

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Cimbria Srl,

Petitioner

v.

3U Vision SRL,

Patent Owner

Patent 11,666,947

Post Grant Review No.

PGR2024- 00018

DECLARATION OF DAVID SCHAAFSMA, PH.D.

Exhibit 1009

I. INTRODUCTION

1. My name is David Schaafsma. I have been retained as an expert on behalf of Cimbria SRL (“Cimbria” or “Petitioner”).

2. I have written this report on behalf of Petitioner to provide my expert opinion regarding technical aspects of US Patent 11,666,947 (hereinafter “’947 Patent”) and prior art references cited in the Petition for Post Grant Review (hereinafter “Petition”), and historical background of the related technology.

3. I reserve the right to supplement or amend my opinions, and bases for them, in response to any additional evidence, testimony, discovery, argument, and/or other additional information that may be provided to me after the date of this report.

4. I am being compensated for my time spent working on this matter at my normal consulting rate of \$630 per hour, plus reimbursement for any additional reasonable expenses (\$300 per hour for travel time). My compensation is not in any way tied to the content of this report, the substance of my opinions, or the outcome of this proceeding. I have no other interests in this proceeding or with any of the parties.

5. All of the materials that I considered are discussed explicitly in this declaration.

II. QUALIFICATIONS

6. I am currently president and principal of California Optical Engineering, Inc. I obtained a Master of Science in Physics from Brown University in 1989 and a Ph.D. in Physics from the University of Colorado of Boulder in 1996. Over the last 30 plus years, I have held various positions and have diverse experience in the fields of optical systems, microscopy, fluorescence & spectroscopy, optical materials, lasers, optoelectronics, sensors, control systems, infrared technology, and data acquisition. I was first employed as a research engineer in 1984 and have been involved in the above-mentioned fields ever since.

7. I have also spoken about many topics at professional venues such as conferences, to potential clients and corporate offices of large companies, as well as to classes of students. I have written numerous publications in various areas of expertise related to optical technology. I have worked for both large and small industrial clients, developing sensing and control systems in a wide range of applications from industrial processes to in-vitro and in-vivo diagnostics. At the Naval Research Laboratory, I worked on infrared technology and materials spanning the near, short, mid, and far infrared (1-10 μm), and have continued to work on infrared applications since then.

8. My full curriculum vitae is attached hereto as Exhibit 1016.

III. PRELIMINARIES

Scope of this declaration. I am not an attorney and will not offer opinions on the law. I am, however, rendering my expert opinion on technical aspects of the '947 Patent, prior art referenced by the Petition, and historical background of the related technology.

IV. HISTORICAL BACKGROUND OF THE RELATED TECHNOLOGY

9. Optical sorting and separation technology has a very long history that spans numerous industries, with a genesis in agriculture. Food sorting dates to roughly the 1930s, while other solid materials such as metals were sorted optically starting in the 1960s. In the 1990s, optical sorting was applied to waste streams; I collaborated at the time with a company that made spectrometers for mid-infrared systems for sorting different plastics in recyclable waste streams. Many of the same principles are applied to flow cytometry (using optical methods as early as 1968 [Goehde]), where different cells are sorted according to optical characteristics. Infrared emission spectroscopy itself dates to the early 1900s [Coblentz], and the field has long been championed by firms such as Beckmann-Coulter, Perkin-Elmer, and Baird.

10. In the food industry, an example is provided by Satake, who (as the Electric Sorting Machine Company), first commercialized a color bean sorting

machine in 1932 (Exhibit 1011). Satake's timeline indicates that they developed an infrared sorter as early as 1986, and this is consistent with other literature on the state of the art at the time.

11. Another example is provided by the MSS company, which developed magnetic separation technology for metals starting in the 1970s and then in the 1990s made a near-infrared system for sorting plastics from mixed recycling streams (www.mssoptical.com/about/history, Exhibit 1012). As I mentioned above, in the 1990s I worked with a company that made acousto-optic tunable filters for IR spectroscopy, used in waste sorting systems, so I can personally attest that this technology was available at the time.

12. I believe the product histories shown on the Satake (Exhibit 1011) and MSS (1012) websites to be consistent with the state of the art at the various times in their timelines, though I have not attempted to independently verify the claims of either website.

V. SUMMARY OF LITERATURE CITED

13. The literature is likewise replete with examples of this technology. Of particular relevance, the Pearson paper (Exhibit 1013) discusses a fully automated system, using three visible spectrum LEDs and three NIR spectrum LEDs, to make a multispectral sorting device functionally identical to the selector machines

disclosed by the '947 Patent. The striking similarities – including 3 IR sources, sequential illumination, and the significance of the IR bands - between the multispectral sorting device of the Pearson paper and the selector machines disclosed in the '947 Patent show that selector machines similar to those of the '947 Patent were known in the art at least as early as the 2013 publication date of the Pearson paper.

14. The review article by ElMasry et al.¹ discusses the state of the art in optical sorting machines for agricultural applications, including multispectral and hyperspectral imaging. In particular, ElMasry et al. show that practitioners in the field knew the value of multispectral imaging as discussed in the '947 Patent, as well as the value of infrared spectral data for evaluating agricultural products at least by the 2019 time frame (and in many cases, much earlier).

15. The patent of Lane² is a 1985 invention showing that the basic architecture of the machine described in the '947 Patent, along with the value of infrared multispectral data, was known at that time.

¹ 1. G. ElMasry, N. Mandour, S. Al-Rejaie, E. Belin, D. Rousseau, “Recent Applications of Multispectral Imaging in Seed Phenotyping and Quality Monitoring—An Overview,” Sensors 2019 (EX1002).

² US Patent 4,558,786 (EX1003)

16. The patent of Gray et al.³ shows a similar optically-based sorter for agricultural use that uses multichromatic sorting principles of the type described by the ‘947 Patent.

17. The patent of Adams et al.⁴ describes a multispectral imaging system for use in sorting agricultural products, similar to the embodiments described in the ‘947 Patent.

18. The patent of Hagiwara et al.⁵ is a system that uses multispectral infrared imaging to evaluate objects and translates the infrared data into a false-color visible image, essentially a more descriptive version of the concept enumerated in the ‘947 Patent for making a false-color image. The method of Hagiwara describes hardware and algorithms for making the false-color images based on user-defined sensitivity characteristics.

19. Gerken et al.⁶ describe a multispectral imaging system in the “shortwave infrared band from approximately 900 nm to approximately 1700 nm” which corresponds to the preferred wavelength embodiment of the ‘947 Patent

³ US Patent 5,508,512 (EX1006)

⁴ US Patent 9,795,996 (EX1005)

⁵ US Patent 10,911,731 (EX1007)

⁶ UK Patent Application GB2578180 (EX1004)

(and dependent claim 2). Gerken also describes the use of InGaAs image (“two-dimensional”) sensors for sensing in the shortwave IR band, as described by the ‘947 Patent. These InGaAs image sensors could be used in the multispectral imaging systems discussed in ElMasry, and were used in similar systems, to detect short-wave infrared (SWIR) wavebands without altering the principle of operation of the multispectral imaging systems of ElMasry or of the InGaAs image sensors of Gerken.

20. Darty et al.⁷ further describe a method for translating spectral image data, based on spectral information extracted from regions of interest (ROI) in a larger image, into false-color images that represent spectral signatures or other relevant information (e.g. water and melanin in skin). Again, this is a more detailed and functional description of the false-color imaging concept presented in the ‘947 Patent. Although the context of the spectral imaging taught by Darty is in taking measurements of a patient in a medical setting (see Exhibit 1008, ¶ [0044]), some of the spectral imaging equipment would be similar or the same to that of ‘947 Patent, especially because Darty discusses using near infrared light (see Exhibit 1008, ¶ [0106]). Darty also discusses spectral sensitivity to water in a region of interest of a patient (Exhibit 1008, ¶¶ [0018], [0027], [0099], [0100],

⁷ US Patent Publication 2020/0088580 (EX1008)

[0104], [0128], and [0146]), which is also of interest in spectral imaging in sorting of agricultural/food products such as seeds (see Exhibit 1002, pages 21-22). As a result, light sources, optical sensors, and other optics relevant to the near infrared spectral imaging applications of Darty would be pertinent to the selector machines of the '947 Patent, which also use near infrared light.

VI. LEVEL OF ORDINARY SKILL IN THE ART

21. In my experience with technology similar to the selector machines of '947 Patent, the level of ordinary skill in the art at the time of the invention was a Bachelors degree in Physics, Electrical Engineering, Chemistry, or an equivalent field, as well as at least 2—3 years of academic or industry experience in engineering related to optical sorting systems and infrared spectroscopy.

VII. TECHNICAL COMMENTARY ON '947 PATENT TECHNOLOGY AND THE PRIOR ART

22. One of the purposes of differentiating between samples in an image as discussed on page 5 of ElMasry (Exhibit 1002), is sorting. (“The decreasing cost and increasing power of ... software packages for image processing have made image analysis systems more attractive in automatic inspection of different aspects of quality evaluation and sorting processes”). This appears to be one of the main

themes of ElMasry, as indicated in the penultimate sentence: “it is anticipated that the multispectral imaging technique can be moved from laboratories to practical applications in the form of real-time seed monitoring systems that meet the requirements of the modern industrial control and sorting systems” (Exhibit 1002, p. 26). One of ordinary skill in the art would know that a computer such as the pre-programmed microcontroller and computer combination taught by ElMasry (see Exhibit 1002, Figure 3) would be used to generate the control signals to control an expulsion device such as the robotic picking, pneumatic, or mechanical gate system taught by ElMasry (Exhibit 1002, page 25). The basic architecture proposed in the ‘947 Patent is by no means new.

23. The patent claims and specification refer to the “shortwave infrared” band of the electromagnetic spectrum. As a matter of technical import, the precise definition of the SWIR and NIR (and MIR/MWIR, LIR/LWIR) bands in fact varies among sources in the literature; ISO 20473 defines “near-infrared” as wavelengths between 780 nm and 3 μm [ISO 20473, 2007], while the International Commission on Illumination (CIE) defines IR-A as wavelengths between 780 nm and 1400 nm, and IR-B as wavelengths from 1400 to 3000 nm. Similiar contradictory conventions exist in astronomy, telecommunications and IR sensing. The ‘947 patent clarifies the spectral range as “substantially comprised between 900 nm and 2200 nm” (7:29-30), which is substantially similar to the wavelength range of the

LEDs used by Pearson et al., and found in several of the references cited by ElMasry et al. I can attest from decades of experience that terms like “shortwave infrared” do not connote a precise (only approximate) wavelength range to knowledgeable practitioners.

24. The authors of ‘947 Patent claim the prior art comprises selector machines where “the optical sensor is constituted by a hyperspectral video camera” (Exhibit 1001, 2:2-3) and that hyperspectral cameras are “unable to acquire images with high resolution, since the pixel matrix of the video camera is separated into multiple sectors, each of which associated with the corresponding optical filter” (Exhibit 1001, 2:41-44). This is not necessarily the case. Hyperspectral imaging systems often used acousto-optic tunable filter (AOTF) or similar imaging devices to separate the wavelength bands of the image prior to detection by a (potentially high density) sensor array (this is described by ElMasry et al. and I can attest to it from personal experience). In addition, as the Pearson, ElMasry, and Hagiwara references show, the technique of multispectral imaging using more limited spectral information was well known prior to the ‘947 Patent. Indeed, multispectral and hyperspectral imaging systems have long been distinguished by having fewer (multi) or more (hyper) spectral bands.

25. The authors further state that it is an object of the invention to “provide a selector machine, which operates in an efficient manner, in particular

without having to execute heavy computational processing by the electronic control unit” (Exhibit 1001, 2:57-58). Notwithstanding that the state of the art in 2023 might render such concerns moot, there are adequate descriptions of multispectral systems, both imaging and non-imaging, in the pre-2020 literature cited herein that could easily be considered not to require “heavy computational processing.” Indeed, even ElMasry et al. note that “[b]ecause hyperspectral cameras are expensive and not suited for high throughput testing,” “most of the research works using hyperspectral imaging systems were basically conducted in the hope of developing a multispectral imaging system” (Exhibit 1002, p.25).

26. ElMasry et al. also teach that “real-time operations are very complicated processes that require acquisition of images at several bands and process such images simultaneously,” “discarding the unnecessary wavelengths that add complexity of the model and reduce its efficiency,” and “using fewer wavebands in multispectral imaging designs can lead to faster sensor systems, thus reducing total integration time and increasing the number of samples inspected per second” (Exhibit 1002, p. 26). ElMasry also teaches that “[a]s a mean[s] of simplicity, any three of these grey sub-images (slices) ... (one slice for each color channel)” could be used to “form a pseudo-color image for the target sample ...” (Exhibit 1002, p. 10). Thus, a POSITA would have known that in a rubric where three grey sub-images are mapped to the three RGB color channels, taking

extraneous and unnecessary bands beyond the three mapped to the RGB color channels would not have any advantages, and would in fact be disadvantageous because doing so would reduce its efficiency, increase integration time, and decrease the number of samples inspected per second (see Exhibit 1002, p. 26). Adams teaches using three spectral bands, and the principle of sequential illumination operation of the imaging system of ElMasry is the same as that of Adams. Accordingly, combining teachings of Adams with those of ElMasry would not change their principles of operation. In my view, the '947 Patent's comparison of the proposed multispectral system as an improvement to existing hyperspectral systems must be either naive or disingenuous, given that the authors claim familiarity with this field of art. In any event, it is evident to me that a POSITA would have known that a) hyperspectral imaging methods can be adapted to multispectral imaging, b) taking images in fewer wavelength bands would result in a higher aggregate sampling rate, and c) taking extraneous or unnecessary data does not have any advantages.

27. It is evident in all the literature cited (including ElMasry) that it was understood that an optical sorting system would include a module for illumination, a means of measuring optical signals, and a control unit such as a computer, microcontroller, and/or other processor that would be used to emit control signals to control robotic picking, pneumatic, or mechanical gate systems. The '947

Patent does not elucidate the structure of the “electronic control unit” other than to describe that it comprises a “processing module” or “electronic processor,” though it does describe some of the functionality encompassed by the electronic control unit. Given the descriptions of the specification and the general state of knowledge in the 2020 time frame, a POSITA would have understood such an “electronic control unit” to convey a category of devices including microcontrollers, field-programmable gate arrays (FPGAs), microprocessors, or similar device(s) loosely sharing some common functionality (e.g., reading data from sensors and generating control outputs, i.e. controlling a system). The structure and components of these devices can vary widely. Accordingly, their inclusion in the “electronic control unit” category depends more on common functional similarities than on structural similarities. A name for a device category that is defined loosely by common functionality (e.g., reading data from sensors and generating control outputs, controlling a system) of the devices belonging to the category would not have been understood to a POSITA to convey a definite structure. Rather, a name that identifies a category of devices that loosely share common functionality would have primarily conveyed functionality, not a definite structure, to a POSITA.

28. As noted in the Petition, the “at least one thresholding software, per se of known type ... ,” referenced in the ’947 Patent (Exhibit 1001, 6:9-15) does not have the capability of performing all the functions ascribed to the electronic

control unit by itself. Indeed, this software would comprise only a part of an electronic control system with the functionality described in the patent. Thus, at best the description in the '947 Patent of the "electronic control unit" is a known category of devices loosely sharing some common functionality, though varying in structure and components.

29. As an example, a thresholding algorithm might identify regions of say, seeds, that have a particular size, shape, color, etc. and pass this information along to a decision making algorithm to make decisions on how to sort them. A decision making algorithm is necessarily a distinct part from the thresholding algorithm. Yet further, another algorithm, distinct from the thresholding algorithm, is required to actually generate the signals that actuate mechanisms for an expulsion device, such as an air jet (as described in the prior art). ElMasry et al. (Exhibit 1002) describe the use of microcontrollers or similar systems to control the data acquisition, processing (e.g. thresholding functions), and potentially control signals. Likewise, Fig. 2 of the Pearson paper (Exhibit 1013) shows a control system based on discrete logic for controlling a "solenoid air valve," and similar descriptions are found in Lane (Exhibit 1003) and Adams (Exhibit 1005). Given that the prior art comprises over 40 years of development of automated optical sorting systems, it would have been unsurprising to a POSITA in 2020 to find computerized automation at the heart of the system. But thresholding

software itself is not capable of making a decision as to which items to remove from the advancement path or of generating control signals to drive operation of an expulsion device. Rather, separate algorithms would be required and the '947 Patent does not provide algorithms for performing these functions.

30. Nor would a POSITA be unfamiliar with the concept of performing control functions such as turning on and off LEDs using a microcontroller- or microprocessor-based system. I taught such techniques, in fact, at the undergraduate level from 2006-2022, and have used them many times in product development projects. ElMasry et al. (Exhibit 1002) give an example of this concept in an agricultural multispectral imaging application shown in Fig. 3, which is based on a commercially-available system made by Videometer Lab Company (Hørsholm, Denmark).

31. I note that the operating principle of the “expulsion device” illustrated by the '947 Patent is a forced air mechanism, which causes rejected material to be blown out of the falling path of the product. This exact mechanism is described by Pearson et al. using a “solenoid air valve” that “diverted the kernels with a short blast of air” (Exhibit 1013, p. 49, Pearson’s solenoid air valve is referenced by ElMasry et al. at p. 18), and by Gray et al., who describe “(a)n ejector 36 located underneath and adjacent optical sensor means 20 ... actuated by the actuation electrical signal just mentioned to produce an air blast to remove the unwanted

substandard product from the flow of products in the stream” (Exhibit 1006, 4:18-22). Lane describes a concept where “an air supply is provided to the pneumatic valve 33, so that when the reject pulse actuates the coil 32, a pulse of pressurized air is passed to the reject mechanism 34. Unripe tomatoes 39 and inorganic extraneous materials 41 are actively removed from the object stream by a pneumatically actuated reject rod 37” (Exhibit 1003, 11:1-7). Adams et al. employ “an air ejector of traditional design ... which removes predetermined products from a product stream through the release of pressurized air” (Exhibit 1005, 14:9-11). ElMasry et al. discuss “robotic picking or some kind of pneumatic or mechanical gate system” (Exhibit 1002, page 25) as well as a “pneumatic system in which an air valve diverted the wheat kernels to the classification assignment” (Exhibit 1002, page 18). Pearson et al., Gray, Lane, Adams, and the work discussed in ElMasry et al. all use an optical sensor mechanism for evaluating the product, which in all cases is connected to the expulsion device. Given that no new mechanism is described by the ‘947 Patent, a POSITA would simply refer to the prior art for designs and description of this element.

32. The ‘947 Patent also lays claim to an architecture where “emitter device(s)” are arranged to emit radiation “adapted to hit said at least one product.” Given that the technology area of the patent is automated optical sorting, and that illumination is a well understood aspect of this technology, it stands to reason that

a POSITA would have comprehended fully that such a system would be doomed to failure were its emitters not “adapted to hit said at least one product.” Fig. 1 of Lane (Exhibit 1003), Fig. 1 of Adams (Exhibit 1005), Figs. 1 & 2 of Gray et al. (Exhibit 1006), the discussion of prior art by ElMasry et al. (notably Exhibit 1002, p. 18), and the admittedly known optical emitters discussed at 1:50-52 of the ’947 Patent all demonstrate how fundamental this aspect is to optical sorting. In order to optically interrogate a sample for sorting, the light from the system must hit the sample.

33. It would have been similarly obvious to a POSITA that some element of diversion or expulsion is required to make an optical sorter, and a POSITA would have been familiar with extant prior art examples of this architecture such as Lane, Adams, Gray, and ElMasry. In the case of ElMasry, a POSITA would have understood that the computer and microcontroller combination of FIG. 3 would be capable of generating control signals to drive operation of an expulsion device. Given that the ’947 Patent does not describe any new system for detection, control systems, or expulsion devices (and certainly not advancement paths), a POSITA would have simply referred to the prior art for substantive description of this element.

34. Likewise, the claim language describing a bandpass filter positioned between the scanned object and the optical sensor is simply a statement of well-

known practice in optics. Mounting a filter on the optical sensor was a well-known subset of positioning a bandpass filter between the scanned object and the optical sensor. Many camera lenses of the time for industrial applications were even made to have specialized filters screwed onto the lens assembly. ElMasry's red, green, and blue-passing light filters on the image sensor of a mono CCD camera (Exhibit 2, p. 6) and Hagiwara's NIR Bayer array filter on the image sensor (Exhibit 1007, 4:54-56 and 4:62-64) are examples of bandpass filters positioned on the image sensor. In order to spectrally filter reflected light from an object, the filter must be in the optical path upstream of the sensing device. In any other configuration, the system does not work as intended since the reflected light will not be filtered. Examples are given by ElMasry et al. (Exhibit 1002, Fig. 2 & pp. 8-9) and by Gray (e.g., Exhibit 1006, 5:19-26). I can personally attest that this type of practice was standard and well-known to a POSITA from my experience over the course of 30-plus years of building multispectral systems.

35. The '947 Patent is largely agnostic about what comprises an "optical sensor," though much of the specification appears directed toward imaging systems. While the "optical sensor" is described as able to "generate a measurement signal, preferably in the form of a grayscale image" (Exhibit 1001, 5:47-48), it is also said that it "comprises a linear video camera (provided with the aforesaid row of optical transducers 5') (Exhibit 1001, 7:40-42). A POSITA thus

could reasonably conclude that the “optical sensor 5” could have one row of a single element of “optical transducer 5” or could be a linear photodiode array, not necessarily a full image sensor. Pearson et al. used a photodiode to generate signals based on light from the LEDs reflected from a kernel (p. 48), but ElMasry et al. clearly identify the motivation for using an imaging system, since “colour alone did not adequately describe all differences among seeds of different quality grades” (Exhibit 1002, p. 7).

36. There are three basic types of sensing mechanism that can be used for that purpose, which are in fact well illustrated by Fig. 2 of ElMasry et al. (Exhibit 1002). A single detector element can be used to interrogate either just a single point on the sample (or potentially almost the entire sample) or the object field of the single detector can be scanned across the object to build a full image pixel by pixel. Several spectral data points can be taken at each spatial position, as illustrated by Fig. 2(a) of ElMasry (Exhibit 1002). A single row of detector elements can be scanned in much the same spatial and spectral manner across the surface of the object, as in Fig. 2(b). This approach is commonly called “raster imaging” and dates to the earliest photocopier devices. I can personally attest that such techniques were used in multispectral format in the infrared in the 1990s, and that “linear image sensor” devices were made for visible and IR use by companies like Hamamatsu at that time. Lane also describes a system in which a row of

detectors is used, having “a line of detector lenses 17 for collecting reflected light and concentrating same on rearwardly positioned detectors” (Exhibit 1003, 5:48-50). It should be apparent to anyone, and would certainly be to a POSITA, that Lane’s optical detectors lie on the same optic axis as the detector lenses, or the function described would not be achieved. It is also apparent from FIG. 1 and FIG. 4 of Lane (Exhibit 1003) that the line of optical detectors extends in a line substantially transverse to an advancement path of the items to be sorted. Finally, a 2-D array (image sensor) can be used to acquire an entire (grayscale) image in one exposure, no spatial scanning required. As illustrated by Fig. 2(c) of ElMasry (Exhibit 1002), a filter wheel can be used to take multiple grayscale images in different wavelength bands. Alternately, different illumination sources can be used to selectively illuminate the object while taking different grayscale exposures. All of these techniques have been part of the working knowledge of a POSITA for many decades, though certain technological advances in devices and materials have been made.

37. As noted above, the method of sequential illumination suggested by the ‘947 Patent was also well known in the art of imaging. ElMasry et al. describe the known technique of “‘sequentially’ illuminating the scene with different narrow-band wavelength light sources” (Exhibit 1002, pages 10-11) where “[e]ach LED is sequentially switched on for a definite period during image acquisition”

(Exhibit 1002, page 12). This technique is identical to that described in the claim language above. Likewise, ElMasry's description of "taking greyscale images under the illumination of these LEDs in turn" and "activating the illuminations one by one" (Exhibit 1002, page 11), means that each of the LEDs takes its own individual turn radiating during its own period of time while the other LEDs are turned off, and is functionally identical to the method of claim 1 of the '947 Patent. Sequential illumination and sensor signal generation are also taught by Pearson et al. (Exhibit 1013, p. 47), Lane (Exhibit 1003, 2:50 – 3:3), and Adams (e.g., Exhibit 1005, 13:20-31). I can personally attest that taking composite-wavelength (multispectral) images using discrete-wavelength sources was known at least in the 1990s, even in the infrared spectrum.

38. Likewise, controlling the illumination of an image, including the avoidance of issues such as specular reflection, was a well understood aspect of the art. In most illumination systems, the goal was to achieve uniform illuminance with little directional character, using techniques such as Köhler illumination (where the source itself cannot be imaged by the system). Another common solution was to distribute the source itself, as evidenced by the "plurality of sources" described by Lane (Exhibit 1003, 6:35-50). The description in the specification is consistent with prior art practice and the knowledge of a POSITA, and arranging the LEDs of ElMasry in lines as taught by Lane would not change

the principle of operation and would produce results predictable to a POSITA as of the 2020 effective filing date of the '947 Patent.

39. The '947 Patent does indeed describe some examples of useful infrared data (e.g., Exhibit 1001, 6:22-28 and 6:29-33), but does not describe the method by which the proposed device will utilize or obtain such data. As ElMasry notes, “due to the complex nature of samples, there is no single magic algorithm valid for all image analyses” (Exhibit 1002, p. 5) and this fact is well known to those skilled in the art of spectroscopy. The method by which the proposed device will utilize or obtain infrared data is in fact what gives chemometric spectroscopy its inherent value. The '947 Patent attempts to lay claim to all spectral analysis in the IR region (with preference for the shortwave IR), without disclosing any specifics for a new method or analysis or algorithm, and would thus conceivably ensnare prior decades of agricultural chemometric spectroscopy and multispectral imaging. A POSITA would not have been able to tell from a review of the specification what specific implementation (e.g. wavelength bands) or what algorithm the '947 Patents envisions, in my opinion.

40. ElMasry et al. teach the value of infrared optical data through prior art examples, illustrating that this technique was well established in the art; in particular in discussing the work Sendin et al., which identifies two near-IR (NIR) wavelengths (890 and 940 nm) that are associated with fat, and one NIR

wavelength (970 nm) that is associated with water content. ElMasry also indicates that lipids (fats) and moisture (water) content of seeds are parameters that are relevant to predicting seed quality (Exhibit 1002, page 13). ElMasry et al. also discuss the work of Olesen et al. in the VIS-IR range for identifying fungal infections on spinach seeds using a multispectral imaging system “for discrimination among healthy and seeds with different Fusarium strains” (Exhibit 1002, p. 20). A similar multispectral imaging system used by Versak et al. in the 375-970 nm range is also described by ElMasry et al. (Exhibit 1002, p. 21). Gray states that “sensing in the infrared range is commonly done” (Exhibit 1006, 4:12-13). As noted, the Pearson paper describes a system using three IR LEDs (Exhibit 1013, p. 47). The value of multispectral data in the infrared is also taught by Gerken: “the production of spectral information items or the creation of a colour metric in the shortwave infrared region is very advantageous in conjunction with a less complicated and expensive HDTV camera system” (Exhibit 1004, p.1, 20-22). In stating that “multispectral imaging has found its way toward automating the inspection and evaluation practices of seed health and proved to be useful in the separation of infected seeds from uninfected seeds in several species” (Exhibit 1002, p. 20), and the discussion of the significance of IR data, ElMasry et al. provide nearly all the description given in the ‘947 Patent specification.

41. As I have noted previously, the use of hyperspectral imaging can be seen as an intermediate step to a less data-intensive, potentially higher-throughput multispectral system. ElMasry et al. also teach that “[d]ata extracted from images can be used to describe differences among samples ...” (Exhibit 1002, p. 13), in their discussion of “Chemometrics and Spectral Analysis.” As this discussion indicates, and roughly two centuries of chemical spectroscopy have shown, the details (e.g., wavelengths and bandwidths) of the spectroscopic analysis are of crucial importance and it is both wildly insufficient and utterly non-descriptive to describe one’s novel system as analyzing “infrared spectra.” What is taught in the prior art literature is vastly more informative than the teachings of the ‘947 Patent, and thus a POSITA would have used the prior art to tailor a spectral analysis to the particular application rather than any description of the ‘947 Patent.

42. Standard near-IR and mid-IR features, such as the C-H, N-H, and O-H functional group vibrations described by ElMasry et al. (Exhibit 1002, p. 13), are well known to practitioners in the field, but they are found in so many natural substances that analyses based on them may have little specific value for a given application. In other words, the true value of IR spectroscopic analysis lies in the IR spectra themselves. Even chemometric analysis of strong features such as those above, using modern spectroscopic analysis methods such as back-propagation

neural networks and k-nearest neighbor algorithms (see ElMasry et al. (Exhibit 1002) references, p. 13) must be customized to a specific set of data (application).

43. Even then, after a complex algorithm such as a neural net has been trained to analyze the chemometric data in an image, producing a single output metric is yet another sizable task specific to a particular data set, just for the spectral content. A separate algorithm, completely lacking any description in the ‘947 Patent, is also required for the spatial data of the image. Thus, the operation of “generat[ing] said control signals as a function of said synthesis image” is a vastly larger task than the vague claim language based on non-existent description in the ‘947 Patent implies.

44. The claims also reference the false-color image that is ostensibly formed from the IR grayscale images. The generation of false-color images from IR data is also described by Hagiwara (Exhibit 1007), Gerken (Exhibit 1004), and Darty (Exhibit 1008). I note that the ‘947 Patent provides only the most vague and general descriptions of this process and no guidance on how any selection mechanism is to be based on it. For example, the preferred embodiment appears to be a simple direct mapping of 3 IR bands to an RGB color space: “a processing module 9 ... is provided with three chromatic channels 10 of a RGB color space ... the processing module 9 is arranged for associating the measurement signals corresponding to each IR source 8 with a corresponding chromatic channel 10 in

order to compose a false color synthesis image of the product” (Exhibit 1001, 5:26-34). Such a direct mapping does not take into account the chemical origins of the information being obtained, and is thus a reduction of the techniques described by Gerken (Exhibit 1004), Hagiwara (Exhibit 1007), and Darty (Exhibit 1008). If the ‘947 Patent were limited in scope to sorting peanuts from their shells, then a POSITA might have found some very limited guidance, though no specific wavelengths or image processing methods, in the specification. However, the ‘947 Patent has absolutely no basis to lay claim to the entire infrared spectrum, or even the shortwave infrared.

45. The ‘947 Patent also describes the “optical transducers” being made from indium gallium arsenide (InGaAs), a ternary III-V compound that has been used for infrared measurements since the 1970s. I can attest that companies such as Hamamatsu and Sensors Unlimited have been making InGaAs linear and area image sensors since the 1990s. As an example, Gerken et al. describe a multispectral infrared image sensing system using “an InGaAs (indium-gallium-arsenide) or an MCT (mercury-cadmium-telluride) detector” (Exhibit 1004, p. 5:28-29), and that “two-dimensional InGaAs detectors for detection in the shortwave infrared region from 900 nm to 1700 nm can be used” (Exhibit 1004, p. 5:31-32). Hagiwara et al. employ an image sensor that is “photosensitive to light in the range of 800 nm to 2000 nm” (Exhibit 1007, ¶ [0033]) with “a plurality of

pixels arrayed two-dimensionally” (Exhibit 1007, ¶ [0034]). The image sensor in this case has “three types of bandpass filter” to allow “part of continuous near infrared bands in an object light flux to pass through,” where the filters are “allocated like a Bayer array” (Exhibit 1007, ¶ [0046]). Even with current technology, the choices for materials that are photosensitive in the 900-2200 nm region are limited, and those that can be made into a practical solid state, low-noise image sensor are even more limited. The InGaAs(Sb) materials system is one of the few that satisfies these requirements.

46. As noted above, the false color image generation from IR data is an object of Hagiwara et al., who describe a system that maps an infrared “color space” to a visible color space using definable chromaticity references. This feature allows the color mapping to be customized so that “oil is recognized in whitish colors as compared with water in an image after conversion into the visible wavelength band” Exhibit 1007, ¶ [0066]. Hagiwara et al. describe the method of color mapping in considerable detail and one specific case of their algorithm is the case where three IR bands are mapped directly and at corresponding intensity into three visible wavelength bands, i.e. the system described by the ‘947 Patent.

47. The data rate for multispectral imaging systems is driven largely by the image sensor readout rate, though the sampling rate is determined by both the readout (frame) rate and the number of frames taken per sample. A VGA

monochrome sensor of 640x480 pixels, with 8-bit pixel depth, represents about 2.5 megabits of data, or about 300 kilobytes. A 1 megabyte per second link can transfer such an image in about 1/3 of a second, or about 3 frames/second. This means that a three-wavelength multispectral system could have a 1 sample per second update rate. Obviously, higher sampling rates are achievable based on the link speed, camera frame rate, etc. Video image sensors with frame rates in the 60-100 frames/second range (10-17 millisecond intervals) are commonly available, and higher speeds have been available as industrial items since the early 2000s. Adams provides an example of a camera that takes successive-wavelength images at “about 50 microseconds to about 500 microseconds” (Exhibit 1005, 18:22). Such a camera can thus update frames at a rate between 2 kHz and 20 kHz, which overlaps the range that the ‘947 Patent describes as “substantially comprised between 15 and 25 kHz” (Exhibit 1001, 12:23-24). The ‘947 Patent states that “the present selector machine 1 is capable of acquiring the measurement signals and processing the synthesis images with a frequency that is so high ... since the optical sensor 5 only acquires three measurement signals for each synthesis image.” Exhibit 1001, 7:5-10. I note that the Adams example applies to a full image sensor; in the ‘947 Patent, the “optical sensor” can be a linear image array of far fewer pixels. For example, the linear equivalent of a VGA image sensor row could have a “frame” (row) rate of roughly 480 times the speed of the full VGA

sensor. The art of sampling images at this speed was thus quite well understood and utilized long before the '947 Patent. In the 1990s, I worked on a mid-infrared imaging system that was designed for frame rates well in excess of 1 kHz.

48. The '947 Patent also makes reference to some spectral widths for the various sampling bands, notably in the context of IR spectral identification of plastics, though very few specifics are given to enable any useful spectroscopy. In the 1990s, numerous machines were made to sort plastics by their hydrocarbon bonds (whose vibrational modes can appear as reflection features in the near- and mid-IR, often called near-infrared spectroscopy, or NIRS). The spectral features that discriminate common plastics such as polyethylene, polypropylene, and polystyrene have been well documented in the literature (but are absent in the '947 Patent, as is any kind of algorithm for discrimination).⁸ The support for the dependent claim in the '947 Patent appears to be the paragraph in column 10: “Advantageously, each narrow spectral band 110 of the bandpass filter 11 has a bandwidth 111 substantially comprised between 15 and 35 nm and, still more preferably, substantially comprised between 20 and 30 nm” (Exhibit 1001, 10:18-

⁸For example, see N. Eisenreich, H. Kull, and E. Thinnies, “Fast Identification of Plastic Materials by Near-Infrared Spectroscopy,” in *Conversion of Polymer Wastes & Energetics*, ed. H.H. Krause & J.M.L. Penninger, ChemTec Publishing (1994).

21). These numbers may be optimal for some specific applications in the near infrared, but it should be noted that most chemical modes in solid materials are broadened in energy, not wavelength (the inverse of energy). So bandwidths of 15-35 nm in the mid-IR and long-IR will be very narrow, indeed, and represent much less spectral content than in the near-IR. This is why features of interest are usually specified either in wavelength or wavenumber, with an associated width. The information provided in the '947 Patent in this regard is, in my view, insufficient to enable the application of the proposed filtering because the '947 Patent does not provide any wavelength or wavenumber to accompany the claimed 15-35 nm bandwidth. ElMasry et al. confirm this assertion in saying that “[t]he method of wavelength selection should also identify the optical center frequency and bandwidth (FWHM) that provide optimal discrimination in the multispectral imaging system” (p. 26).

49. Sources also have spectral widths that vary with the type of emission process; this fact was well known to undergraduate students in physics and optics, certainly to a POSITA. Lasers (operating by stimulated emission) typically have narrow linewidths – a few nanometers or more (in the VIS-NIR) for many solid state lasers (e.g. semiconductor-based) and sub-nanometer for gas lasers. LEDs operate by spontaneous emission and can have linewidths of tens of nanometers or more (in the VIS-NIR). A POSITA would have understood an LED (such as those

used in the multispectral imaging system of ElMasry) to be a broad-bandwidth source (e.g., broader spectral bands than those of interest to a multispectral imaging system in many cases), and that spectral filtering using a narrower bandwidth filter could reduce the overall spectral width of the source. A POSITA would have further understood that, taking the prior art as example, if three spectral bands were centered on three features of interest (e.g. the 2nd overtone of the C-H stretch mode at roughly 1100-1250 nm, the 1st overtone of the C-H stretch mode at 2150 to 2500 nm, and the NH band at about 1500 nm), that if one wanted to interrogate each feature independently, then the spectral bands of the LED-filter combinations used should not overlap each other. It was known to a POSITA that overlap of the bands would result in overlap of the spectral information in each band, and that overlap of information could reduce a multispectral imaging system's ability to distinguish between elements desired to be sorted. It would have been readily apparent to a POSITA that a multi-peak filter such as described by Gray et al. could be used in the multispectral imaging system of ElMasry to separate signals from time-multiplexed LEDs in wavelength so that a given feature is not interrogated by multiple LEDs. A POSITA would have known that narrowing the bands of interest from the LEDs of ElMasry using the multi-peak filter of Gray would reduce the overlap between the bands. A POSITA would have also known that reducing the overlap between the bands would improve sorting

accuracy in a sorting system in many cases. Using the multi-peak filter of Gray with the multispectral imaging system of ElMasry would not change the principle of operation of the multispectral imaging system of ElMasry, or of the multi-peak filter of Gray. The practice of partitioning segments of a spectrum either by filtering sources or filtering the light traveling to the photodetection system was not only part of the standard practice of optical spectroscopy, it was a large part of the reason that optical filters with unique response curves were made. The multi-peak filter of Gray is analogous to a filter wheel (for sequential illumination, as discussed in ElMasry (Exhibit 1002) at p. 9 and shown in Figure 2c.), save that the multi-peak filter of Gray removes the need to mechanically change filters.

50. The elements of independent claim 1 of the ‘947 Patent are, therefore, all taught by the prior art, as noted in the Petition. What is described by the ‘947 Patent is a multispectral imaging optical sorter system that generates (but does not have any provision for using or analyzing) false-color imagery from IR multispectral data.

51. An examination of Fig. 1 of the review by ElMasry et al. (Exhibit 1002) shows that this set of features was indeed known and the target of research and development before 2019. Fig. 1 of ElMasry (Exhibit 1002) clearly shows the “Multispectral Imaging system” and the “Image processing routines for extracting spectral fingerprints” as well as the “Data modeling and visualization” showing the

false-color image of the multispectral data. While the task of connecting such a system to a real time selector/sorting mechanism would have been obvious to a POSITA based on the prior art, El Masry et al. also discuss “Real-Time Systems for High-Throughput Applications,” stating that “the timely detection of seed quality attributes that do not meet quality specification standards is advantageous” (Exhibit 1002, p. 25). In fact, El Masry et al. acknowledge that “it is extremely important to develop a computer-integrated system that has the ability to deliver a large amount of seeds to the imaging system (e.g., through a conveying system) and subsequently sort the seeds into different fractions using robotic picking or some kind of pneumatic or mechanical gate system” (Exhibit 1002, p. 25). Taken in the context of the discussion of prior art in the area of multispectral imaging of agricultural products, this statement in my view encapsulates the sum total of the disclosure of the ‘947 Patent.

52. Even making the assumption, for the sake of argument only, that the exact combination as described in the ‘947 Patent is absent in the prior art (which I disagree with), it is my opinion that a POSITA would be motivated to make such a combination (for the reasons described in ElMasry et al.) and that such a combination would yield the type of results predicted by ElMasry et al. and others; namely, a system capable of sorting agricultural products based on multispectral imaging and providing a false-color data visualization feature.

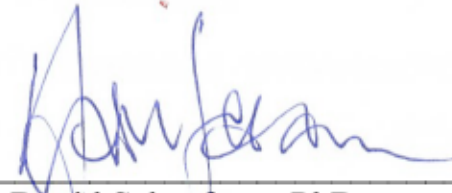
53. It would have been apparent and desirable to a person of ordinary skill in the art wishing to separate seeds based on seed quality, for example, to capture greyscale images corresponding to 890, 940, and 970 nm measurement signals, and map the captured greyscale images to respective R, G, and B channels of the RGB colour space to generate a pseudo-colour image because this image could be used to separate seeds based on their fat and water content and, by extension, seed quality. This process and its desirability are in fact documented by ElMasry et al. The spacing between the 890, 940, and 970 nm center frequencies for the wavebands describe allows roughly 30-50 nm width for each band if they are not to overlap significantly. This fact would have motivated a POSITA, when non-overlapping bands are desirable, to use a multi-peak filter such as that disclosed by Gray to narrow the wavebands reaching the light sensor to 30 nm or less to reduce or prevent overlap between the bands.

54. In signing this Declaration, I recognize that the Declaration will be filed as evidence in a case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

55. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further 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 1034 of Title 18 of the United States Code.

DATED: February 23, 2024

By:



David Schaafsma, PhD.