is titled *Arrays of individually oriented micro mirrors providing infinite axis activation imaging for imaging security devices*. Ex. 1001. It issued from United States Patent Application No. 15/588,831, which was filed on May 8, 2017. I understand that the '691 patent is a continuation-in-part of U.S. patent application No. 15/162,113, filed on May 23, 2016, now U.S. Patent No. 10,189,294. *Id.* The '691 patent claims priority from Provisional Application No. 62/262,767, filed on December 3, 2015. *Id.* 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, 2015.¹

B. Specification

49. The '691 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, 1:19-2:32.

50. The solution described in the '691 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, 2:36-39, 3:13-18.

51. A micro mirror is simply a very small mirror. For example, the '691 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

¹ I note that the '691 patent includes additional matter beyond the content of the '294 patent. This additional matter relates to FIGS. 16A to 27, and associated description at 21:14-28:11. I reserve the right to challenge any priority claim to the provisional application filing date at a later point in time.

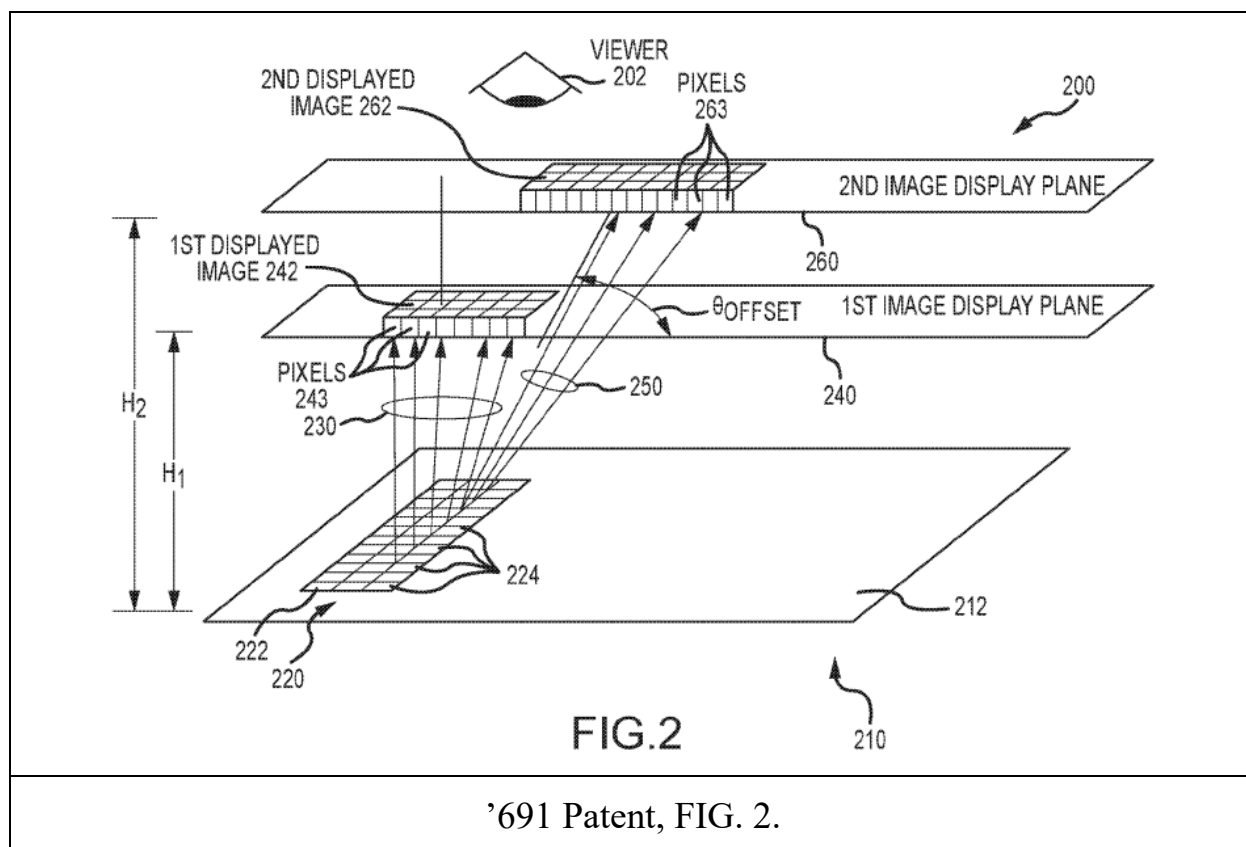
examples, it is circular in shape with a diameter of around 50 micrometers. Ex. 1001, 4:7-12. Each micro mirror “typically will be formed of a metal or metallic compound or other material chosen for its reflective properties.” Ex. 1001, 7:48-52.

52. The concept described in the '691 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, 6:20-7:22.

53. 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, 7:43-48.

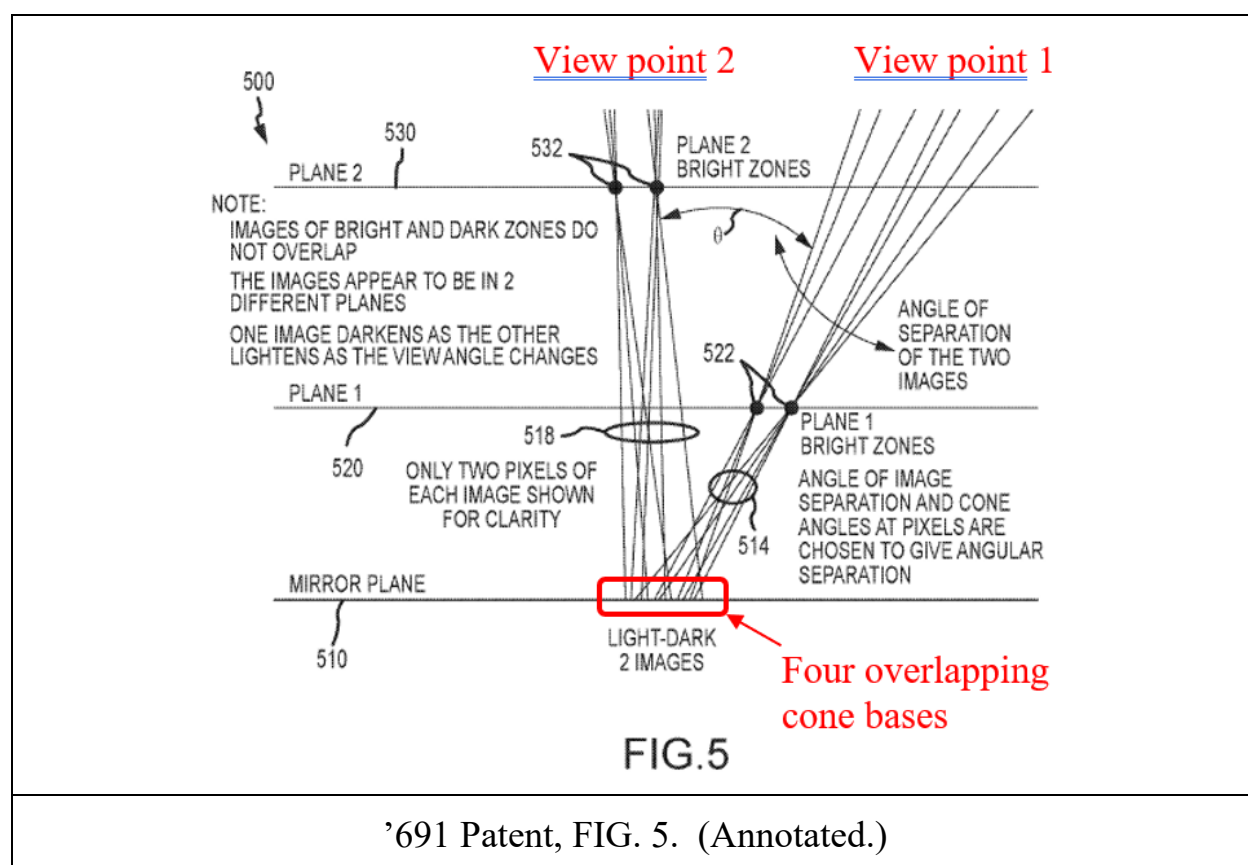
54. The micro mirrors in the subsets that create the first displayed image are oriented relative to those in the subsets that create the second displayed image “so that the pixels 243 of the first image 242 are a viewing angle offset, θ_{Offset} , (e.g., 10 to 30 degrees) from the pixels 263 of the second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

202 typically only views one of the floating images 242, 262 at a time.” Ex. 1001, 9:15-21.



55. 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, 9:2-6. 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, 9:34-38.

56. 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, 10:38-64.



57. In embodiments such as that illustrated in FIG. 5, the micro mirrors are “adapted specifically to provide two light and dark images.” Ex. 1001, 10:38-41. When the security element is viewed from view point 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 view point 1, will appear dark. When the security element is viewed from view point 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 view points. Ex. 1001, 10:64-11:10. Because the image can appear to change as the viewing angle changes, it is possible to produce an “animation effect.” Ex. 1001, 18:5-28.

58. According to FIGS. 16A and 16B, as shown below, a “voxel” is a pixel from a particular image/frame that is configured to be visible at a particular height/level associated with a particular offset value, defining a relative offset angle and direction relative to an orthogonal, for use in producing animations and 3D effects at different heights. Ex. 1001, 21:20-25; *see also*, 22:34-42 (“FIGS. 16A and 16B illustrate schematically side and top views, respectfully, of a security element or visual display assembly 1600 during its use to display a single voxel 1640, such as a pixel from a particular image/frame that is configured to be visible at a particular height/level, H_{Voxel} , and associated with a particular offset value (defining a relative offset angle and direction relative to an orthogonal or “0” offset of the cone axis 1650 such as with the DX, DY, and DZ values).”)

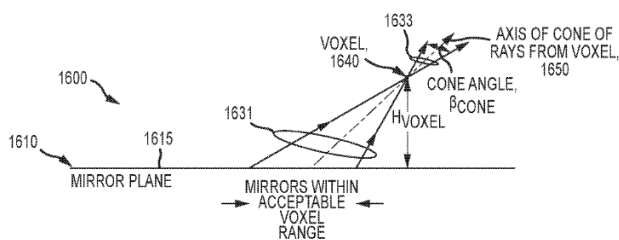


FIG. 16A

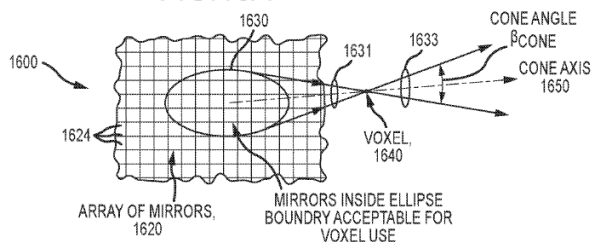


FIG. 16B

59. The animations are exemplified by multiple images in FIG. 19 where there is no cone overlap (as shown in FIG. 23, 24) so as to produce the effect of a moving star in multiple axes where only one image is visible at any one time from a particular viewing angle. Ex. 1001, 24:44-60; 26:6-37. Fig. 23 shows a viewer seeing an image associated with a given voxel 2016, with “rays/beams” 2017 (depicted in a form of a cone, based on a viewing angle) being received by the viewer’s eye 2002. EX1001, 26:18-23.

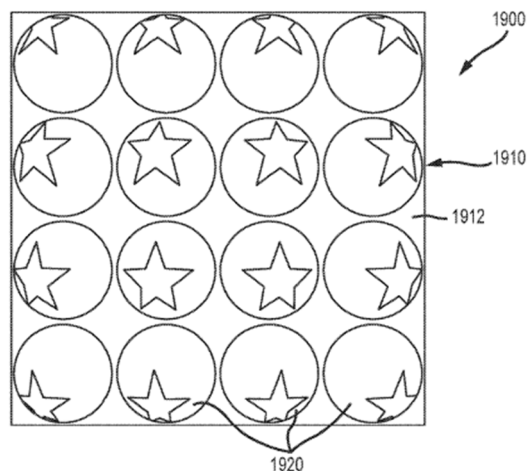
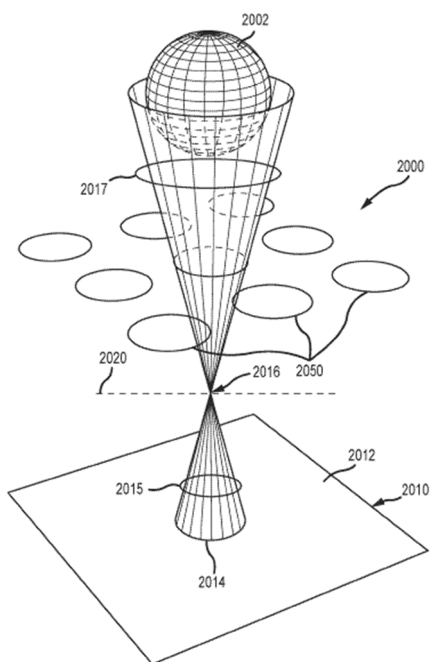
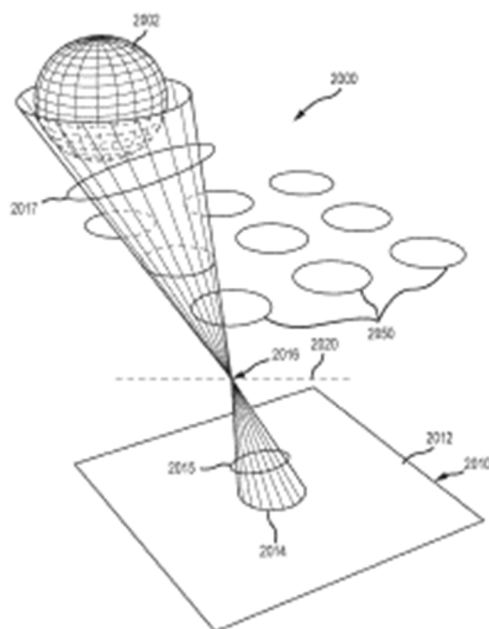


FIG. 19

'691 Patent, FIG. 19.



'691 Patent, Fig. 23.



'691 Patent, Fig. 24.

C. Prosecution History

60. One non-final Office Action and one final Office Action were issued during the prosecution of the application from which the '691 patent issued.

61. On January 23, 2019, a non-final rejection was issued where claims 1-6, 41-45 and 49 were rejected as being anticipated by WO2010/048847 (“Kaule”) (p. 3); and claims 7, 46 and 50 were rejected as being unpatentable as obvious over Kaule in view of US2012/0098249 (“Rahm”) (p. 7). Ex. 1002, pp. 107-17.

62. On January 29, 2019, Applicant amended claims 1, 41, 49, cancelled claims 2, 3, 10-40, 44 and 45, while other original claims remain, unamended, and added new claim 52. Ex. 1002, pp. 164-71. Applicant also amended several paragraphs of the description to correct typographical errors. *Id.* Applicant premised its response by opining that Kaule teaches light spots created by micromirrors with a single and not differing cones so there is no cone angle offset taught or suggested by this reference:

“Kaule fails to show “each of the sets of the micro mirrors providing the pixels for each of the differing ones of the images has a differing cone angle offset” (again see Applicant’s Figure 21 illustrating pixel sets with nine differing cone angle offsets each associated with one of nine differing images). The Office Action argues that Kaule shows this in Figure 9B with its light spots 110 and 112 with reference generally to pages 89 and 90 of Kaule. However, the light spots 110 and 112 actually are pixels of a single image and are viewable concurrently - which is only possible if they have or are within a single cone or are viewable from a common viewing angle. No cone offset discusses or shown in Kaule. Kaule - while discussing Figures 8A-9B - is describing how to create a single image with micro-optical elements 100 and is not teaching how to providing a plurality of images, which supports the understanding that light spots 110 and 112 are created by micro mirrors/elements 110 with a single and not “differing” cones so there is no cone angle offset taught or described (and, note, Kaule fails to mention the term cone angle offset or usefulness of having it differ to

display different images). For these reasons, Kaule fails to anticipate the visual display assembly of claim 1.”

Ex. 1002, p. 100.

63. On March 20, 2019, the Examiner again issued a series of prior art rejections against claims 41-43 based on Kaule, and against claims 1 and 4-6 based on Kaule in view of Rahm (pp. 3-12); and identifies claim 52 as allowable (p. 12).

Ex. 1002, p. 66-80.

64. On the same day, Applicant amended each of claims 1, 41, and 49 with allowable subject matter from claim 52, and cancelled claims 5, 6, 51 and 52, while other claims remain, unamended. Ex. 1002, pp. 56-64.

65. On April 25, 2019, the Examiner allowed the claims. Ex. 1002, pp. 31-38. Examiner’s statement of reasons for allowance stated as follows:

“Claims 1, 41 and 49 are allowable over the prior art of record for at least the reason that even though the prior art discloses a visual display assembly useful as a security element on paper and coin currency and on product labels, comprising: a substrate; and on a surface of the substrate, an array of micro mirrors receiving ambient light and, in response, displaying a plurality of images in a plane spaced a distance apart from the surface of the substrate, wherein each of the images comprises a plurality of pixels, wherein the array of micro mirrors includes, for each of the images, a set of 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, wherein each of the sets of the micro mirrors providing the pixels for each of the differing ones of the images has a differing cone angle offset, wherein the cone angle offset is defined based upon a relative position of a cone axis for a cone of rays projected by the sets of the micro mirrors through each of the pixels, wherein the cone has a cone angle in the range of 10 to 45 degrees, wherein the cone angle offsets are selected whereby the cones

do not overlap at a predefined height above the substrate, whereby only one of the images is observable at a time by a viewer, the prior art fails to teach or reasonably suggest, that each of the sets of the micro mirrors includes at least two of the micro mirrors, wherein the ambient light from the at least two of the micro mirrors intersects at the point corresponding to the one of the pixels, wherein the point on the plane corresponds to an apex of a cone and the at least two of the micro mirrors are located within a base of the cone coplanar with the surface of the substrate, and wherein each of the micro mirrors in each of the sets for the micro mirrors is selected randomly from available micro mirrors in the base of the cone coplanar with the surface of the substrate, whereby each of the sets of the micro mirrors is arranged in a random pattern, in combination with the other limitations of claims 1, 41 and 49.”

Ex. 1002, pp. 36-37.

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

VII. LEVEL OF ORDINARY SKILL IN THE ART

67. 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.

68. 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.

69. Certain engineers will have more advanced degrees, such as a masters or Ph.D. degree 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.

70. Second, at least 2 years of experience in the field would be typical for a person deemed to have ordinary skill in the technology underlying the '691 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 '691 patent.

71. 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 2 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. These activities are customarily part of a practical design process.

72. Fourth, the proposed level of skill is consistent with the sophistication of the technology claimed in the '691 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.

73. 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 two years of experience in micro-optic based security features.

VIII. CLAIM CONSTRUCTION

74. 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 '691 Patent, and I have considered that meaning in the context of the patent and its prosecution history.

75. 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

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

A. German Patent No. DE102010048262 (“Fuhse262”) (Ex. 1006)

77. Fuhse262 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.” Fuhse262, ¶0013-15.

78. An image can also contain multiple two-dimensional images that are “visible from the same or different viewing angles.” Fuhse262, ¶0118. Each image is “only visible in a limited angle range.” Fuhse262, ¶0112.

79. With respect to the optical elements, Fuhse262 recognizes that curved mirrors and lenses may be broken down into arrays of smaller, flat micromirrors, with the advantage of easier fabrication and calculation:

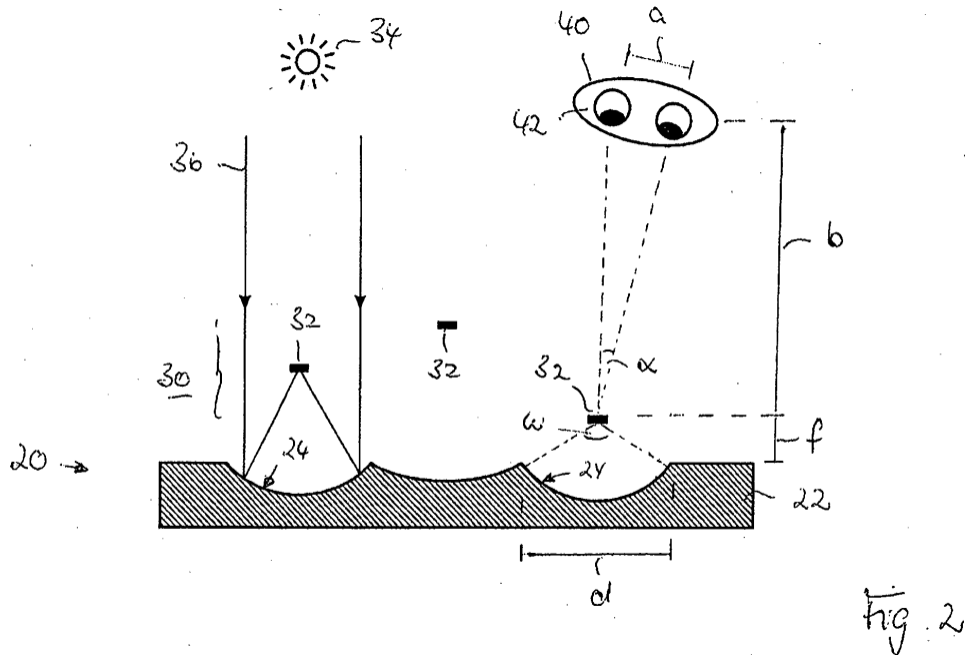
“[0086] In addition, when breaking down a convex mirror or a curved lens into a plurality of micro-optical elements, the

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.”

Fuhse262, ¶0086.

80. Fuhse262 continues that curved mirrors may be replaced by “an arrangement of $n \times n$ micromirrors.” Fuhse262, ¶0087. The micromirrors may, for example, have “a flat mirror surface” with a “dimension of $50 \mu\text{m} \times 50 \mu\text{m}$.” Fuhse262, ¶0087.

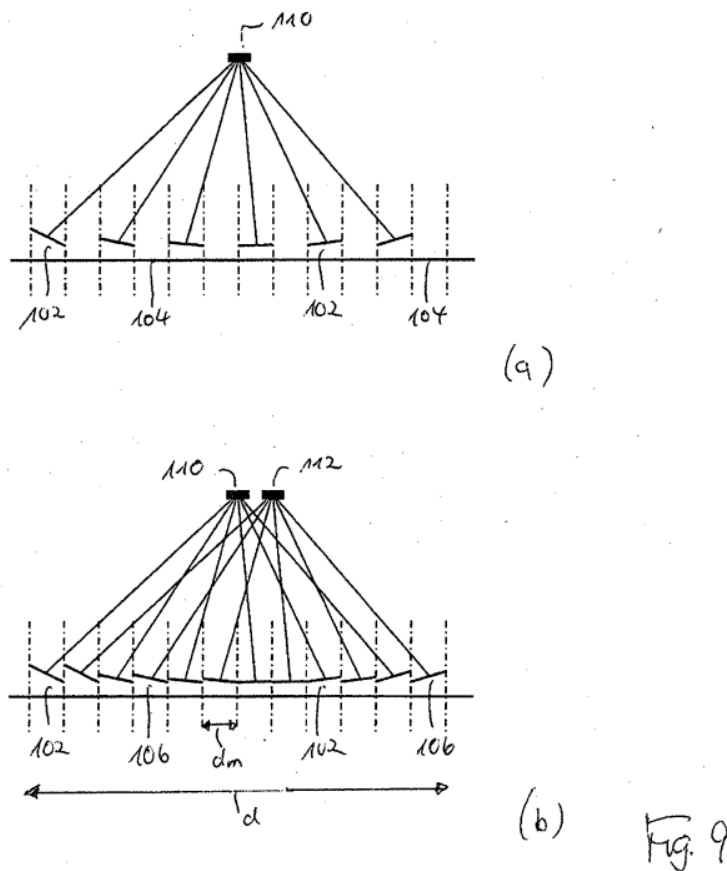
81. Figure 2 shows a simplified example with three image points produced by three mirrors, but in practice “a security element 20 will typically have a large number, for example a few tens, a few hundred or even several thousand, refractive and/or reflective optical elements 24.” Fuhse262, ¶0056.



Fuhse262, FIG. 2.

82. Alternatively, “not only one optical element, but a plurality of optical elements is assigned to every light spot of the light-spot image.” Fuhse262, ¶0019.

This is shown in Figure 9:



Fuhse262, FIGS. 9(a), 9(b).

83. Fuhse262 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 xy plane,

- the xy 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 .”

Fuhse262, ¶0036.

84. This method is described in further detail at ¶¶0125-31.

85. Fuhse262 teaches that the orientation of each mirror within the array necessary to form the required images can be calculated as follows:

“[0096] 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.

[0097] 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 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 $\vec{n}$

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

wherein the abbreviation

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

was used.”

Fuhse262, ¶0096-99.

86. 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.” Fuhse262, ¶ 0108. For this purpose, the mirrors can be directed, for example, at the viewer’s body.

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

87. Fuhse925 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 alternately a few millimeters above or below the plane of the security thread.” Fuhse925, Abstract, 6:67-7:1.

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

C. U.S. Pat. App. Pub. No. 2014/0367957 (“Jordan”) (Ex. 1009)

89. Jordan teaches methods of using arrays of reflective microstructures that produce images “as a security and anti-counterfeiting feature to identify and distinguish authentic products from counterfeit products,” such as “banknotes” or “coinage,” as well as “product marking and labeling” and “packaging.” Jordan, Abstract, ¶¶0013, 0002-04, 0113-14, 0124-25, 0154, 0159, 0174-77.

D. U.S. Pat. App. Pub. No. 2013/0093172 (“Fuhse172”) (Ex. 1035)

90. Fuhse172 discloses that in order “to apply a color-shifting coating, in particular a thin-film system, to the facets ... the thin-film system can have for example a first, a second and a third **dielectric** layer.” Fuhse172, ¶¶0118, 0027-29. (Emphasis added.) For example, ZnS, SiO₂, and TiO₂/MgF₂ dielectric materials may be used.

91. Fuhse172 further discloses that in addition to only dielectric layers, a combination of dielectric layers and metal layers may also be used:

“[0027] In a further embodiment, there can be formed on the facets at least in certain regions a color-shifting coating. The color-shifting coating can be configured in particular as a thin-film system or thin-film interference coating. There can be realized here e.g. a layer sequence of metal layer—dielectric layer—metal layer or a layer sequence of three dielectric layers, whereby the refractive index of the middle layer is lower than the refractive index of the two other layers. As a dielectric material there can be employed e.g. ZnS, SiO₂, TiO₂/MgF₂.

[0028] The color-shifting coating can also be configured as an interference filter, thin semi-transparent metal layer with selective transmission through plasma resonance effects, nanoparticles, etc. The color-shifting layer can also be realized in particular as a liquid-crystal layer, diffractive relief structure or subwavelength grating. A thin-film system constructed of reflector, dielectric, absorber (formed on the facets in this order) is also possible.

[0029] The thin-film system plus facet can be configured not only as facet/reflector/dielectric/absorber, as described above, but also as facet/absorber/dielectric/reflector. The order depends in particular on which side the security element is to be viewed from. Further, color-shift effects visible on both sides are also possible when the thin-film system plus facet is configured for example as absorber/dielectric/

absorber/facet
absorber/dielectric/reflector/dielectric/absorber/facet.” or

Fuhse172, ¶¶0027-29.

X. INVALIDITY ANALYSIS

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

- Ground 1: Claims 1, 4-7 and 10-12 of the '691 Patent are rendered obvious under 35 U.S.C. §103 by Fuhse262 in view of Fuhse925;
- Ground 2: Claims 1, 4-7 and 10-12 of the '691 Patent are rendered obvious under 35 U.S.C. §103 by Fuhse262 in view of Fuhse925 and Jordan; and
- Ground 3: Claims 3, 9, and 13 of the '691 Patent are rendered obvious under 35 U.S.C. §103 by Fuhse262 in view of Fuhse925 and Fuhse172,
- Ground 4: Claims 3, 9, and 13 of the '691 Patent are rendered obvious under 35 U.S.C. §103 by Fuhse262 in view of Fuhse925, Jordan and Fuhse172.

A. Ground 1: Fuhse262 in view of Fuhse925 renders obvious claims 1, 4-7 and 10-12.

93. It is my opinion, the combined teachings of Fuhse262 in view of Fuhse925 renders obvious claims 1, 6 and 12 of the '691 patent.

1. Combined Teachings of Fuhse262 in view of Fuhse925

a) Motivation to combine

Fuhse262

94. Fuhse262 describes an invention of “a depiction” element. Fuhse262, ¶¶0001, 0010-11, 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.

95. To the extent that these descriptions represent different embodiments for purposes of obviousness, in my opinion, it would have been obvious to combine them.

96. Fuhse262 provides express motivation and direction to combine the features of its embodiments. Figure 2 of Fuhse262 shows various aspects and elements “[t]o explain the principle of the invention.” Fuhse262, ¶¶0056-60. Figures 8(a)-(d) build on Figure 2 by replacing the “curved concave mirror” of Figure 2 by using micromirrors. Fuhse262 ¶0048 (“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”). Fuhse262 explicitly refers back to the “previous exemplary embodiments” in building on those teachings. Fuhse262, ¶0083, 0087. Also, the Figures 8(a)-8(d) show different variations of the same teachings, such as different numbers of groupings of micromirrors.

97. Fuhse262 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.” Fuhse262, ¶¶0083.

98. Likewise, Figure 9 builds on the teachings of Figures 8(a)-8(d) by illustrating them “in a sectional view” and providing further explanation. Fuhse262, ¶¶0091-94, 0049. Finally, Figure 10 builds on the teachings of Figures 8(a)-8(d) and 9 by describing how to calculate orientation of the surfaces of the micromirrors. Fuhse262, ¶¶0095-101, 0050 (“Fig. 10 illustrates the calculation of the flat mirror surfaces of the micromirrors of Figs. 8 and 9”). Fuhse262 also describes a “further development of the invention” regarding providing different images to the viewer when viewed at different angles (*see* ¶¶0111-15) and describes a “preferred procedure” to produce the structures of these combined teachings. Fuhse262, ¶¶0125-28, 0036.

Fuhse262 in view of Fuhse925

99. In my opinion, it is obvious to apply the teachings of Fuhse925 to Fuhse262. Fuhse262 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. Fuhse262, Abstract; Fuhse925, Abstract.

100. One reviewing Fuhse262 would have looked to Fuhse925. Fuhse262 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. Fuhse262, ¶¶95-99. 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 Fuhse262 (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 Fuhse262.

101. Fuhse925 provides explicit detail for implementing what Fuhse262 teaches, namely a micromirror with a desired surface normal 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 Fuhse262 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 Fuhse262 and Fuhse925.

102. Additionally, using Fuhse925’s teachings regarding inclination components in Fuhse262’s system would have involved using a known technique to improve Fuhse262 in a known way, without unpredictable results, and would thus also have been obvious.

b) Reasonable Expectation of Success

103. In my opinion, there would have been a reasonable expectation of success combining the embodiments of Fuhse262, and in implementing the combination of Fuhse262 and Fuhse925.

Fuhse262

104. As a POSITA would have recognized, the teachings of Fuhse262 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. Fuhse262 teaches to “replace[]” the curved mirrors of Figure 2 with the plurality of flat micromirrors 100 (see Fuhse262, ¶¶0083-86), and a POSITA would have reasonably been able to adapt those teachings regarding Figure 2 to flat micromirrors.

105. Likewise, the different specific implementations, such as possible arrays sizes of 100 micromirrors (see ¶0087) or 288 micromirrors (see ¶¶0090-92), would have been routinely and predictably implemented by a POSITA.

106. 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. The predictable nature of the art 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. 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), and orientations of mirrors (V.C) 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 '691 Patent were textbook

knowledge at the time of the alleged invention, a POSITA would have no difficulty combining embodiments of Fuhse262. Given that micromirror arrays of the type contemplated in the '691 Patent were textbook knowledge at the time of the alleged invention, a POSITA would have no difficulty combining embodiments of Fuhse262.

107. Thus, it is my opinion that a POSITA would have been able to implement the obviousness modifications in this ground without difficulty and with a reasonable expectation of success. *Id.*

Fuhse262 in view of Fuhse925

108. It is my opinion that a POSITA would have recognized, the structures of Fuhse262 and Fuhse925 are similar and compatible.

109. For example, Fuhse262 teaches that its micromirrors may “for example, have a dimension of $50\text{ }\mu\text{m} \times 50\text{ }\mu\text{m}$ and can be formed with a flat mirror surface.” Fuhse262, ¶¶95-99. Fuhse925’s facets are “micromirrors” with “the dimensions... between $20\text{ }\mu\text{m}$ and $300\text{ }\mu\text{m}$, preferably between $50\text{ }\mu\text{m}$ and $200\text{ }\mu\text{m}$.” Fuhse925, 5:36-38, 7:43-48. Fuhse262 and Fuhse925 provide almost identical teachings regarding how the micromirrors in Fuhse262 and Fuhse925 should be made, further showing the compatibility in their teachings. *Compare* Fuhse262, ¶0032 (“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* Fuhse925, 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 Fuhse262 with no difficulty.

110. 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.* As discussed in Section V.A (Technology Background, Optical Security Feature), the art of micro-mirror arrays was mature and known to work well before the time of the alleged invention. *See* Section V.A.

111. The required mathematics regarding surface orientations (see Section 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 to the surface inclination teachings of Fuhse925 in 2015.

2. Application to the Challenged Claims

112. In my opinion, Fuhse262 in view of Fuhse925 teaches the limitations of the claims. The mapping below provides my analysis on a limitation-by-limitation basis, with relevant citations to the teachings of Fuhse262 and Fuhse925.

a) Claim 1

113. In my opinion, Fuhse262 in view of Fuhse925 teaches claim 1, as detailed below.

(1) Claim 1, Element [1Pre]: *A visual display assembly useful as a security element on paper and coin currency and on product labels, comprising:*

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

115. 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.

116. In my opinion, to the extent the preamble is limiting, Fuhse262 teaches the preamble. Fuhse262, ¶¶0008-12, 0037, FIG. 1.

117. Fuhse262’s invention relates to “a depiction element” ([a] **visual display assembly**) “[f]or security applications” and with “an attractive visual appearance.” Fuhse262, ¶¶0008-12. The depiction element is **useful as a security element** for a “data carrier” and “[t]he data carrier can in particular be a value document,” such as a “paper banknote” (**paper... currency**). Fuhse262, ¶0037, FIG. 1.

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

119. Based on Fuhse262’s teachings that the depiction element would be useful for data carriers such as currency, it is my opinion that a POSITA would have

found it obvious to recognize that the depiction element would be useful for coin currency and product labels.

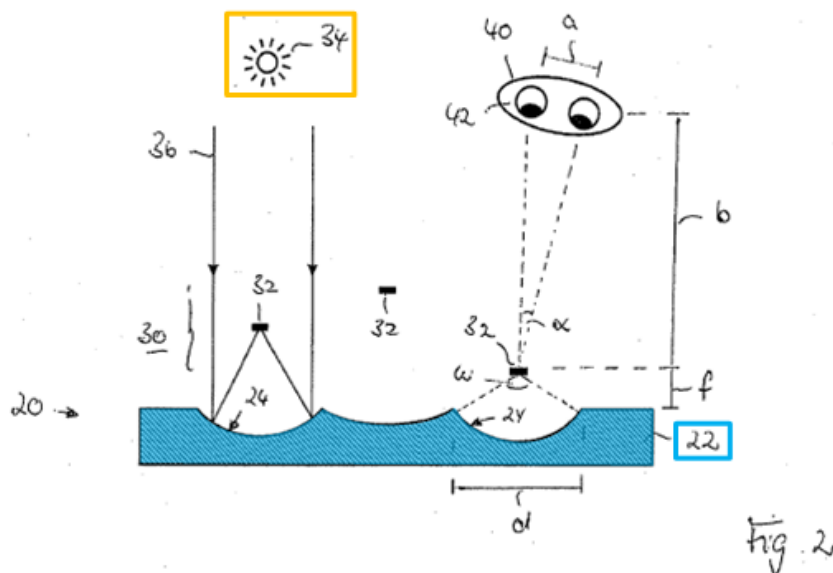
120. As discussed in Ground 2, it was known in the art to apply depiction elements to coin currency and product labels. Jordan, Abstract, ¶¶0013, 0002-04, 0113-14, 0124-25, 0154, 0159, 0174-77.

121. 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.

(2) Claim 1, Element [1a]: *a substrate; and on a surface of the substrate, an array of micro mirrors receiving ambient light and,*

122. In my opinion, Fuhse262 teaches element [1a]. Fuhse262, Abstract, ¶¶0001, 0010, 0035, 0056-65, 0110.

123. Fuhse262 discloses “a substrate” (**a substrate**), such as substrate 22, shown annotated in blue in the below reproduction of Figure 2. Fuhse262, Abstract, ¶¶0001, 0010, 0035, 0056-65, 0110.



Fuhse262, FIG. 2. (Annotated.)

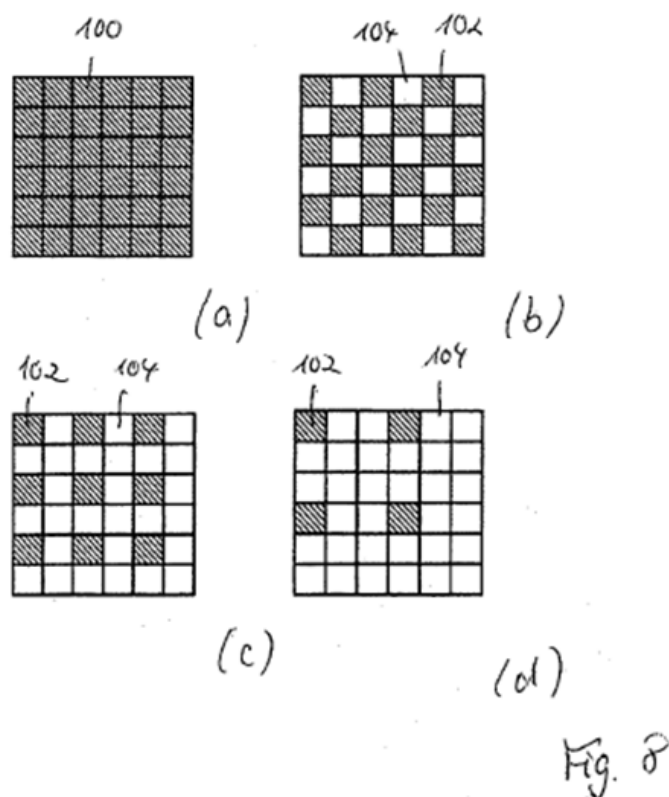
124. The surface of the substrate defines a “xy plane” or “substrate plane.” Fuhse262, ¶¶0126-27, 0110. In Fuhse262’s coordinate system, this surface corresponds to $z=0$. Fuhse262, ¶¶0110, 0126.

125. Fuhse262 teaches an arrangement of $n \times n$ micromirrors (**an array of micro mirrors**) on “a surface region” of the substrate that receive **ambient light** (e.g., sunlight).

126. Fuhse262’s substrate has “a surface region” (**on a surface of the substrate**) “in which a plurality of optical elements are arranged.” See Fuhse262, Abstract, ¶¶0010, 0001, 0035, 0056-65, 0110. 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**). Fuhse262, ¶¶0060, 0013, 0022, 0030, 0083, 0087-95.

127. The surface of the substrate defines a “x-y plane” or “substrate plane.” Fuhse262, ¶¶0126-27, 0110. In Fuhse262’s coordinate system, this surface corresponds to $z=0$. Fuhse262, ¶¶0110, 0126.

128. 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.” Fuhse262, ¶¶0060, 0013, 0022, 0030, 0083, 0087-95. Specifically, the curved mirrors of Figure 2 are “replaced by” the plurality of flat micromirrors 100 because they are “easier to calculate and produce.” Fuhse262, ¶¶0083-86.



129. This ordered arrangement of micromirrors 100 is **an array**. 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 Fuhse262. Fuhse262, ¶¶0082-83, 0091. Fuhse262 discloses that the illumination is with **ambient light** such as “sunlight or a ceiling lamp.” Fuhse262, ¶0054. For example, Fuhse262 discloses illumination by “distant light source 34,” depicted in Figure 2 as sunlight (see yellow box annotation in Figure 2 above). See Fuhse262, ¶¶0057-58, 0061; *see also* ¶0029 (distinguishing “normal illumination” “visible to the naked eye” with “directed illumination with laser light”)

130. 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.4. Fuhse262 distinguishes “normal illumination” “visible to the naked eye” (i.e., ambient light) with “directed illumination with laser light.” Fuhse262, ¶0029.

131. Accordingly, Fuhse262 teaches the element [1a].

(3) **Claim 1, Element [1b]: *in response, displaying a plurality of images in a plane spaced a distance apart from the surface of the substrate, wherein each of the images comprises a plurality of pixels,***

132. In my opinion, Fuhse262 teaches element [1b]. See Fuhse262, ¶¶0010-12, 0015, 0035-36, 0049, 0054-56, 0068, 0083-84, 0091-92, 0126-28.

133. Fuhse262 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 floating height”, meaning they are in a plane). That image in the plane is above the surface region of the substrate (**a distance apart from the surface of the substrate**). Fuhse262, e.g., ¶0015 (“[T]he light spots of the light-spot image float at several different floating heights above or below the surface region in order to form a three-dimensional motif.”)

134. The image is **in a plane**. First, Fuhse262 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 Fuhse262’s teaching. Fuhse262, e.g., ¶0026 (“2D-3D images can also be formed as a light-spot image. In addition to parts with 3-dimensional effects (which can be seen in front of or behind the plane of the depiction element or appear to penetrate the plane of the depiction element), there are also parts with 2-dimensional effects in or near the plane of the depiction element (at height level 0 or near height level 0).”). Fuhse262 also teaches that all the light spots may be at the “same floating height” or at “a certain height above or below the substrate surface.” Fuhse262, ¶68.

135. Second, Fuhse262 teaches that arbitrary three-dimensional images may be produced. Fuhse262, e.g., ¶54 (“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. Different light spots have different floating heights, so that the light spots together form a three-dimensional motif, for example a light pyramid protruding from the banknote.”). It is my opinion that 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).

136. Fuhse262 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**). Fuhse262, ¶¶0010-12, 0015, 0035-36, 0054-56, 0083-84, 0126-28.

137. 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 predetermined 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.

138. 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 '691 patent describes "pixels." For example, with respect to FIG. 2, the '691 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)."

'691 patent, 8:50-56 (emphasis added).

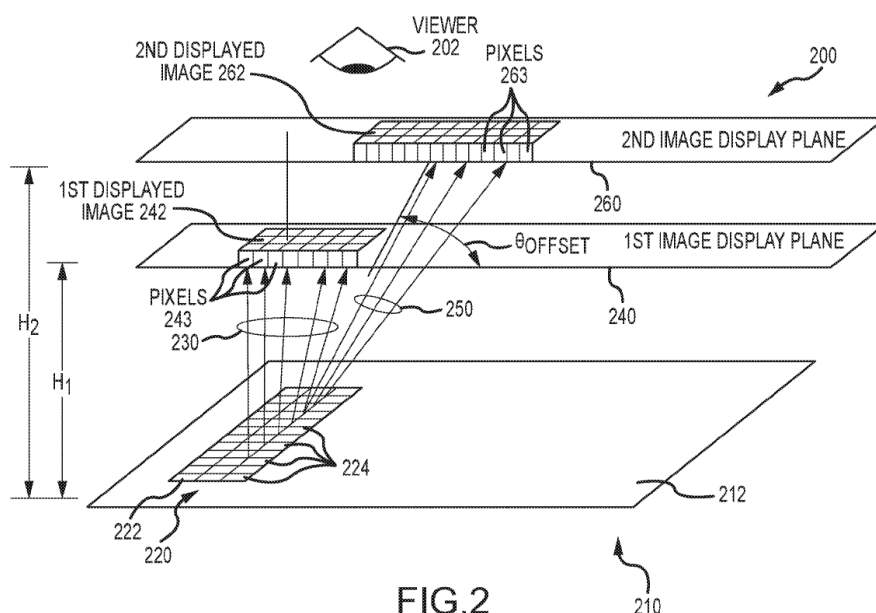


FIG.2

'691 patent, FIG. 2.

139. Fuhse262 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.” Fuhse262, ¶¶0068.

140. Fuhse262 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**. Fuhse262, ¶¶0036, 0125-28. Fuhse262 interchangeably refers to image point P_j (**pixel**) and its corresponding light spot as “pixel P_j .” Fuhse262, ¶¶0126, 0128. 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 [a] (*see* element [a]). Fuhse262, ¶¶0036, 0125-28.

141. 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 $z=0$. Fuhse262, ¶¶0126-27, 0110. 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.

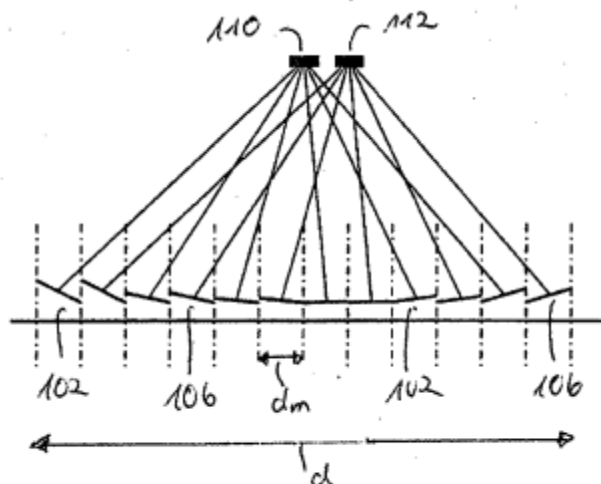
142. While providing a two-dimensional image in a plane is obvious based on teaching an arbitrary three-dimensional image, Fuhse262 *explicitly* teaches that a two-dimensional image may be formed by fixing the height (z) values of the pixels:

“[0068] 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.”

Fuhse262, ¶¶0068, 0015 (emphasis added). In fact, Fuhse262 refers to the resulting image as “a two-dimensional motif,” such as “a font or a logo.” Fuhse262, ¶¶ 0015, 0027, 0117.

143. 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).

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



Fuhse262, FIG. 9(b).

145. Fuhse also teaches **displaying a plurality of images**, such as “image A” and “image B,” which are “different images” that “become visible to the viewer from different directions.” Fuhse262, ¶¶0111-13. Each of these images is **a plane spaced a distance apart from the surface of the substrate** in the manner discussed above.

146. Further, Fuhse262 Fuhse262 teaches “two-dimensional” images such as “a font or a logo” (see Fuhse262, ¶¶0015, 0027, 0117), and teaches that “several” images may be produced. Fuhse262, ¶¶0116-17.

147. Fuhse262 further teaches that two images may “lie next to each other and/or appear alternately in the same place when the viewing direction changes.” Fuhse262, ¶¶0027, 0118. Whether image A and B “lie next to each other” or are “in the same place,” they are in the same **plane spaced a distance apart from the**

surface of the substrate. For example, when the two images are in the same place, their pixels have the same heights, and therefore are in the same plane. This is accomplished as discussed above, by selecting all of the image points P_j of the **second image** with the same height values Z_j , the **first image**. Fuhse262, ¶¶0036, 0125-28, 0117 (“a two-dimensional motif” has “all image points are at the same height”).

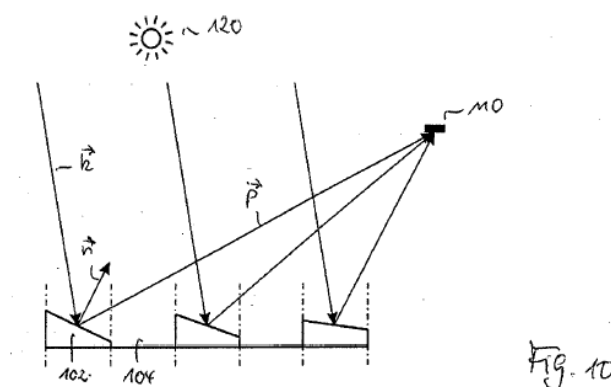
148. To the extent it could be argued that Fuhse262 only explicitly discloses a three-dimensional image in the same place or next to a two-dimensional image (*see* ¶¶0027, 0118), it would have been understood to provide two two-dimensional images. As discussed above, by teaching any arbitrary three-dimensional image in space (*i.e.*, x, y, z space) can be constructed of pixels, a POSITA would understand that a two-dimensional image can be constructed by fixing the height (z) values of the pixels. Based on Fuhse262’s teachings that multiple images may be created in the same place or next to each other, and that images may be two-dimensional, it would have been understood to a POSITA to provide two two-dimensional images at the same height (*i.e.*, in the same plane).

149. Accordingly, Fuhse262 teaches the element [1b].

- (4) **Claim 1, Element [1c]:** *wherein the array of micro mirrors includes, for each of the pixels of each of the images, a set of 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,*

150. In my opinion, Fuhse262 teaches element [1c]. See Fuhse262, ¶¶0010-11, 0013, 0019-20, 0036, 0060, 0084, 0088, 0091-92, 0095-0101, FIGs. 8(b), 9(b), and 10.

151. Fuhse262 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 (reproduced below) and its descriptions teach how to properly orient each micromirror to reflect light to its assigned pixel. See, *supra*, Section IX.A (describing calculations of each orientation of the reflective surfaces to reflect light to a pixel).



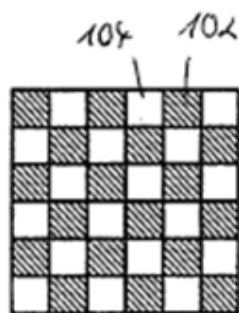
Fuhse262, FIG. 10

152. Specifically, Fuhse262 discloses that **the array of micro mirrors includes for each of the pixels a set of the micro mirrors**. Fuhse262, ¶¶0019-20, 0036, 0084, 0088, 0091-92. Fuhse262 explains that “a plurality of optical elements is assigned to every light spot” (**for each of the pixels a set of the micro mirrors**), such that “groups of optical elements” “are each assigned to different light spots.”

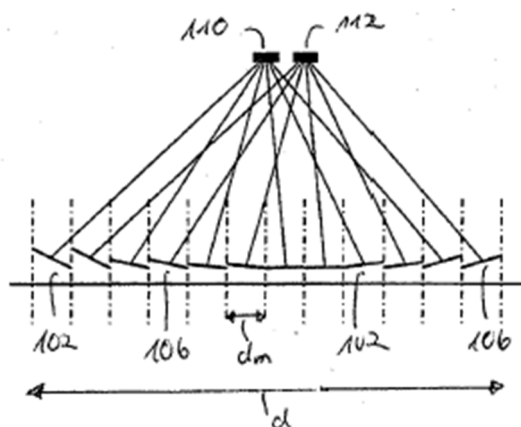
Id., ¶¶0019-20 (emphasis added). Fuhse262 does so by defining “a number of fine fields” “for every image point P_j ,” (**each of the pixels**), and providing that the optical elements in those fine fields (**a set of the micro mirrors**) “contribute to producing the light spot that corresponds to image point P_j .” *Id.*, ¶¶0036, 0126-28, cl. 25.

153. In the example of FIG. 8(b), (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. *Id.*, ¶¶0091-92. 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.

154. As shown in FIG. 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 **set of the micro mirrors is assigned for each of the pixels**. *Id.* Fuhse262 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. *Id.*, ¶0087.



Fuhse262, FIG. 8(b).



Fuhse262, FIG. 9(b).

155. Fuhse262 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**. Fuhse262 discloses that its micromirrors may be “purely reflective.” Fuhse262, ¶¶0013, 0010-11, 0036, 0060. In particular, Fuhse262 discloses that “the flat mirror surfaces of the micromirrors” “reflect[]” incident light (**the micro mirrors each having a reflective surface**). *Id.*, ¶¶0095-97. 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**). *Id.*, ¶¶0095-97. Fuhse262 also discloses the light spots of an image all float “at the same floating height” (**a point on the plane corresponding to one of the pixels**) “above or below the surface region in order to form a backdrop motif” (**for each of the pixels of each of the images**). *Id.*, ¶¶0015.

156. Accordingly, Fuhse262 teaches the element [1c].

- (5) **Claim 1, Element [1d]:** *wherein each of the sets of the micro mirrors providing the pixels for each of the differing ones of the images has a differing cone angle offset, wherein the cone angle offset is defined based upon a relative position of a cone axis for a cone of rays projected by the sets of the micro mirrors through each of the pixels,*

157. In my opinion, Fuhse262 teaches element [1d]. See Fuhse262, ¶¶0015-0019-20, 0091-92, FIGS. 8(b), 9(b).

158. Fuhse262 discloses that **each of the sets of micro mirrors providing the pixels for each of the differing ones of images has a differing cone angle offset**. As discussed in section X.A.2.a)(4), Fuhse262 explains that “a plurality of optical elements is assigned to every light spot” (**for each of the pixels a set of the micro mirrors**), such that “groups of optical elements” “are each assigned to different light spots.” *Id.*, ¶¶0019-20. In the example of FIG. 8(b), (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. *Id.*, ¶¶0091-92. 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. Fuhse262 also discloses the light spots of an image “all float at the same floating height above or below the surface region in order to form

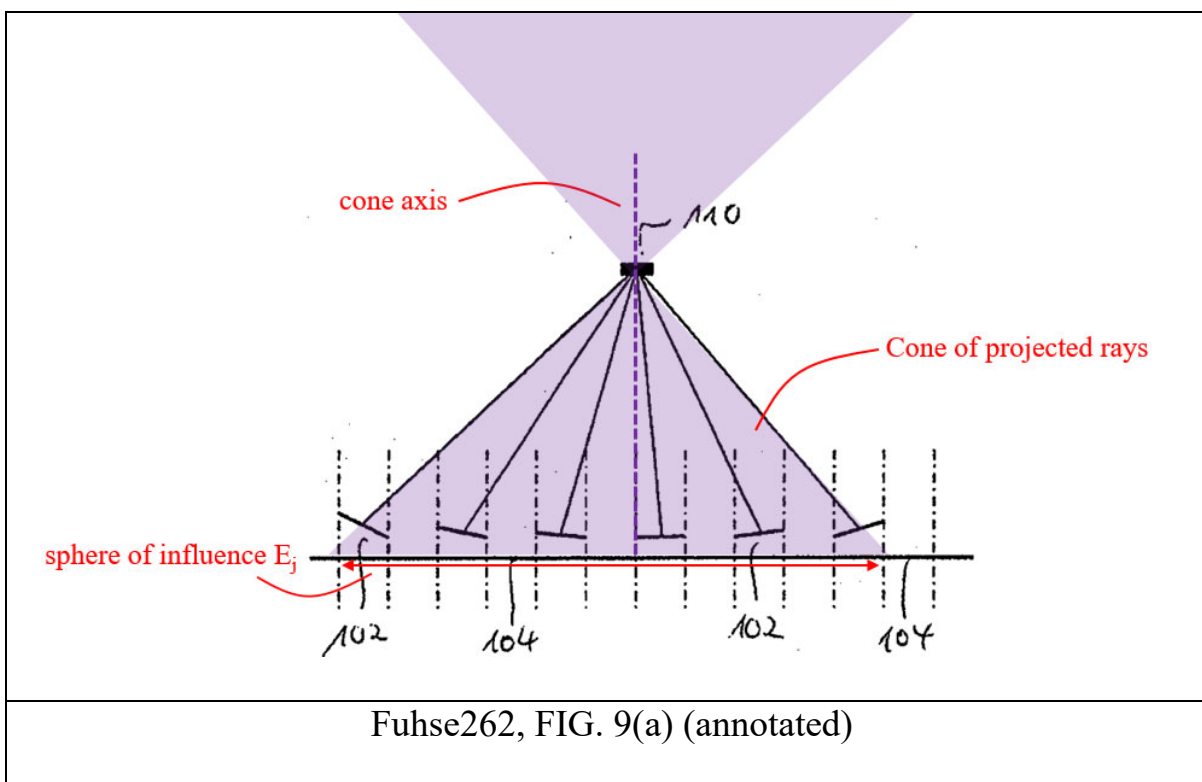
a backdrop motif” (**providing the pixels for each of the differing ones of the images**). *Id.*, ¶¶0015.

159. As shown in FIG. 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 **set of the micro mirrors is assigned for each of the pixels**. *Id.*, ¶¶0091-92.

160. Fuhse262 teaches that for “every image point P_j ,” (every **pixel**), there is a “cone originating from” or “emanating from” the image point (an apex of a cone). Fuhse262, ¶¶0036, 0126. Further, “a sphere of influence E_j ” or “catchment area 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” (the surface of the substrate). *Id.*

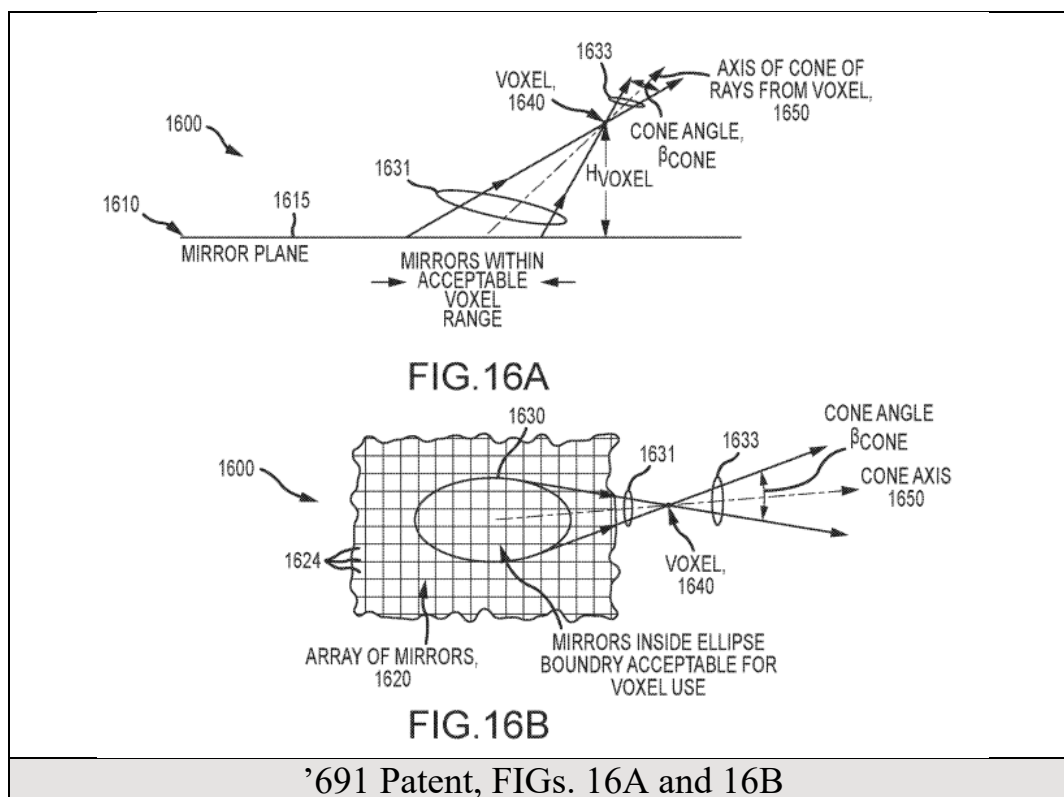
161. Below I have annotated FIG. 9(a) of Fuhse262 applying these teachings to light spot 110 (a pixel). As shown, the cone formed with the pixel as the apex and the base of the cone as the catchment area of the substrate surface, as taught by Fuhse262, **a cone of rays projected by the sets of the micro mirrors through each of the pixels** is formed, as shown below. Fuhse262, ¶¶0036, 0126. As shown, the cone formed by the pixel (at the apex) and the catchment area (at the substrate surface) define the **cone of rays**, and a **cone axis** is formed through the apex and

center of the catchment area of each cone (*i.e.*, the center point of the sphere of influence).



162. Based on Fuhse262's teachings to define a cone with an apex at the pixel, and a cone base defined on the surface of the substrate, a POSITA would have recognized that the **axis** of that **cone** would be formed through the apex and center of the catchment area of each cone (*i.e.*, the center point of the sphere of influence).

163. This understanding of the cone axis agrees with the '691 Patent, which states that cone axis 1650 (see below in FIGs. 16A and 16B) "passes through the voxel 1640 and also through the center point of the cone base 1630." '691 Patent, 22:34-60.



164. Fuhse also teaches producing two images that are visible at different viewing angles:

“[0111] In a further development of the invention, the security element can also produce a changing light-spot image when illuminated, in which **different images become visible to the viewer from different directions**. For example, the procedure for a reflective security element can be as follows; the procedure for a see-through security element is analogous:

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.

[0112] When arranging the micromirrors in the surface region of the security element, **those micromirrors in which the x component n_x of the normal vector is greater than zero are then omitted for the**

light-spot image A. This frees up half of the mirror space and the image is only visible in a limited angle range.

[0113] For the light-spot image B, those micromirrors are omitted where the x component n_x of the normal vector is less than zero.

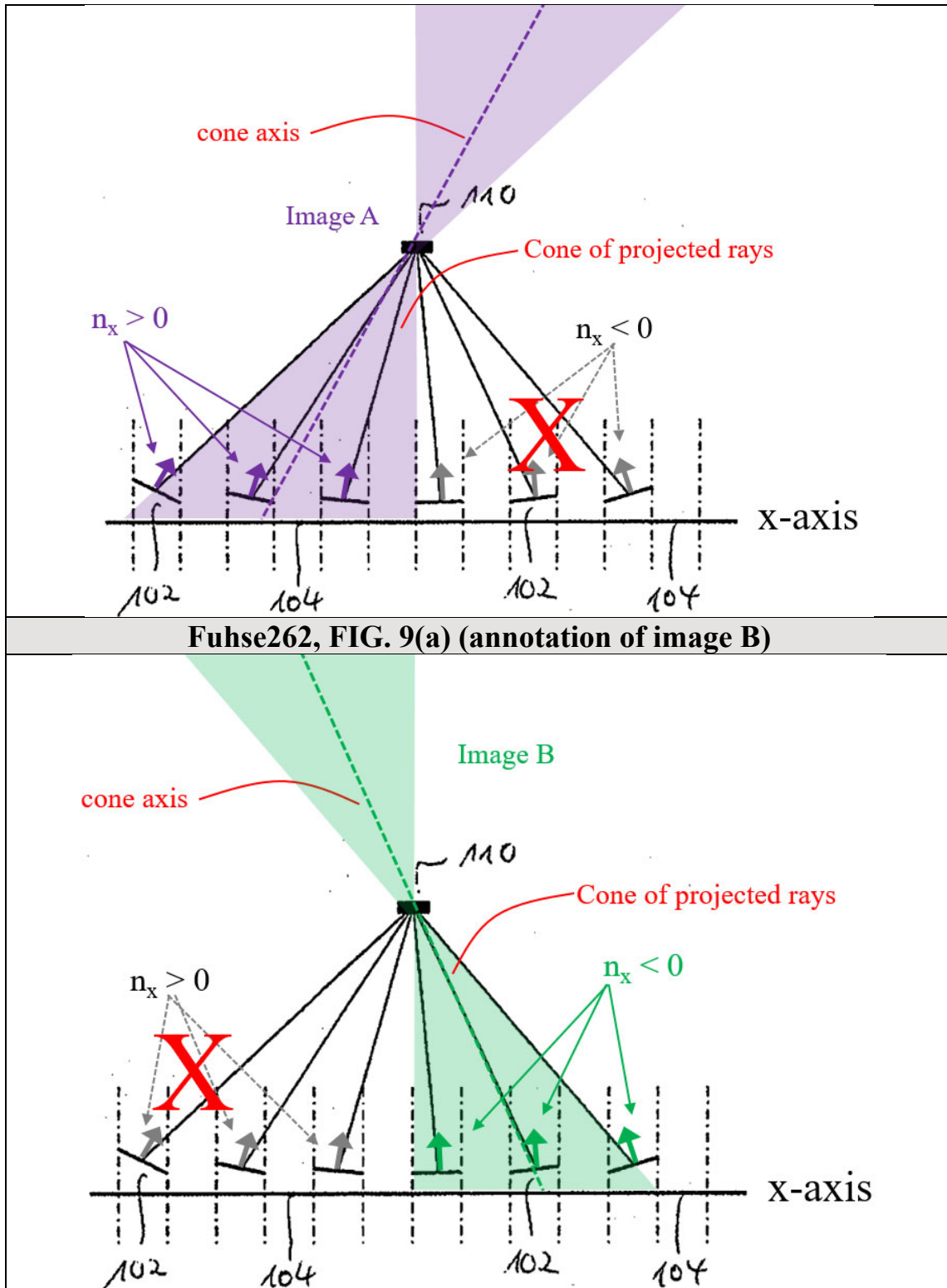
With this reduced mirror arrangement, the freed-up mirror positions of the light-spot image A are covered. When the arrangement is tilted sideways, the light-spot image A and the light-spot image B alternately become visible.”

Fuhse262, ¶¶0111-13 (annotated).

165. As explained by Fuhse262, the two viewing angles are accomplished by omitting mirrors with certain x-components of the micro mirror normal. Vertical tilting is provided in the same way, but in the y-axis. Fuhse262, ¶0114.

166. These teachings have been applied to FIG. 9 (as explicitly contemplated by Fuhse262 in ¶0111) in the Figure below. For image A, micromirrors in which the x component n_x of the normal vector is greater than zero have been omitted, meaning that in the below image all of image A’s rays (in purple) will “point” from right to left (i.e., $n_x > 0$). For image B, with the “free[d] up half of the mirror space,” micromirrors are omitted where the x component n_x of the normal vector is less than zero, this means in the above image that all of image B’s rays (in green) will “point” from left to right (i.e., $n_x < 0$).

Fuhse262, FIG. 9(a) (annotation of image A)



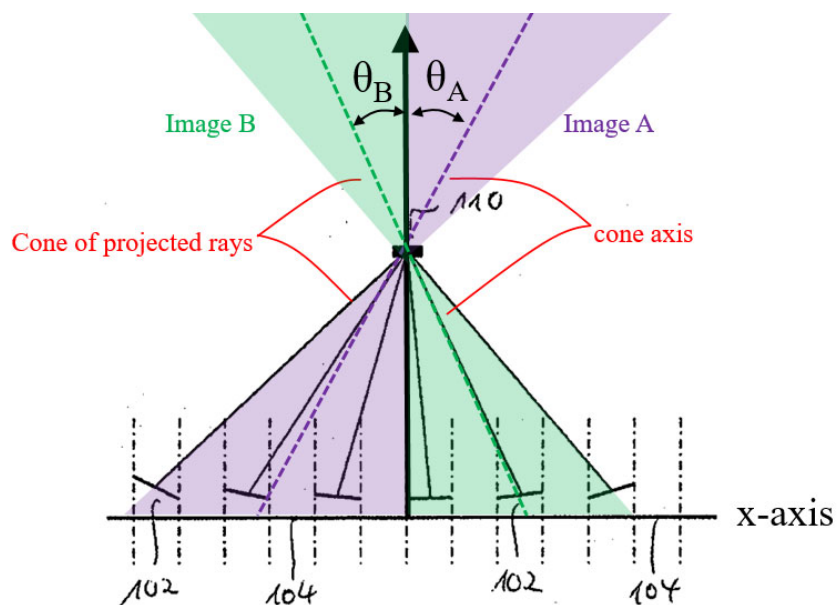
167. As shown above, for each image, there is **a cone of rays projected by the sets of the micro mirrors through each of the pixels**. While only a single pixel is shown for each image, Fuhse262 teaches that many pixels (or “light spots”) will form each image. It should be noted that the ’691 Patent generally also shows one pixel and cone of projected rays per image “for ease of explanation” (see FIG. 21) as it would be difficult to depict multiple images, each with many cones. ’691 Patent, 25:53-66.

168. Fuhse flexibly allows different cones to be defined in different ways, explaining that “other criteria can of course also be used to separate the light-spot images of a changing image.” Fuhse262, ¶0115. For example, three images may be produced with the following conditions:

$$n_y > c_1 \text{ for image A, } c_1 < n_y < c_2 \text{ for image B, } n_y < c_2 \text{ for image C}$$

169. When the “two numerical values” satisfy $c_1 < c_2$, this “allow[s] three light-spot images A, B, C to change when tilted vertically. By choosing the numerical values c_1 and c_2 , the size of the visibility range can be set as desired.” Fuhse262, ¶0115.

170. Fuhse262 teaches a **cone angle offset**, as shown by θ_A and θ_B in the annotated FIG. 9(a) below. The particular offset for each cone depends on the range of normal values of the micro mirrors for the given pixel, as taught by Fuhse262.



171. As shown in the Figure above visualizing Fuhse262's teaching, this **cone angle offset is defined based upon a relative position of a cone axis for a cone of rays projected by the sets of the micro mirrors through each of the pixels.** As discussed, the cone axis passes through the apex and center of the catchment area of each cone (*i.e.*, the center point of the sphere of influence), and the **cone angle offset is defined based upon a relative position of a cone axis to the surface orthogonal.**

172. Because the normals of the micro mirrors each image are exclusive of each other (*i.e.*, each image has a distinct range of normal values to "separate" the images (*see* ¶0115), **each of the sets of the micro mirrors providing the pixels for each of the differing ones of the images has a differing cone angle offset.** In other words, there is a **differing cone angle offset** for each image because the surface

normal of each image, which dictate the cone of reflected rays and cone axis, are required to be different.

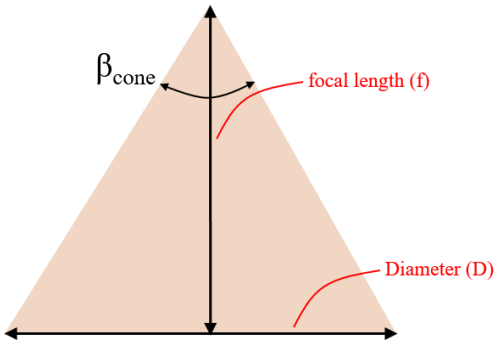
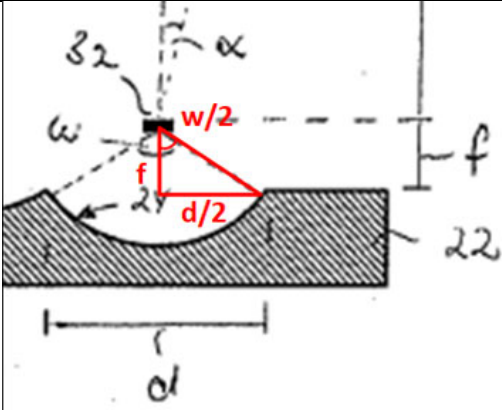
173. It should be noted that defining the **cone angle offset based upon a relative position of a cone axis to the surface orthogonal** is taught by the '691 Patent. See EX1001, 24:63-25:2 (“a particular cone angle offset (e.g., a zero offset with the cone axis being orthogonal to the planar substrate containing the mirrors)”); 22:39-42 (“a particular offset value (defining a relative offset angle and direction relative to an orthogonal or ‘0’ offset of the cone axis 1650 such as with the DX, DY, and DZ values)”); 23:57-62 (“a first cone angle offset (such as with a ‘0’ offset)”).

174. Accordingly, Fuhse262 teaches the element [1d].

(6) Claim 1, Element [1e]: *wherein the cone has a cone angle in the range of 10 to 45 degrees,*

175. In my opinion, Fuhse262 teaches element [1e].

176. Fuhse262 teaches that the pixel “cones that have an aperture ratio > 0.2 , for example an aperture ratio of 0.4.” Fuhse262, ¶¶0126, 0036, 0059 (“The opening angle ω is given by the ratio of the mirror diameter d and the focal length f , $\omega = d/f$,” which may be about 5). The cone angle β_{cone} relates to the focal length (pixel height) and diameter (of the sphere of influence) as follows:

	
Generic cone	Fuhse262, FIG. 2 (part)

177. Thus, applying fundamental trigonometry (which are also shown in in FIG. 2),

$$\frac{D/2}{f} = \tan\left(\frac{\beta_{\text{cone}}}{2}\right) \rightarrow \beta_{\text{cone}} = 2 \times \text{atan}\left(\frac{d}{2f}\right)$$

For an aperture (aperture ratio is given by $\left(\frac{d}{f}\right)$) of 0.2, as taught in Fuhse262, $\beta_{\text{cone}} = 11.42^\circ$, which is within the claimed range of 10° to 45° . For an aperture ratio of 0.4, which is the example given by Fuhse262, this would result in $\beta_{\text{cone}} = 22.62^\circ$, which is within the claimed range of 10° to 45° .

178. It should be noted that some define the aperture ratio to be $\left(\frac{d}{2f}\right)$, instead of $\left(\frac{d}{f}\right)$. In this case, Fuhse's example aperture of 0.4 would result in $\beta_{\text{cone}} = 43.6^\circ$, which is within the claimed range of 10° to 45° . In this case, an aperture ratio of

0.25 (within the range taught by Fuhse262) would result in $\beta_{\text{cone}} = 28.07^\circ$, which is within the claimed range of 10° to 45° .

179. Fuhse262 therefore teaches element [1e].

(7) **Claim 1, Element [1f]: wherein the cone angle offsets are selected whereby the cones do not overlap at a predefined height above the substrate, whereby only one of the images is observable at a time by a viewer,**

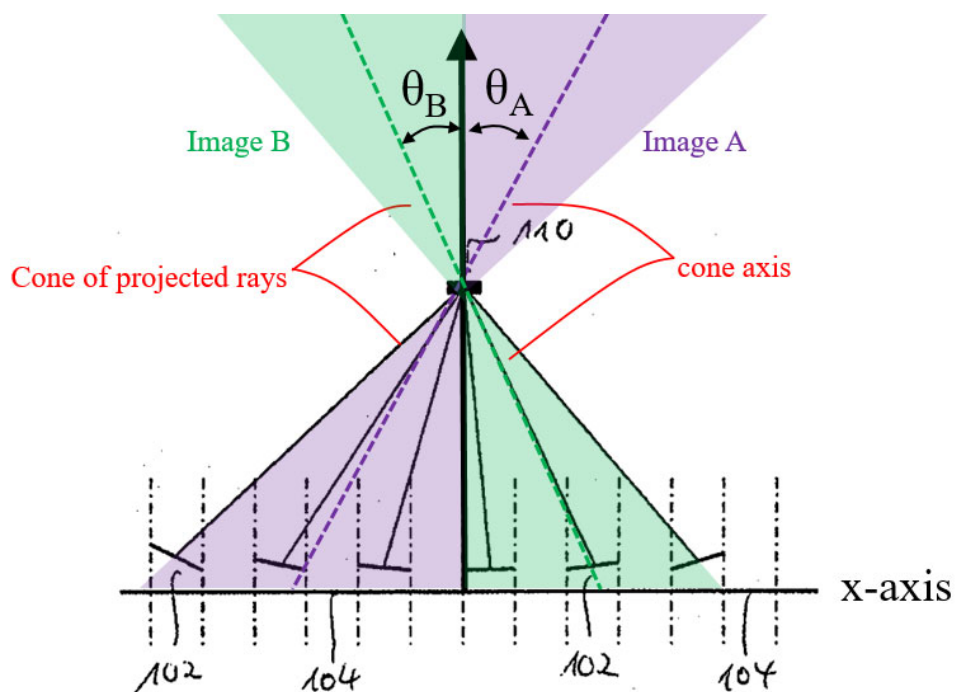
180. In my opinion, Fuhse262 teaches element [1f]. See Fuhse262, ¶¶0015, 91, 95, FIGS. 9(a), 10.

181. As previously discussed in section X.A.2.a)(4), Fuhse262 discloses that light spots of an image all float “at the same floating **height above** or below the **surface region** in order to form a backdrop motif” (pixels of each **image**). *Id.*, ¶0015 (emphasis added). Fuhse262 also discloses a micro mirror array 102 arranged such that reflected rays generate light spot 110. *Id.*, ¶¶0091, 0095, FIGS. 9(a), 10.

182. Because **the cone angle offsets are selected** by defining the normals of the micro mirrors are each image to exclusive of each other (*i.e.*, each image has a distinct range of normal values to “separate” the images (*see* ¶0115, as discussed in element [1d]), **the cones do not overlap at a predefined height above the substrate.**

183. I have reproduced below the Figures from element ([1d]). As shown, as a result of selecting mutually exclusive mirror normal range for each image, and

therefore differing cone angle offsets, **the cones do not overlap at a predefined height above the substrate** (the height of the pixels).



184. As shown in the examples, even in the case where the pixels of the different images are in the exact same place, the cones do not overlap at the height of the pixels. Fuhse262 recognizes this example (the two images may “appear alternately in the same place when the viewing direction is changed”). Fuhse262, ¶¶0118.

185. Fuhse262 also recognizes that two images may “lie next to each other.” (Fuhse262, ¶¶0118, 0027). In this case, at the common height of the two images (**a predefined height above the substrate**), all the cones of image A would reach their apex at the pixels of image A, and all the cones of image B would reach their apex at the pixels of image B, which are in different places because they are “next to each

other.” Thus, when the two images lie next to each other, the cones would also not **overlap at a predefined height above the substrate.**

186. Fuhse262 teaches that these “different images become visible to the viewer from different directions,” such that “[w]hen the arrangement is tilted sideways, the light-spot image A and the light-spot image B alternately become visible,” meaning that **only one of the images is observable at a time by a viewer.** Fuhse262, ¶¶0111-18 (multiple images may “appear alternately in the same place when the viewing direction is changed”).

187. Accordingly, Fuhse262 teaches the element [1f].

(8) Claim 1, Element [1g]: *wherein each of the sets of the micro mirrors includes at least two of the micro mirrors,*

188. In my opinion, Fuhse262 teaches element [1g]. See Fuhse262, ¶¶0091, 96, FIS. 9(a), 9(b), 10.

189. Fuhse262 discloses a plurality of micromirrors that generate a light spot 110 where micromirrors 102 form a group of micromirrors, which are all assigned to the same light spot 110 (“pixel”) and produce it together when illuminated. Fuhse262, ¶¶0091, FIGs 9(a), 9(b). As can be seen in FIGS. 9(a), 9(b) above, reflected chief rays from a plurality of micromirrors (“**at least two micromirrors**”) generate light spot 110. Further, Fuhse262 explains that the position of the mirror surfaces (the normal vector $\vec{n}$) are 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 (“**at least two micromirrors**”) assigned to light spot 110. *Id.*

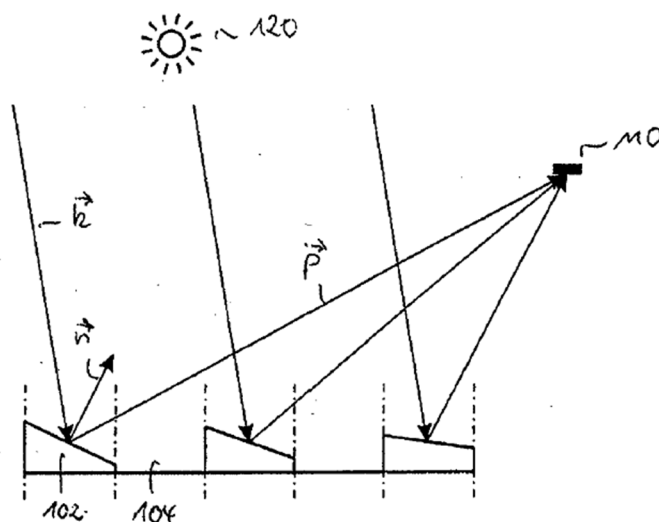
¶¶0096, FIG. 10.

190. Accordingly, Fuhse262 teaches the element [1g].

(9) **Claim 1, Element [1h]:** *wherein the reflected ambient light from the at least two of the micro mirrors intersects at the point corresponding to the one of the pixels,*

191. In my opinion, Fuhse262 teaches element [1h]. See Fuhse262, ¶0097, FIG. 10.

192. Fuhse262 discloses that the light 120 (**ambient light**) “incident from a specified direction $\vec{k}$ is reflected onto the focal point” (**intersects at the point**) “for all micromirrors 102” (**the at least two micromirrors**) “assigned to light spot 110” (**point corresponding to the one of the pixels**). *Id.*, ¶0097, FIG. 10.



Fuhse262, FIG. 10.

193. Accordingly, Fuhse262 teaches the element [1h].

(10) **Claim 1, Element [1i]:** *wherein the point on the plane corresponds to an apex of a cone and the at least two of the micro mirrors are located within a base of the cone coplanar with the surface of the substrate, and*

194. In my opinion, Fuhse262 teaches element [1i]. See Fuhse262, ¶0097, FIG. 10.

195. Fuhse262 discloses a group of micromirrors that generate a light spot 110 where “micromirrors 102 form a group of micromirrors, which are all assigned to the same light spot 110 and produce it together when illuminated.” Fuhse262, ¶0091, FIG. 8(b). Fuhse262 also discloses the light spots of an image all float “at the same floating height” (**a point on the plane**) “above or below the surface region in order to form a backdrop motif.” *Id.*, ¶¶0015.

196. Fuhse262 teaches that “every image point P_j ,” (**the point on the plane**) **corresponds to** a “cone originating from” or “emanating from” the image point (**an apex of a cone**). Fuhse262, ¶¶0036, 0126. 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” (**coplanar with the surface of the substrate**). *Id.* As discussed in element [1b], 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 [1a] (*see* element [1a]). Fuhse262, ¶¶0036, 0125-28.

197. In Fuhse262, all of the micromirrors (in this case, the **at least two of the micro mirrors**) 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 ” (**within a base of the cone**). Fuhse262, ¶¶0036, 0125-28.

198. Accordingly, Fuhse262 teaches the element [1i].

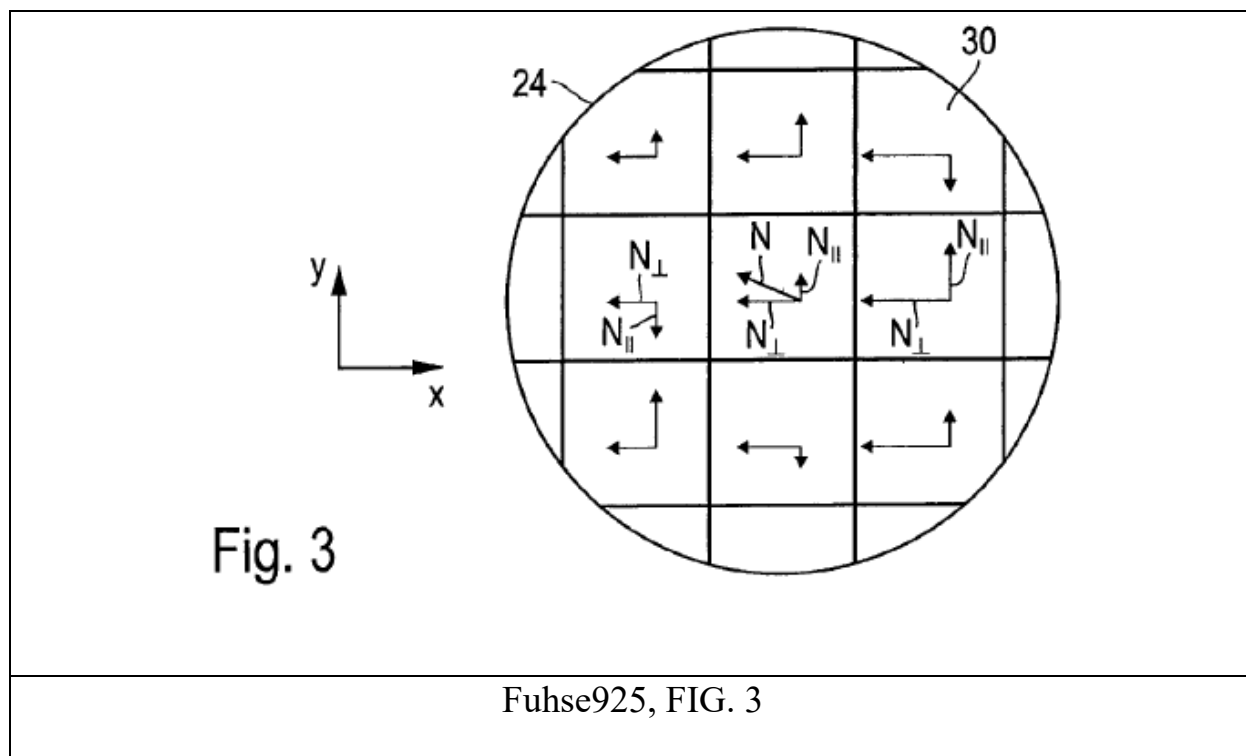
(11) **Claim 1, Element [1j]:** *wherein each of the micro mirrors in each of the sets for the micro mirrors is selected randomly from available micro mirrors in the base of the cone coplanar with the surface of the substrate, whereby each of the sets of the micro mirrors is arranged in a random pattern.*

199. In my opinion, Fuhse262 in view of Fuhse925 teaches element [1j].

200. As discussed in element [1i] directly above, all of the micromirrors in Fuhse262 (including **each of the micro mirrors in each of the sets for the micro mirrors**) is selected... **from available micro mirrors in the base of the cone coplanar with the surface of the substrate.**

201. Fuhse925 shows a depiction region 22 “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.” Fuhse925, 7:33-42. Further, “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).” Fuhse925, 7:37-42.



202. 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 (**the micro mirrors is arranged in a random pattern**). *Id.*

203. 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.*

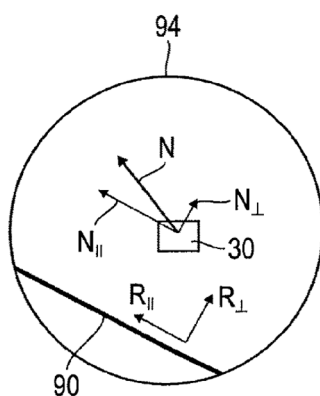


Fig. 7(b)

Fuhse925, FIG. 7(b).

204. 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 (**each of the sets of the micro mirrors arranged in a random pattern**) is such that an image of line 16 floating at depth T is visible to the observer.

205. Accordingly, Fuhse262 in view of Fuhse925 teaches the element [1j].

b) Claim 6

206. In my opinion, Fuhse262 in view of Fuhse925 teaches claim 6, as detailed below.

(1) Claim 6, Element [6Pre]: *A visual display assembly useful as a security element on paper and coin currency and on product labels, comprising:*

207. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(1) ([1Pre]).

(2) Claim 6, Element [6a]: *a substrate; and on a surface of the substrate, a plurality of micro mirrors receiving light and,*

208. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(2) ([1a]).

(3) Claim 6, Element [6b]: *in response, displaying a plurality of images in a plane a distance away from the surface of the substrate,*

209. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(3) ([1b]).

- (4) **Claim 6, Element [6c]:** *wherein the plurality of micro mirrors includes, for each of displayed pixel of each of the images, a number of the micro mirrors each having a reflective surface oriented, in a rigid manner, to reflect the ambient light toward a point on the plane corresponding to one of the pixels,*

210. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(4) ([1c]).

211. The micro mirrors are oriented **rigidly** for the same reasons the micro mirrors are oriented **in a fixed manner**. *See, supra*, Section X.A.2.a)(4). In this context the terms rigid and fixed both describe micromirrors that have a permanently fabricated shape (e.g., from embossing) for reflecting light in a single orientation (e.g., to a single pixel).

- (5) **Claim 6, Element [6d]:** *wherein each of the sets of the micro mirrors providing the pixels for each of the differing ones of the images has a differing cone angle offset, wherein the cone angle offset is defined based upon a relative position of a cone axis for a cone of rays projected through each of the pixels,*

212. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(5) ([1d]).

- (6) **Claim 6, Element [6e]:** *wherein each of the numbers of the micro mirrors includes at least two of the micro mirrors,*

213. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(8) ([1g]).

- (7) **Claim 6, Element [6f]:** *wherein the reflected ambient light from the at least two of the micro mirrors intersects at the point corresponding to the one of the pixels,*

214. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(9) ([1h]).

- (8) **Claim 6, Element [6g]:** *wherein the point on the plane corresponds to an apex of a cone and the at least two of the micro mirrors are located within a base of the cone coplanar with the surface of the substrate, and*

215. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(10) ([1i]).

- (9) **Claim 6, Element [6h]:** *wherein each of the micro mirrors in each of the sets for the micro mirrors is selected randomly from available micro mirrors in the base of the cone coplanar with the surface of the substrate, whereby each of the sets of the micro mirrors is arranged in a random pattern.*

216. In my opinion, Fuhse262 in view of Fuhse925 renders obvious the limitation. *See, supra*, Section X.A.2.a)(11) ([1j]).

c) Claim 12

217. In my opinion, Fuhse262 in view of Fuhse925 renders obvious claim 12, as detailed below.

- (1) **Claim 12, Element [12Pre]:** *A visual display assembly useful as a security element on paper and coin currency and on product labels, comprising:*

218. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(1) ([1Pre]).

- (2) **Claim 12, Element [12a]:** *on a surface of the substrate, an array of micro mirrors receiving light and,*

219. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(2) ([1a]).

- (3) **Claim 12, Element [12b]:** *in response, displaying images; wherein each of the images comprises a plurality of pixels,*

220. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(3) ([1b]).

- (4) **Claim 12, Element [12c]:** *wherein the array of micro mirrors includes, for each of the pixels of the images, a set of the micro mirrors each having a reflective surface oriented to reflect received light toward a point on a plane corresponding to one of the pixels,*

221. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(4) ([1c]).

- (5) **Claim 12, Element [12d]:** *wherein each of the sets of the micro mirrors providing the pixels for each of the images has a differing cone angle offset,*

222. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(5) ([1d]).

- (6) **Claim 12, Element [12e]:** *wherein each of the sets of the micro mirrors includes at least two of the micro mirrors,*

223. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(8) ([1g]).

- (7) **Claim 12, Element [12f]:** *wherein the reflected received light from the at least two of the micro mirrors intersects at the point corresponding to the one of the pixels,*

224. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(9) ([1h]).

- (8) **Claim 12, Element [12g]:** *wherein the point on the plane corresponds to an apex of a cone and the at least two of the micro mirrors are located within a base of the cone coplanar with the surface of the substrate,*

225. In my opinion, Fuhse262 teaches this element. *See, supra*, Section X.A.2.a)(10) ([1i]).

- (9) **Claim 12, Element [12h]:** *wherein the images comprise two or more frames of an animated clip, whereby a viewer observes animation when viewing two or more of the images associated with the two or more frames,*

226. In my opinion, Fuhse262 teaches this element. *See, infra*, Section X.A.2.d)(1) (claim 4).

- (10) **Claim 12, Element [12i]:** *wherein the animation is in both the X axis and in the Y axis, and*

227. In my opinion, Fuhse262 teaches this element. *See, infra*, Section X.A.2.d)(2) (claim 5).

- (11) **Claim 12, Element [12j]:** *wherein each of the micro mirrors in each of the sets for the micro mirrors is selected randomly from available micro mirrors in the base of the cone coplanar with the surface of the substrate, whereby each of the sets of the micro mirrors is arranged in a random pattern.*

228. In my opinion, Fuhse262 in view of Fuhse925 renders obvious the limitation. *See, supra*, Section X.A.2.a)(11) ([1j]).

d) Dependent Claims

- (1) **Claim 4:** *The assembly of claim 1, wherein the images comprise two or more frames of an animated clip, whereby a viewer observes animation when viewing two or more of the images associated with the two or more frames.*

229. In my opinion, Fuhse262 renders this claim obvious.

230. As previously discussed in section X.A.2.a)(7) (Ground 1, element [1f]), Fuhse262 teaches that these “different images become visible to the viewer from different directions,” **(the images comprise two or more frames of an animated clip)** such that “[w]hen the arrangement is tilted sideways, the light-spot image A and the light-spot image B alternately become visible,” meaning that **a viewer observes animation when viewing two or more of the images associated with the two or more frames.** Fuhse262, ¶¶0111-18 (multiple images may “appear alternately in the same place when the viewing direction is changed”).

231. As shown in element [1.f], when an observer tilts the device, or moves across the plane of the device, the viewer will see the images in rapid succession in the form of an animation. As discussed in ¶¶0111-16, the normals for each images may be defined to be non-overlapping but in adjacent ranges, meaning that the images will appear in rapid succession of each other.

232. Each image is a distinct image that appears “alternatively,” so each image corresponds to a **frame**. This agrees with the ’691 Patent, which consistently, and almost exclusively, refers to an “image/frame.” ’691 Patent, 22:34-28:11

233. Accordingly, a POSITA would be able to **observe animation when viewing two or more images** by changing the viewing angle.

234. Accordingly, Fuhse262 teaches claim 4.

(2) Claim 5: *The assembly of claim 4, wherein the animation is in both the X axis and in the Y axis.*

235. In my opinion, Fuhse262 renders this claim obvious.

236. As previously discussed in Section X.A.2.d)(1) (claim 4 above), Fuhse262 teaches that these “different images become visible to the viewer from different directions,” such that an animation is formed when tilting the device.

237. Fuhse262 teaches that **the animation is in both the X axis and in the Y axis**. In particular, Fuhse262 teaches an **animation is in the X axis** in which the “x component n_x ” of the micromirrors are controlled to display the multiple images “alternatively” “[w]hen the arrangement is tilted sideways” (see ¶0112-13), and also

teaches an **animation is in the Y axis** in which the “the y-component of the normal vector n_y ” of the micromirrors are controlled to display the multiple images successively “when tilted vertically” (see ¶0114-15).

238. A POSITA would also understand that the tilting does not need to be strictly confined to a line along the z or y axis, but could be along other lines, such as $y=x$. In this case, **the animation is in both the X axis and in the Y axis**.

239. Accordingly, Fuhse262 renders obvious claim 5.

(3) ***Claim 7: The assembly of claim 6, wherein the cone has a cone angle in the range of 10 to 45 degrees and wherein the cone angle offsets are selected whereby the cones do not overlap at a predefined height above the substrate.***

240. In my opinion, Fuhse262 renders obvious the claim. *See, supra*, Sections X.A.2.a)(6) and X.A.2.a)(7).

(4) ***Claim 10: The assembly of claim 6, wherein the images comprise two or more frames of an animated clip, whereby a viewer observes animation when viewing two or more of the images associated with the two or more frames.***

241. In my opinion, Fuhse262 renders obvious the claim. *See, supra*, Section X.A.2.d)(1).

(5) ***Claim 11: The assembly of claim 10, wherein the animation is in both the X axis and in the Y axis.***

242. In my opinion, Fuhse262 renders obvious the claim. *See, supra*, Section X.A.2.d)(2).

B. Ground 2: Fuhse262 in view of Fuhse925 and Jordan renders obvious claims 1, 4-7 and 10-12

1. Combined Teachings of Fuhse262, Fuhse925, and Jordan

a) Motivation to Combine

243. In my opinion, a POSITA would have been motivated to combine Fuhse262 and Fuhse925 in further view of Jordan, in order to maximize the utility and applications of the invention. While Fuhse262 describes its invention may be applicable to any “data carrier,” it does not explicitly list all of its application. One would have been motivated to look at other references, including Jordan, to find additional data carriers for additional applications to increase the usage and versatility of the security element.

b) Reasonable Expectation of Success

244. In my opinion, one would have had a reasonable expectation of success in implementing the combination of Fuhse262, Fuhse925, and Jordan. The art was relatively predictable in the relevant timeframe (2015). One would have been able to implement the obviousness modifications in this ground without difficulty.

245. Because coin currency and product labels were known in the art as useful applications of OVD technology, a POSITA would have routinely recognized that Fuhse262 would be “useful as a security element” for those applications.

2. Application to the Challenged Claims

246. In my opinion, Fuhse262 in view of Fuhse925 and Jordan teach the limitations of claims 1, 4-7 and 10-12.

247. *See, supra*, Section X.A (Ground 1). Jordan has been used for the preamble and only different elements are addressed below. Otherwise, the positions in Ground 1 apply.

a) Claim 1, Element [1Pre]: *A visual display assembly useful as a security element on paper and coin currency and on product labels, comprising:*

248. To the extent not taught by Fuhse262 and Fuhse925, Fuhse262 in view of Fuhse925, in combination with Jordan teach this element. Jordan, Abstract, ¶¶0013, 0002-04, 0113-14, 0124-25, 0154, 0159, 0174-77.

249. Jordan teaches methods of using arrays of reflective microstructures that produce images “as a security and anti-counterfeiting feature to identify and distinguish authentic products from counterfeit products,” such as “banknotes” or “coinage,” as well as “product marking and labeling” and “packaging.” Jordan, Abstract, ¶¶0013, 0002-04, 0113-14, 0124-25, 0154, 0159, 0174-77.

b) Claim 6, Element [6Pre]: *A visual display assembly useful as a security element on paper and coin currency and on product labels, comprising:*

250. *See* Section X.B.2.a).

c) Claim 12, Element [12Pre]: *A visual display assembly useful as a security element on paper and coin currency and on product labels, comprising:*

251. *See* Section X.B.2.a).

C. Grounds 3 and 4: (Ground 3) Fuhse262 in view of Fuhse925, and Fuhse172 render obvious claims 3, 9, and 13; (Ground 4) Fuhse262 in view of Fuhse925, Jordan, and Fuhse172 render obvious claims 3, 9, and 13

1. Combined Teachings of Fuhse262, Fuhse925, (Jordan (for Ground 4)) and Fuhse172

a) Motivation to Combine

252. In my opinion, it is obvious to apply the teachings of Fuhse172 to Fuhse262. Fuhse262 and Fuhse172 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. Fuhse262, Abstract; Fuhse172, Abstract.

253. One reviewing Fuhse262 would have looked to Fuhse172. Fuhse262 teaches that its micromirrors may be provided with “a thin-film element with a color-shifting effect” (Fuhse262, ¶0032), or are included with “layer systems that show a color change when tilted.” Fuhse262, ¶0034. However, Fuhse262 does not provide explicit detail on how to implement those thin-films or layers, such as what materials to use, in order to provide color-shifting. Fuhse172, however, *does* provide that explicit detail.

254. Fuhse172 further teaches that dielectric materials may be used to provide color-shifting. *See* Fuhse172, ¶¶0118, 0027-29. It would therefore have been obvious to examine how thin-films or layers are implemented to achieve color-shifting when reviewing Fuhse262.

255. Fuhse925 provides explicit detail for implementing what Fuhse262 teaches, namely that dielectric materials may be used to provide a thin-film color-shifting effect.

256. Additionally, using Fuhse172's teachings regarding thin-film dielectrics in Fuhse262's system would have involved using a known technique to improve Fuhse262 in a known way, without unpredictable results, and would thus also have been obvious.

b) Reasonable Expectation of Success

257. In my opinion, a POSITA would have had a reasonable expectation of success in implementing the combination of Fuhse262 and Fuhse172. As a POSITA would have recognized, the structures of Fuhse262 and Fuhse172 are similar and compatible. Like the Fuhse262, Fuhse172 provides reflective facets for security elements that reflect light to produce images. Fuhse172, ¶¶97-98, Abstract. Like Fuhse262's teaching to use "50µm x 50µm" size for the mirrors (Ex. 1005 (Fuhse262), ¶0087), Fuhse172 teaches to use edge lengths of its facets "in the range between 20 and 100 µm." Fuhse172, ¶98.

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

2. Application to the Challenged Claims

259. In my opinion, Fuhse262, et al, (whether in Grounds 1 or 2) in view of Fuhse172 teaches claims 3, 9, and 13.

260. *See, supra*, Section X.A (for Ground 1 which applies to Ground 3) and Section X.B (for Ground 2 which applies to Ground 4)..

a) Claim 3

(1) Claim 3, Element [3a]: *The assembly of claim 1, wherein the micro mirrors are configured to display the images in at least two colors and*

261. In my opinion, Ground 1 references or Ground 2 references renders this element obvious.

262. As an initial matter, **the micro mirrors are configured to** reflect visible light to **display the image**. If the ambient light is white, the image will also be white. If the ambient light is another color, the image will also be that color.

263. To the extent it could be argued that this claim requires the image be displayed with particular colors with certain wavelengths (i.e., red, green, etc.) in response to white light illumination, Fuhse262 satisfies this interpretation in two ways.

264. First, Fuhse262 teaches that its invention can be “combined with other security features,” such as “layer systems that show a color change when tilted.” Fuhse262, ¶0034. As discussed, one of these tilting angles corresponds to **the image**

(see, *supra*, e.g., Section X.A.2.d)(1) (claim 4)), so in this case, the image would show a color change when tilted.”

265. Second, Fuhse262 teaches that its micromirrors may be “designed as embossed structures in an embossing lacquer layer” that are provided with “a thin-film element with a color-shifting effect.” Fuhse262, ¶0032. Because the thin film provides “color-shifting” of the reflected light of **the micro mirrors, the image is display[ed] with the colors** that the film shifted to.

(2) **Claims 3, Element [3b]: *wherein at least one of ink, plasmonic resonance, and dielectric coating is used to configure the micro mirrors to display the image with the colors.***

266. In my opinion, Ground 1 references or Ground 2 references and further in view of Fuhse172 renders this element obvious. See Fuhse172, ¶¶0118, 0027-29.

267. Fuhse172 discloses that in order “to apply a color-shifting coating, in particular a thin-film system, to the facets,” the thin-film system can have for example a first, a second and a third **dielectric** layer which are formed one on the other.” Fuhse172, ¶¶0118, 0027-29. This “dielectric layer” is a **dielectric material** that is **used to configure the micro mirrors to display the image with the colors.**

268. Fuhse172 further discloses that while three dielectric layers may be used, a combination of dielectric layers and metal layers may also be used:

“In a further embodiment, there can be formed on the facets at least in certain regions a color-shifting coating. The color-shifting coating can be configured in particular as a thin-film system or thin-film

interference coating. There can be realized here e.g. **a layer sequence of metal layer—dielectric layer—metal layer or a layer sequence of three dielectric layers**, whereby the refractive index of the middle layer is lower than the refractive index of the two other layers. **As a dielectric material there can be employed e.g. ZnS, SiO₂, TiO₂/MgF₂.**”

Fuhse172, ¶0027.

269. Further explains that for color-shift effects, the “thin-film system” may be “constructed of reflector, dielectric, absorber (formed on the facets in this order),” or “facet/absorber/dielectric/reflector.” Fuhse172, ¶¶0028-29.

270. In each of these cases, the dielectric is a **dielectric material** that is **used to configure the micro mirrors to display the image with the colors.**

b) Claim 9

(1) Claim 9, Element [9a]: *The assembly of claim 6, wherein the micro mirrors are configured to display the images in at least two colors and*

271. In my opinion, Ground 1 references or Ground 2 references and further in view of Fuhse172 renders this element obvious. *See, supra*, Section X.C.2.a)(1).

(2) Claim 9, Element [9b]: *wherein at least one of ink, plasmonic resonance, and dielectric coating is used to configure the micro mirrors to display the image with the colors.*

272. In my opinion, Ground 1 references or Ground 2 references and further in view of Fuhse172 renders this element obvious. *See, supra*, Section X.C.2.a)(2).

c) Claim 13

- (1) **Claim 13, Element [13a]: *The assembly of claim 12, wherein the micro mirrors are configured to display the images in at least two colors and***

273. In my opinion, Ground 1 references or Ground 2 references and further in view of Fuhse172 renders this element obvious. *See, supra*, Section X.C.2.a)(1).

- (2) **Claim 13, Element [13b]: *wherein at least one of ink, plasmonic resonance, and dielectric coating is used to configure the micro mirrors to display the image with the colors.***

274. In my opinion, Ground 1 references or Ground 2 references and further in view of Fuhse172 renders this element obvious. *See, supra*, Section X.C.2.a)(2).

XI. SECONDARY CONSIDERATIONS

275. 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

276. For the foregoing reasons, I am of the opinion that claims 1, 3-7 and 9-13 of the '691 patent would have been obvious based on the prior art cited herein.

Declaration of Prof. Lambertus Hesselink, Ph.D.

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, 2024__

Respectfully Submitted



Prof. Lambertus Hesselink, Ph.D.