

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

QUASAR SCIENCE LLC
Petitioner,

v.

COLT INTERNATIONAL CLOTHING, INC. d/b/a COLT LED
Patent Owner.

Case: IPR2023-00614
U.S. Patent No. 10,566,895

**DECLARATION OF GARY R. ALLEN, Ph.D. IN
SUPPORT OF PATENT OWNER'S RESPONSE**

DECLARATION OF GARY R. ALLEN, Ph.D. IN SUPPORT OF PATENT OWNER'S RESPONSE

I, Gary R. Allen, declare as follows:

1. I have been retained by Colt International Clothing, Inc. d/b/a/ Colt LED ("Patent Owner") as an independent expert consultant in this proceeding before the United States Patent and Trademark Office ("PTO") in the case brought by Quasar Science LLC ("Petitioner" or "Quasar") regarding U.S. Patent No. 10,566,895 ("the '895 patent")(Ex. 1001).

2. I am being compensated at a rate of \$500/hour for my work in this proceeding. My compensation is in no way contingent on the nature of my findings, the presentation of my findings in testimony, or the outcome of this or any other proceeding. I have no other interest in this proceeding.

3. I retired in 2016 from GE Lighting with 30+ years' experience in applied physics, developing energy-efficient lighting technologies and products. I have 92 issued U.S. Patents, 46 of which are directly related to LED lighting products and technology. As GE Lighting's leading innovator of LED consumer products and technology, I had frequent access to the world's leading LED package manufacturers who provided samples of the latest new products prior to

commercial availability. My specific demands on the manufacturers primarily focused on improvements in efficacy (lumens per watt, or “LPW”) and color quality (color tint and color control), along with reduced cost. Appendix A hereto is a copy of my CV; list of US Patents issued and Publications; and Expert Witness Experience.

4. Within the lighting products manufacturing industry, I have deep expertise in LED Lamps and Luminaires, Color Science, Optics, Thermal Management, Systems, Spectral Tailoring, Human Centric Lighting, Circadian Lighting, Disinfection Lighting, Algae Cultivation Lighting, and the legacy lamp technologies: Metal Halide, CMH, Fluorescent, Halogen, and Automotive.

5. In recognition of my expertise, I presented the world’s first-ever TEDx talk on the topic of lighting technology in 2013, titled “A Lighting Revolution”. See, https://www.youtube.com/watch?v=ghwxAlMZF_A. In retirement, I have provided technical consultation to several clients, including my previous employer, GE Current (formerly GE Lighting), and Aeroclenz, Inc. who have retained me to develop Ultraviolet Disinfection Lighting. I have also provided consulting on patents and litigation, including expert witness declarations, deposition, and testimony at a AAA Arbitration hearing.

6. My education is as follows:

- a. 1981 Princeton University - PhD in Astrophysical Sciences,
Plasma Physics Division
- b. 1977 Princeton University - MS in Astrophysical Sciences
- c. 1975 Pennsylvania State University, MS in Nuclear Engineering
- d. 1974 Pennsylvania State University, BS in Nuclear Engineering
- e. 1974 Pennsylvania State University, BS in Engineering Science

7. Highlights of my work experience are as follows:

- a. 1987 – 2016 GE Lighting, Principal Engineer, Engineering
Manager - conceived product designs, and led concept development,
of several of GE Lighting's flagship LED lamp product lines,
resulting in tens of millions of dollars of sales, including of particular
interest to the subject matter of the above referenced matter (see my
CV for other experience):

- world's first color-preference-enhanced LED
replacement lamps (GE's premier reveal® brand) and
luminaires enabled by my co-development of a new

state-of-the-art color preference metric, the Lighting Preference Index (LPI).

b. 1985 - 1987 GTE Sylvania Lighting, Research Physicist -
Conceived and initiated the development of several novel concepts for new lamp products.

c. 1980 – 1985 Sandia National Laboratories, Member Technical Staff
- developed and implemented several novel advanced, laser-based diagnostics on terawatt pulsed-power accelerator experiments.

8. I have been retained to provide this declaration in support of the Patent Owner's Response regarding the validity of claims presented in U.S. Patent No. 10,566,895, as issued to Guillermo Macias, and assigned to Colt International Clothing, Inc. dba Colt LED, including in the above identified matter. Specifically, I have been requested to assess certain issues relating to the validity of Claims 1, 6 and 12-13 and any other claims incorporating the above referenced novel and nonobvious combination of features with respect to Petitioner Quasar Science LLC's proposed obviousness rejections in Grounds 1 and 2 in the above-referenced IPR proceeding. When I refer herein to the '895 patent claims and/or when I refer to Claims I am referring to the claims of U.S. Patent No. 10,566,895 (referred to herein as the claims in the '895 Patent or like language).

9. Specifically, I have been retained to opine on certain questions (addressed below) related to Ground I which asserts that Claims 1–3, 6–18, 21–24, and 27–29 (“Challenged Claims”) would have been obvious based on Kit in view of Ianiro, Ducharme and Katzir; and Ground II which asserts Claims 1–3, 6–18, 21–24, and 27–29 would have been obvious based on Ducharme in view of Ianiro, Katzir and Hasnain.

10. Documents received and reviewed for this IPR proceeding include the Exhibits referenced herein, and including the following:

- a. Petitioner Quasar Science LLC’s Petition for *Inter Partes Review* of U.S. Patent No. 10,566,895
- b. Exhibit 1001, U.S. Patent 10,566,895, Macias
- c. Exhibit 1003, Declaration of Fred Holmes
- d. Exhibit 1004, US Patent 7,507,001, Kit
- e. Exhibit 1005, US Patent 7,350,936, Ducharme
- f. Exhibit 1006, US Patent Application Publication No. 2010/0102729 to Katzir
- g. Exhibit 1007, WIPO Patent Application Publication WO 2009/063520, Ianiro

h. Exhibit 1008, US Patent 8,668,361, Hasnain

11. Claim 1 of the '895 patent recites an "LED light system configured for providing broad-spectrum white light suitable for a commercial image recording, in a form factor of a fluorescent light tube lamp." The LED light system includes:

1[pre] An LED light system configured for providing broad-spectrum white light suitable for a commercial image recording, in a form factor of a fluorescent light tube lamp, the LED light system comprising **[Fluorescent form factor]**:

1[b]. a plurality of first LEDs mounted on the top side of the support structure and configured to emit broad-spectrum white light in a first predetermined Kelvin temperature range of cool white light [**"cool white LEDs"**] ;

1[c]. a plurality of second LEDs ... configured to emit broad-spectrum white light in a second predetermined Kelvin temperature range of warm white light [**"warm white LEDs"**];

1[d]. circuitry mounted to the support structure including an LED driver circuit configured for driving (i) the first LEDs, to provide light in the first predetermined Kelvin temperature range; or (ii) the second LEDs, to provide light in the second predetermined Kelvin

temperature range, wherein the first and second predetermined Kelvin temperature ranges are nonoverlapping...[**“Switchable LED Driver”**];

1[e] an elongate cover extending substantially a length of the support structure and covering the top side of the support structure for diffusing light emitted by the first and second LEDs [**“Diffusion Cover”**]; and

1[f]. wherein the housing and cover together have a linear form factor [**“Linear Form Factor”**],

1[g]. wherein the LED light system is configured for receiving input power to be provided to the LED driver circuit to selectively light the first or second LEDs [**“Input for Selective Drive”**],

1[j]. wherein the light emitted from the LED light system is said suitable for the commercial image recording [**“Commercial Image Recording”**] when said emitted light: (i) is at least 1000 lumens when the first LEDs are lit and is also at least 1000 lumens when the second LEDs are lit [**“1000 Lumen Minimum”**]; (ii) is broad-spectrum white light having a color deviation corresponding to less than five points of green and less than five points of magenta (5M, 5G) of color compensation (CC) [**“G/M 5 Point Limit”**], and (iii) has a color rendering index of light emitted from each of the

first LEDs or each of the second LEDs, whichever respective plurality of first or second LEDs is lit, that is greater than 90 [**“CRI > 90”**] [collectively, **“The Claim 1[j](i)-(iii) Requirements”**].

Ex. 1001 at claim 1; Petition at viii-ix.

12. Claim 6 recites that “the first and second LEDs are phosphor-based light emitters” [**“Phosphor LEDs”**].

13. Claim 12 recites:

The LED light system of claim 1, further comprising a power supply configured to provide at least 42 watts, and wherein the LED driver is configured to selectively drive the first LEDs with at least 42 watts and the second LEDs with at least 42 watts [**“42 Watts Per Color”**].

14. Claim 13 is the same as Claim 12, except that Claim 13 depends on Claim 8 which recites that “the housing has a length of about four feet” (**“Four Foot Housing”**) and depends on Claim 1.

15. I have been asked to assume a date of invention of May 17, 2013 (**“Time of the Invention”**). I have further been asked to consider Petitioner’s

proposed definition for a person of ordinary skill in the art (“**POSITA**”), namely, that a POSITA would have had “at least a Bachelor of Science degree in electrical engineering, or a closely related field, along with at least two years of experience in the design of entertaining [*sic*, entertainment] lighting systems, and the design and use of LEDs lights.” Petition, p. 14 (citing, Exhibit 1003 (Holmes) ¶32). I have been asked whether my conclusions would change if a POSITA:

would have had 2 to 4 years’ experience in electrical engineering/design of film and television lighting systems, including the design and use of LED lights, combined with two to three years of work experience as a set lighting technician in television and/or motion picture industry.

In designing lighting for such a specialized field as commercial image recording, i.e., film and studio recording, a good understanding of the use of set lighting equipment is important. Because of that specialized knowledge, a POSITA, even if using Mr. Holmes’ definition, would have to be familiar enough with the variety of uses and conditions of set lighting. Therefore, my opinions herein are the same using either of the above definitions of a POSITA.

16. My opinions, considering the above Time of the Invention and above definitions of a POSITA, are set forth below concerning the following issues upon which I have been asked to opine.

I. HASNAIN AND HOLMES FAILURE TO DETERMINE THE LUMEN OUTPUT OF A LIGHTING DEVICE AS IN CLAIM 1

17. **Issue 1:** At the Time of the Invention, would it have been obvious to a POSITA to use Hasnain's teachings of LEDs having 70-100 LPW (per LED) in a luminaire for Commercial Image Recording including the G/M 5 Point Limit and the CRI > 90 of 1[j] as asserted by Holmes (Exhibit 1003, ¶s 314-320)? Would a POSITA simply be able to select LEDs with Hasnain's 70-100 LPW per LED and reasonably expect to successfully achieve a luminaire with the 1000 Lumen Minimum, the G/M 5 Point Limit and the CRI > 90 as recited in Claim 1, i.e., element 1[j]?

18. My opinion on Issue 1 is explained below. My conclusion is that a POSITA would not be able to simply select LEDs with Hasnain's asserted 70-100 lumens per watt ("LPW") and achieve the claimed invention's 1000 Lumen Minimum while still achieving the G/M 5 Point Limit and CRI > 90 as the Petitioner's analysis e.g., in the Holmes Declaration as well as in the references, such as Hasnain, fails to address well-known lumen-reducing penalties in going from a proposed LED LPW to a luminaire lumen output. Claim 1 requires in element 1[j] and 1[j](i) that "the light emitted from **the LED light system** is said suitable for the commercial image recording when said emitted light: (i) is at least

1000 lumens when the first LEDs are lit and is also at least 1000 lumens when the second LEDs are lit.”

19. Due to Petitioner’s Declarant Holmes’ and reference Hasnain’s failure to consider lumen reducing penalties resulting from, without limitation the claimed luminaire elements, including, without limitation, the Diffusion Cover, the LED Driver, the G/M 5 Point Limit and $CRI > 90$, the Petitioner has failed to address the lumen output of the luminaire as a combined lighting “system” (the claimed lighting device as required by the ‘895 Patent). Instead, Petitioner focused only on the lumen output of the individual LED sub-components (i.e., only an element of the system). Therefore, a POSITA would not be able to use the teachings of Hasnain to modify Ducharme and/or any of the other references in Ground 2 to achieve the invention as recited in Claim 1 at the Time of the Invention. The 1000 Lumen Minimum of 1[j](i) has not been shown by Petitioner’s analysis as explained below. Based on a failure of the Petitioner to address (and in view of) well-known lumen-reducing penalties and the tradeoffs associated therewith in the design of a successful luminaire, a POSITA also would not have a reasonable expectation of success in creating the claimed luminaire, without hindsight.

20. Hasnain asserts that as much as 70 - 100 LPW per LED may be achieved, but Holmes fails to account for the facts that Hasnain's LED output is for an uncovered LED tube light under ideal test bench conditions with unspecified CRI and unspecified green/magenta deviation, and without taking into account any actual reductions in output for using LEDs with the G/M 5 Point Limit and the CRI > 90. **Moreover, Holmes' use of Hasnain's simplified 70 – 100 LPW for bare (no luminaire) LEDs also fails to take into account** any and all of the luminaire elements that reduce output of the luminaire, e.g., the Diffusion Cover of 1[e], the Switchable LED Driver of 1[d], or the luminaire total lumen output 1000 Lumen Minimum recited in 1[j](i) using just the warm white LEDs or just the cool white LEDs. A POSITA would take into account the above limitations on Hasnain's teachings. In that case, a POSITA would not have a reasonable expectation of success for combining Ducharme, Ianiro, Katzir and Hasnain to achieve the invention of Claim 1 for Commercial Image Recording (in the film and TV industry) at the Time of the Invention.

21. LUMEN LOSSES IN A LUMINAIRE/LIGHT SYSTEM: There are several factors that must be taken into account in estimating the LPW of the light output from a luminaire, "[a]n LED light system" of Claim 1, from the LPW of the LEDs inside. All of the following elements recited in Claim 1 of the '895 Patent

have inherent lumen losses including at least: the Diffusion Cover (to reduce glare from LED point sources of light) of 1[e], the less than 5-step McAdam ellipse, i.e., the G/M 5 Point Limit of 1[j](ii), the CRI > 90 of 1[j](iii), and the circuitry, Switchable LED Driver of element 1[d]. In addition, there is inherently a lower efficacy of the LEDs when operating at an elevated temperature inside a luminaire (particularly one with a Diffusion Cover as recited in 1[e]).

22. A POSITA at the Time of the Invention would typically consider these luminaire factors as significant but they are not considered in the Holmes declaration. For example, there is a first substantial lumen loss due to optical loss from the diffuser covering (Diffusion Cover of 1[e]) the tube in order to blend the individual LEDs into suitable light output, especially to reduce the glare of the point sources of light from individual LEDs. A second, also substantial, lumen loss for electrical losses from circuitry is well known by a POSITA. Here that loss would include from the LED Driver of 1[d]. And there is a third substantial loss due to lower efficacy of the LEDs when operating at an elevated temperature inside a luminaire. Holmes provides no quantitative analysis for the LED LPW to luminaire output losses and therefore presents no basis to get a luminaire with a Diffusion Cover and driver circuitry (1[j](d) and (e)) to get to a 1000+ lumen system (1[j](i)) as recited in the '895 Patent. Accordingly, Petitioner has not shown

that Hasnain teaches this limitation. These “driver, diffuser and thermal droop losses” (or “Luminaire Losses”) cannot be ignored. The Holmes declaration does not account for these losses in as much as there is no discussion and no estimation of these losses. A POSITA trying to design such a luminaire would try to estimate these losses and calculate the lumen output of the luminaire from them.

Accordingly, all luminaires proposed by Holmes and Petitioner have not been shown to produce a 1000 Lumen Minimum output for the claimed invention.

Further, a POSITA could not have a reasonable likelihood of a successful design for a luminaire in accordance with claim 1 without some idea of Luminaire Losses.

23. LED DRIVE CURRENT DROOP LOSSES: Any LED that is driven at a current exceeding its rated current will incur a significant reduction in LPW due to an effect known as current droop. In order for any of the luminaires described in the prior art to provide 1000 lumens of output from the luminaire, considering the optical, electronic, and thermal losses, in addition to the LED efficacy penalties accrued in providing CRI > 90 and G/M 5 Point Limit, the LEDs would have to be driven at much higher current than the rated current of the LEDs, thus incurring the additional loss due to current droop. Accordingly, the 70 – 100 LPW of the LEDs must also, in addition to the “driver, diffuser and heat losses” (or “Luminaire Losses”), must also be further reduced due to current droop. Current droop losses

vary depending upon the LEDs and the drive current and so is indeterminate from Hasnain and Holmes. Neither Hasnain nor Holmes have accounted for any such losses which can be substantial especially as drive current increases. Therefore, a POSITA would know that droop losses would likely be substantial. A POSITA would have to take this droop loss into account in designing a successful luminaire in accordance with claim 1.

24. LOSSES FROM G/M 5 POINT LIMIT of 1[j](ii) and CRI > 90 of 1[j](iii): Holmes fails to account for and factor in LPW losses due to color quality. A POSITA would calculate these and factor them in. But there is no such analysis in Holmes. By way of example, a further correction factor of at least 35% must be included to correct for green and CRI in the demanding applications of Commercial Image Recording as recited in the Claim 1j(ii)-(iii) requirements of the G/M 5 Point Limit and CRI > 90. A POSITA would know that both the CRI > 90 and the G/M 5 Point Limit substantially reduce lumen output (“Color Correction and CRI Losses”). This is another well-known tradeoff in luminaire design that Hasnain does not mention and that Holmes has not accounted for in his luminaire output calculations of driver, diffuser and heat losses, as well as droop losses. See, e.g., Exhibit 1003 (Holmes), ¶s 434-440.

25. These Color Correction and CRI Losses are cumulatively 35% correction factor for the conditions in the quantitative detail (below).

26. The G/M 5 Point Limit Loss: The G/M 5 Point Limit requires, an adjustment, i.e., a reduction or “lumen penalty.” Examples of that penalty are described below. A summary of the color point shifts of an Incandescent light

source created by the CC##M filters are summarized in the Table shown here.

	Inc 2854 K	CC05M	CC10M	CC20M
CCx	0.448	0.452	0.456	0.463
Ccy	0.407	0.400	0.393	0.379
CCT	2854	2724	2608	2407
CRI	100	97	94	87
MacAdam Ellipses	0.0	6.0	11.5	21.7
lumens	100%	85%	79%	69%

Exhibit 2081(“2012 Cree Data Sheet”)(# CLD-DS60 REV 0A”), p. 2 (excerpted

from table at page 2). Of special note in the summary table is the lumen penalty that accrues upon the application of progressively denser magenta filters. The relatively weak CC05M filter (5% peak density at 550 nm) absorbs 15%, while the stronger CC20M filter absorbs 31%, of the lumens of an Incandescent light source. Note, that even though the CC05M filter has peak nominal density of 5%, and thereby a transmittance of about 90% at 550 nm in the green, the lumen penalty accrued by the CC05M filter is even greater than 10%, due to the heavy weighting of the eye response function in the green.

27. This emphasizes the significance of the Claim elements 1[j](ii) requiring the G/M 5 Point Limit. The significance of the “G” (green) limit is that if a light source contains a deviation of as much as five points, then the lumen output of the light source will be reduced by 15% by the required color correction filter to obtain a neutral white light output. Similarly, if a light source contains a deviation of as much as twenty points, then the lumen output of the light source will be reduced by 31% by the required color correction filter to obtain a neutral white light output.

28. But it should be noted that a POSITA would not be able to determine this significant lumen penalty that accrues without knowing the LED’s green deviation and thus it is speculative to assert that the 1000 Lumen Minimum of 1[j](i) is met by any LED LPW whether in Hasnain or otherwise without knowing the green deviation of the LEDs.

29. LOSSES FROM CRI > 90: Neither Hasnain nor Holmes provides any indication of the CRI of the 70 – 100 LPW LEDs. There are substantial lumen penalties. Just by way of example, the lumen-reducing penalty to obtain a 90 CRI LED compared to the same LED with 80 CRI at the Time of the Invention was about 24% for warm white CCT LEDs. This does not include correction to getting over 90 CRI. Hasnain provides no indication of the CRI of the 70 – 100 LPW

LEDs. Without that, it is speculative to rely on any LPW numbers to try to calculate a luminaire lumen output.

30. In a manner similar to the lumen penalty accrued by a light source that has an undesirable color tint that must be corrected using an absorbing filter, a lumen penalty is further accrued if the lighting application requires very high CRI, such as applications producing images with true color rendering, or rendering skin tones attractively. In the time frame of 2009 to 2013, before the advent of narrow-band LED phosphors, the requirement of high CRI from LED sources generally reduced the LPW of the LEDs and thereby the luminaire, by about 20-25% to increase CRI from the nominal 80 to the required 90 CRI.

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FLUX CHARACTERISTICS, STANDARD ORDER CODES AND BINS ($I_f = 700 \text{ mA}$, $T_j = 85 \text{ }^\circ\text{C}$)

The following tables provide order codes for XLamp MK-R EasyWhite LEDs. For a complete description of the order code nomenclature, please reference Bin and Order Code Formats (page 14).

Color	CCT Range	Base Order Codes Min. Luminous Flux @ 700 mA			2-Step Order Code		4-Step Order Code	
		Group	Flux (lm) @ 85 °C	Flux (lm) @ 25 °C*	Chromaticity Region		Chromaticity Region	
80-CRI EasyWhite	5000 K	H2	900	1044	50H	MKRAWT-00-0000-0D0HH250H	50F	MKRAWT-00-0000-0D0HH250F
		G4	840	974		MKRAWT-00-0000-0D0HG450H		MKRAWT-00-0000-0D0HG450F
	4500 K	H2	900	1044	45H	MKRAWT-00-0000-0D0HH245H	45F	MKRAWT-00-0000-0D0HH245F
		G4	840	974		MKRAWT-00-0000-0D0HG445H		MKRAWT-00-0000-0D0HG445F
	4000 K	H2	900	1044	40H	MKRAWT-00-0000-0D0HH240H	40F	MKRAWT-00-0000-0D0HH240F
		G4	840	974		MKRAWT-00-0000-0D0HG440H		MKRAWT-00-0000-0D0HG440F
	3500 K	H2	900	1044	35H	MKRAWT-00-0000-0D0HH235H	35F	MKRAWT-00-0000-0D0HH235F
		G4	840	974		MKRAWT-00-0000-0D0HG435H		MKRAWT-00-0000-0D0HG435F
	3000 K	G4	840	974	30H	MKRAWT-00-0000-0D0HG430H	30F	MKRAWT-00-0000-0D0HG430F
		G2	780	905		MKRAWT-00-0000-0D0HG230H		MKRAWT-00-0000-0D0HG230F
	2700 K	G2	780	905	27H	MKRAWT-00-0000-0D0HG227H	27F	MKRAWT-00-0000-0D0HG227F
		F4	730	847		MKRAWT-00-0000-0D0HF427H		MKRAWT-00-0000-0D0HF427F
90-CRI EasyWhite	3000 K	E4	635	737	30H	MKRAWT-00-0000-0D0UE430H	30F	MKRAWT-00-0000-0D0UE430F
		E2	590	684		MKRAWT-00-0000-0D0UE230H		MKRAWT-00-0000-0D0UE230F
	2700 K	E2	590	684	27H	MKRAWT-00-0000-0D0UE227H	27F	MKRAWT-00-0000-0D0UE227F
		D4	550	638		MKRAWT-00-0000-0D0UD427H		MKRAWT-00-0000-0D0UD427F

Notes:

- Cree maintains a tolerance of $\pm 7\%$ on flux and power measurements, ± 0.005 on chromaticity (CCx, CCy) measurements and ± 2 on CRI measurements.
- Minimum CRI for 80-CRI White is 80.
- Minimum CRI for 90-CRI White is 90.
- * Flux values @ 25 °C are calculated and for reference only.

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Exhibit 2081 (2012 Cree Data Sheet), p. 2.

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28. For clarity, the table to the right summarizes the four lumen

		CRI		lumen ratio 90 vs. 80 CRI
		80	90	
CCT	2700	780	590	76%
	3000	840	635	76%

values for two warm-white CCTs and two CRIs. The lumen penalty in providing 90 CRI vs. 80 CRI is seen to be 24% for warm-white CCTs.

Exhibit 2081 (“2012 Cree Data Sheet”), p. 2 (excerpted from table).

29. To further emphasize, the impact of requiring the CRI > 90 (“the color rendering index of each of the first LEDs and each of the second LEDs is greater than 90”) as in claim element 1[j](iii), the table above illustrates that if the light source must provide CRI greater than 90, then, lumen output of the light source would be reduced by 24% relative to (and in the case of) an equivalent LED light source having a nominal 80 CRI.

30. But Hasnain does not specify the CRI of the 70 to 100 LPW LEDs, it is speculation as to what a luminaire output would be as there is no way to know how much the lumen penalty is and therefore Holmes’ use of LED LPWs to try to establish a luminaire lumen output meeting the claimed 1000 Lumen Minimum using just the warm white LEDs and using just the cool white LEDs is speculative.

31. As an example of how the lumen penalties combine, if there is a 15% reduction due to the specification of the G/M 5 Point Limit and a 24% reduction for getting to 90 CRI then there is a combined lumen reduction of $(1 - 0.15) \times (1 - 0.76) = 0.65$, i.e., a 35% reduction. A POSITA would not have a reasonable expectation of success without knowing the photometric and chromaticity specifications of the LEDs.

32. Due to Petitioner's Declarant Holmes' and Hasnain's failure to consider lumen penalties of the claimed G/M 5 Point Limit and CRI > 90 and lumen losses discussed above, any assertion of luminaire output by Holmes is speculative and does not show the lumen output of the luminaire, as opposed to merely the lumen output of an LED.

33. It should also be noted that at the Time of the Invention, warm white LEDs had significantly lower LPW than cool white LEDs, and so reaching the 1000 Lumen Minimum with only the warm white LEDs on and the cool white LEDs off had yet another significant lumen-reducing penalty from any LPW of cool white LEDs or if the color temperature of the LEDs is unspecified. It should further be noted that manufacturers' LPW ratings would be determined under

essentially test bench conditions and this in itself had to be considered in determining luminaire lumen output from manufacturer-provided LED LPW.

34. CLAIMS 16 and 23: Because independent claims 16 and 23 recite all the above discussed elements present in Claim 1, the reasoning set forth above applies equally to these claims.

II. DUE TO THERMAL ISSUES, A POSITA WOULD NOT HAVE A REASONABLE EXPECTATION OF SUCCESS IN TRYING TO CREATE THE DEVICE OF CLAIM 1

35. Issue 2: How would a POSITA take into account thermal issues in looking at Hasnain and attempting to design an LED luminaire having the elements of Claim 1 by combining it with Ducharme and the other references in Ground 2? Does the Declaration of Fred Holmes (Exhibit 1003) properly take thermal issues into account?

36. My opinion on Issue 2 is explained below. My conclusion is that there are compound errors in the Declaration of Fred Holmes and in Hasnain concerning thermal design considerations of LED luminaires and thus Holmes' analysis fails to even reach the claimed invention, much less show obviousness or that a POSITA would have any reasonable likelihood of success in a luminaire design

due to failure to properly take into account thermal management considerations that are critical to a successful luminaire design including achieving the 1000 Lumen Minimum, the G/M 5 Point Limit and the CRI > 90 of 1[j](i)-(iii).

37. Paragraphs 471 and 483 of the Holmes Declaration overly simplify conclusions about the thermal load that may be borne in a 4-foot LED Tube based on the teachings of Hasnain. There are compound errors concerning thermal design considerations of LED luminaires and thus the analysis fails to show any reasonable likelihood of success in a luminaire design as thermal management considerations are critical to a successful luminaire design.

38. Initially, a POSITA would consider ambient temperature for the field of use, here commercial image recording, on a film or television set. Accordingly, I have read and considered Exhibit 2041 (Declaration of Todd Csernecky) and its Exhibits 2042-2045 with regard to set lighting conditions and their effect on thermal design of a luminaire which are harsher than consumer and office use. A POSITA would design an LED luminaire for ambient temperature being significantly higher than it might otherwise be for a luminaire on a test bench (as in Hasnain) or otherwise used, e.g., in a fluorescent box (“troffer”) in a ceiling where the LED tubes would be horizontally positioned and subject to a lesser thermal

load than when positioned vertically above each other in a “ladder” stacking. When positioned vertically, the heat from lower luminaires rises towards the upper luminaires. In particular, because of adjacent LED luminaires and/or other luminaires on a film set, common use of vertical arrays of LED luminaires, and use of LED luminaires in limited air flow configurations such as taped to a wall and/or manner covered with a gel and/or black wrap, a POSITA would design for a sufficient factor of thermal safety as explained below.

39. I have reviewed Holmes’ description of Hasnain (Exhibit 1008) as well as Hasnain itself. Exhibit 1003 (Holmes), e.g., ¶s 82-83. In paragraph 83 Holmes describes Hasnain as follows:

83. Hasnain teaches that the support structure of the invention upon which the plurality of LEDs are disposed is able “to dissipate a significant fraction of the heat of each LED to the surrounding air without the use of finned heat radiators or direct connections to larger heat-radiating surfaces,” specifically stating that **“between 0.5 and 1 watt of heat per square inch of surface area,” may be dissipated by the support structure “without raising the temperature of the LEDs by more than 30° C. above ambient.”** Id. at 4:23–40. Hasnain further discloses that by September 2010, there existed “white light sources based on

GaN blue emitting LEDs [that] generate 70 to 100 lumens per watt.” Id. at 4:1–3.

Exhibit 1003 (Holmes), ¶83 (emphasis added).

40. I have also considered Holmes discussion of Hasnain’s reported lumen output of 70 – 100 lumens per watt from a thermal design perspective. Exhibit 1003 (Holmes), ¶s 471 and 483; Exhibit 1008 (Hasnain), at 4:2-3 and 4:37-40. Holmes’ calculations in paragraph 471 are set forth below (and are the same or substantially the same in paragraph 483):

471. Hasnain discloses that “white light sources based on GaN blue emitting LEDs generate 70 to 100 lumens per watt.” Ex. 1008 at 4:2–3. If the LEDs are spaced apart along the length of heat-dissipating structure, **between 0.5 and 1 watt of heat per square inch of surface area can be dissipated without raising the temperature of the LEDs by more than 30° C above ambient.** Id. at 4:37–40.

Hasnain teaches that additional heat-dissipating surface on the backside of the light source can be utilized to dissipate more heat if required. Id. Accordingly, on an almost one-inch wide printed circuit board (corresponding to the one-inch diameter of a T8 bulb, such that the board on a T12 would be almost one and a half inches wide corresponding to the diameter of a T12 bulb) within a fixture having a length of four feet (having approximately forty-four inches

of usable surface area), there exists 44 square inches of surface area to dissipate heat, such that anywhere from 22 to 44 watts can be dissipated without the necessity of additional heat sinks. **A POSITA armed with the teachings of Hasnain would know that even assuming using LEDs capable of emitting 70 lumens per watt, an LED-based lamp having an elongated forty-four inch long and one-inch-wide circuit board would be able to produce 1,540 lumens from just 22 watts, and up to 3,080 lumens at 44 watts.**

Exhibit 1003 (Holmes), ¶471 (and similar ¶483) (emphasis added).

41. HASNAIN'S AND HOLMES' ANALYSIS IS INCOMPLETE: There are several factors that must be considered in estimating the LED junction temperature, thermal circuit issues, and temperature limits of an LED luminaire beyond the incomplete analysis provided in Hasnain and conclusory analysis of Holmes. A POSITA would be well aware of these additional factors which are critically important in the successful design of an LED luminaire for applications in Commercial Image Recording. The additional, critical factors omitted by Hasnain and Holmes would cause the junction temperature of the LED to be overheated by at least about 50 °C in a typical Commercial Image Recording application (and possibly substantially more depending upon the luminaire design specifications which include but are not limited to just the LED specifications).

Such an overheat would be expected to result in a rapid shift of the color point from its initial color, resulting in unacceptable performance of the luminaire in the Commercial Image Recording application, i.e., by **very quickly irreparably destroying phosphors in the LED and thus very quickly irreparably destroying CRI and/or resulting in loss of the G/M 5 Point Limit of 1[j](ii) and 1[j](iii)**. Therefore, a POSITA would not have a reasonable expectation of success of such a design, particularly one of claim 1 having a Switchable LED Driver (1[d]), Diffusion Cover (1[e]), 1000 Lumen Minimum (1[j](i)), G/M 5 Point Limit (1[j](ii)) and CRI > 90 (1[j](iii)) for Commercial Image Recording. A POSITA, designing a luminaire for commercial image recording having the claimed elements including the 1000 Lumen Minimum (1[j](i)), G/M 5 Point Limit (1[j](ii)) and CRI > 90 (1[j](iii)) would want a thermal design that stays significantly below risking and below appearing to risk any damage to the LEDs and thus to The Claim 1[j](i)-(iii) Requirements to maintain suitability for commercial image recording.

42. HOLMES OMITTS SUBSTANTIAL THERMAL MANAGEMENT DESIGN CONSIDERATIONS: The only thermal management factor considered by Hasnain and Holmes is the LPW of the LED. Both Hasnain and Holmes ignore the luminaire efficiency losses for the claimed luminaire (and the thermal

conditions for the claimed luminaire for its Commercial Image Recording application (see “Color Correction and CRI Losses,” “(Current) Droop Losses” and “Luminaire Losses” of Section I above). Holmes asserts, relying on Hasnain, that if the LEDs are spaced apart along the length of a heat dissipating structure, between 0.5 and 1 watt of heat per square inch of surface area can be dissipated without raising the temperature of the LEDs by more than 30° C above ambient. A POSITA would understand that this 30° C measurement above ambient was the result of a benchtop experiment by Hasnain that was intended to quantify **only** the thermal management feature of Hasnain’s heat dissipating structure (39) of Figs. 2 and 3 (reproduced below), which represents only a very small subset of the many thermal management issues that must be quantitatively included in the design of a commercial product, in contrast to a scientific experiment.

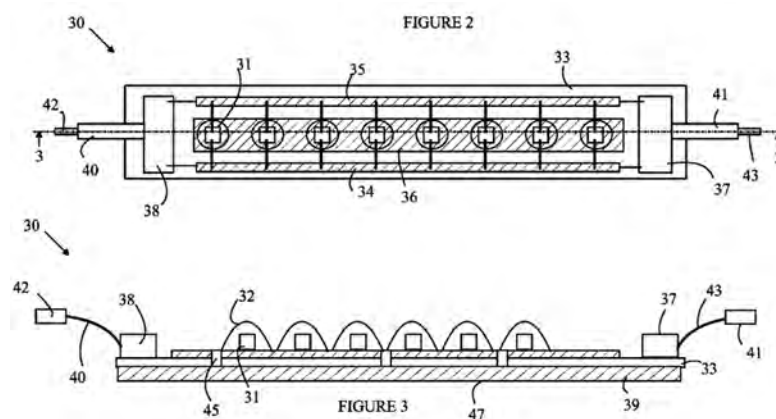


Exhibit 1008 (Hasnain), Figs. 2-3.

43. LED P-N JUNCTION VS. SOLDER POINT TEMPERATURE: LEDs do not have a single temperature, but rather are significantly hotter at the p-n junction than at the solder point where the LED is attached to the printed circuit board. As Hasnain uses the term “LED temperature” and asserts that it is only 30° C above ambient in his benchtop experiment, a POSITA would understand, or at least likely consider this to mean the solder point temperature, T_{sp} . The junction temperature, T_j , in typical LEDs in the 2010 to 2013 time frame would have been ~ 10 °C above ambient T_{sp} . In particular, per the Cree Design Guide for Cree X-Lamps, T_j is higher than T_{sp} by an amount equal to the LED power times the thermal resistance of the LED package which is given as 8 °C/watt. Exhibit 2083, p. 13 (in the box, under the “Example luminaire values” – see “ $R_{th\ j-sp} = 8\text{ °C/W}$ ”). Other manufacturers LEDs will typically be comparable, or higher, than this 8 °C difference, due to Cree’s best-in-class LED package thermal design. A POSITA therefore would take Hasnain to be referring to the solder point since whereas T_{sp} can be easily measured with a thermocouple or infrared camera, T_j can only be inferred from the manufacturer’s thermal resistance specification.

44. THERMAL DESIGN GUIDELINES: A general guideline for thermal management of LEDs circa 2013 can be found in Cree Application Note CLD-

AP15 rev 0E. Exhibit 2083 (“Cree Design Guide”) (from <https://www.scribd.com/document/359929637/LED-Luminaire-Design-Guide>).

Cree “X-Lamps” generally provided LEDs having the highest available temperature ratings in 2010 to 2013, so that their operating temperature guidelines may be considered to be upper limits, in particular for designing a successful luminaire with The Claim 1j(i)-(iii) Requirements for commercial image recording. Furthermore, the copyright date of the Cree document is 2007 – 2016, from which it is clear that the data is from 2016. Exhibit 2083, bottom p. 1. Therefore, LEDs in 2010 to 2013 at the Time of the Invention would have thermal limits no higher than those quoted in the Cree Luminaire Design Guide. Cree’s recommended T_j limit from their Design Guide is excerpted here: “*xLamp XR-E LEDs are rated to provide an average of 70% lumen maintenance after 50,000 hours, provided the junction temperature is kept at 80 °C or lower.*” Exhibit 2083 (Cree Design Guide), p. 8, bottom paragraph (italics added for emphasis). In fact, due to the combination of the need for maintaining the G/M 5 Point Limit and the CRI > 90 as well as the lumen output, and on film or TV set conditions such as wrapping a luminaire in black wrap or a gel and/or taping it against a wall where the thermal circuit is blocked or hampered, a POSITA would certainly not want to go above the Cree Design Guide recommended p-n junction 80 °C limit.

45. I should note here that I led a team that published an invited paper and presented on “Thermal Design of Integral LED Replacement Lamps” which was presented at the 13th International Symposium on the Science and Technology of Lighting (LS13), on June 26, 2012. Exhibit 2084 (Dr. Allen Thermal Design Paper). That paper’s thermal design applies to typical residential and office building and otherwise conventional lighting, not very high CRI, very low green luminaires for commercial image recording on a film or TV set. Accordingly, the statement that “[t]he temperature of the p-n junction typically must be maintained below ~ 100 - 150 °C for long life and high efficiency of an LED lamp or luminaire” is entirely consistent with the adoption of the Cree Design Guide’s 80 °C p-n junction temperature limit. See Exhibit 2084 (Dr. Allen Thermal Design Paper), p. 1 (first sentence). The paper states in the next sentence that “the thermal management system of an LED lamp ... is intended to replace a traditional lamp, e.g. in an Edison socket....” *Id.* (second sentence). Such a traditional lamp is not designed for the conditions (see below) of commercial image recording and is not designed for maintaining the high optical performance recited in claim 1 such as the G/M 5 Point Limit (1[j](ii)) and CRI > 90 (1[j](iii)).

46. Referring to the Cree Design Guide, T_j is higher than T_{sp} by an amount equal to the LED power times the thermal resistance of the LED package which is

given as 8 °C/watt, so that a typical 1-Watt LED will operate with $T_j = T_{sp} + 8\text{ °C}$.

Id., p. 13 ($T_j = T_{sp} + (R_{th\ j-sp} \times P_{LED})$), where P_{LED} is the single LED power consumption, i.e., 1 watt (per Holmes and Hasnain) and $R_{th\ j-sp}$ is the LED package thermal resistance which Cree gives as 8 °C/W. Exhibit 2083 (Cree Design Guide), p. 13.

47. Therefore, T_{sp} , the LED temperature which Hasnain refers to, should be maintained below 72 °C (“ **T_{sp} Max**”) in recommended thermal design. **Even assuming that Hasnain’s conclusion that his invention provides for only a 30 °C rise (“Hasnain Postulated Rise”) above ambient in a benchtop experiment, then the maximum ambient temperature, T_a , that can be tolerated with Hasnain’s solution is 72 °C (T_{sp} Max) - 30 °C (Hasnain Postulated Rise) = 42 °C (Ambient Max Before Design Deductions).**

48. JUNCTION TEMPERATURE VS. SOLDER POINT TEMPERATURE
DEDUCTION: However, Hasnain’s benchtop experiment ignores many critical thermal factors that must be considered in a Commercial Image Recording application as recited in Claim 1, e.g., 1[j](i)-(iii). Hasnain determined this 30 °C rise above ambient in a benchtop experiment, depicted in Figs. 2 and 3, copied below from Hasnain.

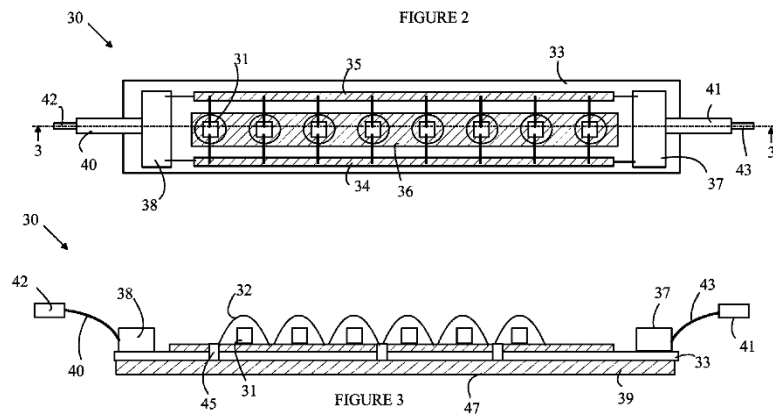


Exhibit 1008 (Hasnain), Figs. 2-3.

49. HOLMES USE OF HASNAIN FAILS TO ACCOUNT FOR A DIFFUSION COVER OF CLAIM ELEMENT 1[e]: A critical omission is Holmes' failure to account for a diffusion cover. In Fig. 2 of Hasnain, the LEDs (32) are depicted mounted onto electrical traces (34 and 35) which are mounted on an insulating layer (33) and thermally connected by vias (45) to the heat dissipating structure (39) below. The entire assembly (30) of Fig. 2 and of Fig. 3 is immersed in the ambient air of the laboratory as described in Hasnain (Exhibit 1008, Col. 4, lines 23-32). There is no mention of any type of enclosure surrounding the assembly (30) (in contrast to the cover recited in Claim 1[e]). Therefore the air flow around Hasnain's device would be substantially greater allowing for substantially greater thermal dissipation than that of the lighting device of Claim 1 given its cover and housing 1[e] and 1[f]. Therefore, Hasnain and thus Holmes fail

to provide any way to simulate the thermal impedance created by a T8 or T12 tube surrounding the assembly as in Claim 1[e] and 1[f]. Reinforcing this point, Hasnain refers to the surrounding air as dissipating heat:

In one aspect of the present invention, the LEDs are distributed on heat-dissipating structure 36 such that the surface area presented by the heat-dissipating structure is sufficient to dissipate a significant fraction of the heat of each LED to **the surrounding air** without the use of finned heat radiators or direct connections to larger heat-radiating Surfaces. In one embodiment, the LEDs are distributed such that the heat generated on heat-dissipating structure 36 is less than 1 watt per square inch of Surface area on the top Surface of heat dissipating structure 36.

Exhibit 1008, Col. 4, lines 23-32 (emphasis added).

50. Thus, Hasnain is presenting an analysis based on open air design of LEDs on a benchtop, not a luminaire having an enclosed diffusion cover and housing as in Claim elements 1[e] and 1[f]. A POSITA would recognize this and increase Hasnain's Postulated Rise of **30 °C** LED temperature above ambient air design guidance to a substantially greater temperature rise to make sure to account for a Diffusion Cover and housing as required by '895 Patent Claim 1, element 1[e] and 1[f]. Due to the thermal insulation created by enclosing the assembly of claim 1 with a fluorescent form factor (e.g., T8 or T12) tube formed by the cover

and housing, the ambient air (or other gas) inside the tube will be substantially warmer than the ambient air surrounding the claimed luminaire. Thus, Holmes has failed to reach the invention as recited in Claim 1 and has also failed to show that a POSITA would have a reasonable likelihood of success.

51. ACCOUNTING FOR A DIFFUSION COVER: Due to the thermal insulation created by enclosing the assembly of Figs. 2 and 3 of Hasnain with a T8 or T12 tube, the ambient air (or other gas) inside the tube will be substantially warmer than the ambient air surrounding the assembly (30) of Hasnain. This insulating effect of a T8 or T12 would have on Hasnain's benchtop result is at least the same insulating effect provided by the T8 or T12 tube of a fluorescent lamp. Hasnain's LEDs, even assuming for purposes of argument that they can provide 70 – 100 LPW, if enclosed will shed the same amount of heat as a fluorescent lamp operating at 70 – 100 LPW, and that equivalent amount of heat in the two cases will be insulated from the ambient air by a T8 or T12 tube having at least the same insulating properties for either an LED tube lamp or a fluorescent tube lamp if not more (due to the Diffusion Cover of 1[e]). Therefore, the temperature inside the tube of the LED lamp will be approximately equal to the temperature inside the tube of the fluorescent lamp. It is well known by a POSITA that a standard 32 – 34 Watt, 4-foot T12 fluorescent lamp from 2010 to 2013 operates most efficiently

when the cold-spot temperature of the tube (typically located at a bottom of the tube, while the top is considerably hotter) is about 40 °C when operated in 25 °C ambient air. Exhibit 2085 (Lamptech Effect of Ambient Temp), p. 1, 1st paragraph.

52. Given that the cold-spot temperature of a fluorescent lamp in 25 °C when operating in ambient air having $T_a = 40$ °C, then the average temperature over the entire T12 tube will be significantly higher, e.g., at least about 45 °C, thus at least about 20 °C higher than ambient air if ambient is 25 °C. **Therefore, the assembly (30) of Hasnain may be expected to operate at least about 20 °C (“Cover Temp Component”) higher when mounted inside the T8 or T12 tube of an LED luminaire product.** Given this 45 °C interior luminaire temperature, the maximum ambient temperature, T_a , that can be tolerated with Hasnain’s solution is 72 °C (T_{sp} Max) – 30 °C (Hasnain Postulated Rise) – 20 °C (Cover Temp Component) = 22 °C (“Maximum Ambient Allowable”). Therefore, even without considering the range of ambient temperatures under use conditions, and even assuming that Hasnain’s Postulated Rise is correct, Hasnain’s solution leaves zero engineering margin relative to an actual ambient air temperature to account for factors related to applications of the luminaire, especially the unusual and high application-specific demands of Commercial Image Recording applications. A POSITA would not design a luminaire to work based on 22°C (about 72 °F)

without a margin of safety or consideration of the range of ambient temperatures under use conditions. In fact, due to the combination of the need for maintaining the G/M 5 Point Limit and the $CRI > 90$ as well as the lumen output, and on film or TV set conditions such as wrapping a luminaire in black wrap or a gel and/or taping it against a wall where the thermal circuit is blocked or hampered, a POSITA would certainly not want to go above the Cree Design Guide recommended p-n junction $80\text{ }^{\circ}\text{C}$ limit.

53. HASNAIN AND HOLMES FAIL TO ACCOUNT FOR NEARBY EQUIPMENT HEAT AND STUDIO SET AMBIENT, AND LOCATION CONDITIONS: For example, the ambient temperature on the set of a Commercial Image Recording application should be designed for significantly higher than the usual $T_a \sim 25\text{ }^{\circ}\text{C}$ because of the unusually high load of heat-producing equipment (e.g., adjacent lighting and/or limited air flow locations), and people on the set. Even assuming for purposes of argument that $T_a \sim 25\text{ }^{\circ}\text{C}$ is maintained for the comfort of the actors and crew, then the temperature in proximity to the high-wattage light sources will be significantly higher, especially when banks of lights are located close together. See Exhibit 2041 (Csernecky), e.g., ¶s 7, 9 and its Exhibits 2042 and 2043. The luminaire for a Commercial Image Recording application must be designed not for the best case thermally (i.e., not assuming just

$T_a \sim 25\text{ }^{\circ}\text{C}$), but for a typical case or even a worst case, which may involve $T_a \sim 45\text{ }^{\circ}\text{C}$ (“Ambient Temp for Design”) for the air in close proximity to the lights. **Given the likely $45\text{ }^{\circ}\text{C}$ ambient temperature of a Commercial Image Recording application proximate the lighting devices, Hasnain’s thermal design will be overheated by at least about $23\text{ }^{\circ}\text{C}$ (“Baseline Overheat”), i.e., $45\text{ }^{\circ}\text{C}$ (Ambient Temp for Design) – $22\text{ }^{\circ}\text{C}$ (Maximum Ambient Allowable).** Overheating will be more severe in scenarios on set using black wrap or gels or taping a luminaire to the wall compromising or otherwise further hampering cooling. See Exhibit 2041 (Csernecky), ¶s 24-27 and Exhibit 2044 (lighting tube taped to a wall).

54. THERMAL EFFECT OF INCREASED OPERATION POWER TO OVERCOME LUMEN PENALTIES: Furthermore, Hasnain and Holmes omit another key factor. That is, in order to meet the rigorous color quality demands in a Commercial Image Recording application in 2010 to 2013, a correction factor of over 35% for the claimed elements 1[j](ii) and 1[j](iii) ($\text{CRI} > 90$ and the G/M 5 Point Limit) as explained above, the LED tube must be operated at over $1/(1.00 - 0.35) = 54\%$ higher power to provide the same luminaire lumen output as a standard luminaire with typical CRI and color deviation in 2010 to 2013. Note that since Hasnain has not specified any CRI or color deviation of the LEDs, the below analysis is provided for purposes of argument. A POSITA would not even be able

to do such a thermal analysis based on Hasnain's incomplete specification. In fact, a simple thermal management principle may be used to estimate the extent of LED overheating in a 45 °C ambient air, inside the T8 or T12 tube (with a diffusion cover), with a power loading of 1.4 W/inch vs. 0.9 W/inch (54% higher power). With Hasnain's 0.9 W/inch loading it was established above that T_{sp} (72 °C) operates 50 °C higher (30 °C (Hasnain Postulated Rise) + 20 °C (Cover Temp Component)) than T_a (22 °C). If the power loading is increased by 54% in order to provide the required color quality for a Commercial Image Recording application, then that temperature difference between the heat source (T_{sp}) and the heat sink (T_a) will also increase by 54%, since the heat transfer is dominated by convection, which scales linearly with the temperature difference. So, the temperature difference of 50 °C will increase to $1.54 \times 50 \text{ °C} = 77 \text{ °C}$, i.e., yet another 27 °C overheated (**"Color Adjustment Overheat"**).

55. Assuming for purposes of argument and illustration that only 54% higher power is needed, and the above calculations that Hasnain's solution would operate the LEDs at least 23 °C higher than the LED rated temperature in a Commercial Image Recording application (i.e., $T_a \sim 45 \text{ °C}$) with a color quality of CRI = 80 and green about five to ten points above the Black Body, operating with a T8 or T12 tube even before considering all of the lumen losses discussed above.

56. Given Hasnain's incomplete specifications of the luminaire including incomplete specifications for the LEDs for 70 – 100 lumens per Watt, neither a POSITA nor Holmes would be able to do a meaningful thermal analysis.

57. ADDITIONAL LIKELY THERMAL CONCERNS FOR COMMERCIAL IMAGE RECORDING USE WITH GELS OR WRAP OR THE LIKE: In addition to the need to account for this at least 54% increased power (even assuming best case scenario) in a POSITA's thermal design of the luminaire of Claim 1, the LEDs would be subject to even significantly greater overheating in a likely scenario in a Commercial Image Recording application whereby the T8 or T12 tube is covered with a black wrap and/or a gel (a transparent colored material that is used in theater, event production, photography, videography and cinematography to color light and for color correction) for adjustment of color or intensity. See, Exhibit 2041 (Csernecky) ¶¶ 24 to 27. The trapping of light energy by the color correcting wrap or gel will further overheat the luminaire, and the LEDs contained inside by potentially another 10 °C to 20 °C and possibly more.

58. Even without accounting for the additional 10 °C to 20 °C and possibly more for use of gels and/or black wrap or the like, Hasnain's solution, which he

asserts will work only below one watt per inch would not be viable for a real world luminaire with a Diffusion Cover and housing as recited in Claim 1[e] and 1[f], and particularly not where such a luminaire has the 1000 Lumen Minimum, G/M 5 Point Limit and CRI > 90 for Commercial Image Recording as recited in Claim 1. Rather, a POSITA would not have a reasonable expectation of success in using any of Hasnain's teachings to achieve a luminaire for Commercial Image Recording as recited in Claim 1, and particularly not if trying to use Ianiro's low green/magenta deviation teaching and Ducharme's CRI greater than 90.

59. CONCLUSION: In view of the above, my conclusion is that Hasnain's solution, would be at least 23 °C ("Baseline Overheat") overheated in the high ambient temperature of a Commercial Image Recording application even before considering the elements of Claim 1. Then when adding in the overheating due to having to use at least 1.4 W/inch to overcome the lumen penalties for use of LEDs having CRI > 90 and the G/M 5 Point Limit the design is overheated by a minimum of about 50 °C. This is calculated by adding 27 °C ("Color Adjustment Overheat") + 23 °C (Baseline Overheat) = 50 °C ("Minimum Overheat") when used to provide acceptable color quality, i.e., the CRI > 90 and the G/M 5 Point Limit and having a Diffusion Cover in a Commercial Image Recording application. Since the trapping of light energy by the color correcting wrap or gel will further

overheat the luminaire, and the LEDs contained inside by potentially another 10 °C to 20 °C and possibly more, the target maximum 80 °C T_j of the LED would then operate at a disastrous 140 °C to 150 °C or more (80 °C + 23 °C + 27 °C + 10 °C to 20 °C), resulting in unacceptable color, photometric and chromaticity stability and extremely short life, and thus a POSITA would not have a reasonable expectation of success.

60. DISASTROUS EFFECTS OF HEAT ON CRI, G/M AND COLOR CORRECTED TEMPERATURE (CCT): Excessive heat can drastically change the SPD (Spectral Power Distribution) of a phosphor-coated white LED, with some colors (wavelengths) enhanced and some depressed, greatly and irreparably affecting CRI, CCT and G/M color deviation from the Black Body. See, Exhibit 2086 (Color Shift Report), p. 8. Moreover, significant color shifts occur at a rate of about four times as fast increasing the junction temperature by just ten degrees from 75 °C (at 75% humidity) to 85 °C (at 85% humidity) (reinforcing the Cree Design Guide p-n junction temperature limit). Exhibit 2086 (Color Shift Report), p. 19 (“The move from 75/75 to 85/85 corresponds to an acceleration factor of approximately 4X.”) This rapid rate of degradation shows the sensitivity of the phosphors and substantial deleterious effects of even small increases in temperature and/or humidity. The Color Shift Report concludes that “Further

research is required to understand the different color shift mechanisms in the different luminaire subsystems and to develop accelerated testing methods and predicative models to further improve the manufacturer's ability to bring color-stable lighting products to the customer." Exhibit 2085, p. 26 (bottom). The Color Shift report was in 2017 and shows the relatively unpredictable nature of LED luminaire design even as late as 2017.

61. The LPW, CRI, color temperature, and green/magenta deviation, and other attributes of phosphor white LEDs in 2013, and even to the present date, was very sensitive to the p-n junction temperature where LEDs get the hottest. The phosphors are applied in very thin coats, e.g., ~ 100 um, in different colors in order to obtain the different spectra of broad-spectrum white LEDs and thus CRI. Each color phosphor has a different sensitivity to heat. Red phosphors are typically the most sensitive to heat. Therefore, when heated too much, some phosphors (especially red) drop out more quickly than others (resulting in green shift and loss of CRI), irreparably damaging CRI, green deviation, color temperature and other attributes of the LEDs. In the Commercial Image Recording environment, due to the heat, CRI, green deviation and color temperature can all quickly be significantly distorted. While this distortion is sometimes temporary, the phosphors can quickly become permanently damaged, especially if the thermal design is

compromised by use of black wrap or gels, or by taping a lighting tube to a wall (Ex. 2044). See, Ex. 2041 (Csernecky Decl.), ¶s 24-27. A POSITA would need to limit the risk of thermal runaway where the LEDs heat up too much resulting in significantly degraded color quality.

62. CLAIMS 16 and 23: Because independent claims 16 and 23 recite all the above discussed elements present in Claim 1, the reasoning set forth above applies equally to these claims. CLAIMS 6 and 27: These claims specifically recite that the LEDs are Phosphor LEDs and depend on independent claims 1 and 23, and therefore the reasoning above applies to these claims as well.

III. A POSITA WOULD NOT HAVE A REASONABLE EXPECTATION OF SUCCESS IN TRYING TO CREATE THE DEVICE OF DEPENDENT CLAIMS 12-13 USING 42 WATTS

63. Issue 3: Would a POSITA have a reasonable expectation of success in combining Hasnain with Ducharme and the other references in Ground 2 (or Ground 1) in trying to achieve the combination of claim 1, where further including the 42 Watts Per Color to drive each of the warm white LEDs or the cool white LEDs in the embodiment recited in Claims 12 and 13?

64. My Opinion on Issue 3: Neither Hasnain nor Holmes nor any other reference in Grounds 1 and 2 provide any disclosure, suggestion, or motivation for a POSITA to apply 42 watts to the luminaire of claims 12-13. This element of 42 watts Per Color in claims 12-13, which is directed to the warm white LEDs or the cool white LEDs, is completely lacking in any of these references. Moreover, a POSITA would not have a reasonable expectation of success in attempting to combine the teachings of Hasnain and Ducharme and the other references in Ground 2 or any references in Ground 1 to achieve an LED luminaire of claim 1 and including the 42 Watts Per Color of Claims 12 and 13.

65. Specifically, Holmes relies on Hasnain's thermal design to assert that the power loading aspects of the '895 patent would be obvious to a POSITA. In Section II above, paragraphs 35 to 59, it was shown quantitatively that Hasnain's thermal management solution is far too inadequate for a T8 or T12 LED luminaire loaded at 0.9 W/inch, equating to 43.2 watts for a 48" linear tube. Thereby, it has been quantitatively established above that Hasnain's thermal solution is also far too inadequate for a T8 or T12 LED luminaire at 42 watts for a 48" linear tube, since 42 watts is only about 3% less than the 43.2 watts analysis of Section II above, supporting this conclusion as well.

66. In the case of such overheating, as well as the case of the overheating in Section II above, the enhanced thermal management solutions suggested in Figs. 4 and 5 of Hasnain would be needed because the luminaire would be using beyond the one watt per inch teaching of Hasnain. It is my opinion that a POSITA would not look to such drastic thermal management solutions as further explained below. But, even assuming for purposes of argument that a POSITA were to look to Hasnain's Figs. 4 and 5 in order to sufficiently cool the LEDs in a Commercial Image Recording application providing acceptable color quality (i.e., requiring at least 50 °C overheated as explained above), Hasnain's solutions would not work and would not be workable. One would need to resort to extreme measures such as Hasnain's Fig. 4 and 5 embodiments where the LED assembly is mechanically and thermally connected to the sheet metal enclosure of the lighting fixture (e.g., a troffer, or box). Such a connection incurs severe limitations in the usability and flexibility of the luminaire.

67. Hasnain's assertion, excerpted below, regarding the functionality of his proposed thermal management feature in Figure 4 is incomplete and incorrect:

However, more effective heat transfer can be provided by mounting light source 30 such that surface 47 is in thermal contact with the back wall of the existing fluorescent tube

enclosure. Refer now to FIG. 4, which is a cross-sectional view of another embodiment of a light source according to the present invention mounted against the back wall of enclosure 21 shown in FIGS. 1A and 1B. Light source 50 utilizes a heat-dissipating structure 52 that is part of heat-dissipating structure 59 and has a sufficient contact area with heat-dissipating structure 59 to assure that the thermal resistance between heat-dissipating structure 52 and heat-dissipating structure 59 is much less than the thermal resistance between the LEDs 51 and heat-dissipating structure 52. Heat-dissipating structure 59 has a surface 58 that is in thermal contact with wall 25 of enclosure 21 when light source 50 is mounted in enclosure 21.

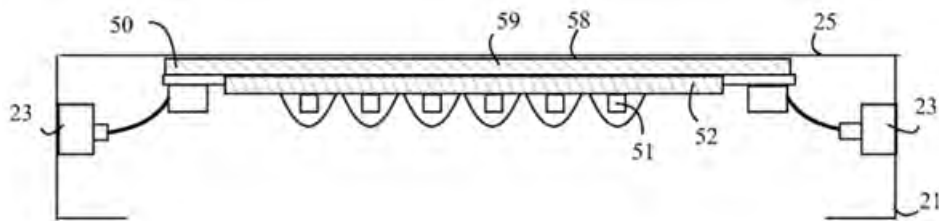


FIGURE 4

Exhibit 1008 (Hasnain), 4:58 – 5:6 and Fig. 4.

68. In the excerpt above Hasnain assumes that the enclosure (also called the luminaire or fixture) is in good thermal contact with the heat-dissipating structure. This would require a very large and highly unusual amount of thermal grease, involving an undesirable manufacturing process and expense. Moreover, the enclosure wall 21 must be rigidly mechanically attached to the heat-dissipating

structure 59, typically with screws, cement, or as suggested elsewhere in Hasnain, magnets. This would also be highly unusual and involve substantial undesirable manufacturing processes and expense. Moreover, Hasnain ignores the most challenging design feature of his proposed solution, and that is the thermal conductance of the enclosure 21. Exhibit 1008 (Hasnain) 6:21 – 26 (incorrectly noting that paint on the thermal enclosure is the only limiting factor to thermal conductance). Conductance is NOT primarily limited by the paint, contrary to Hasnain's assertions. Rather, it is primarily limited by the thermal conductivity and thickness of the metal of the luminaire.

69. Because independent claims 16 and 23 recite all the above discussed elements present in Claim 1, and because dependent claim 22 and 29 recite the 42-Watt Input and depend directly or indirectly on claim 23, the reasoning set forth above applies equally to claims 22 and 29.

IV. A POSITA WOULD NOT HAVE USED HOLMES LED BINNING SOLUTIONS BECAUSE THEY ARE TAKEN FROM THREE TO FOUR YEARS AFTER THE TIME OF THE INVENTION (AND RELY ON A NONEXISTENT BIN)

70. Issue 4: Would a POSITA at the Time of the Invention have been able to select LEDs from the binning standards referred to by Holmes?

71. My Opinion on Issue 4: In paragraph 51, Holmes states his understanding of ANSI standards pertaining to LED color binning. He references ANSI/NEMA C78 377A, which was published in 2008 as ANSI_NEMA_ANSLG C78.377-2008, the first such standard. Holmes specifically states:

51. By 2008, standards organizations realized the need to develop industry wide standards for chromaticity of LEDs. The American National Standards Institute (ANSI), a private, non-profit organization that administers and coordinates the U.S. voluntary standards and conformity assessment system, and the National Electrical Manufacturers Association, an ANSI accredited standards organization, jointly addressed the need and published ANSI/NEMA C78 377A. This standard specified standardized chromaticity bins for phosphor-based LEDs. Most LED manufacturers adopted the ANSI bins, but even those that did not provided a similar structure for a customer to specify the region in xy color space for purchased LEDs....

Exhibit 1003 (Holmes Decl.), ¶51.

72. These assertions in Holmes paragraph 51 regarding binning are misleading of both the state-of-the-art, and the published standards, at the Time of Invention. Rather than showing the binning diagram of the ANSI accredited

standard, ANSI/NEMA C78 377A, instead Holmes shows a binning diagram (Ex. 1003, top of p. 22) from a company called MADPCB which the company labelled as: “ANSI NEMA LED Binning Standard | Turnkey PCB Assembler | MADPCB.” MADPCB’s diagram is from at least three years after the Time of Invention, i.e., from at least 2016, and contrary to the assertions or implications of Holmes paragraph 51, is NOT an ANSI approved representation of LED binning. Rather, this reference is taken from an online commercial advertisement from MADPCB, a contract manufacturing service, <https://madpcb.com/>, promoting their own hypothetical, aspirational, unproven capability for solving the very complex challenge of LED binning. Exhibit 2087 (MADPCB 2016 Blog) (See diagram on page 1 and note **2016** initial copyright date near bottom of page 8). In contrast, the commercially available binning options at the Time of Invention are represented by the leading LED manufacturer, Cree, who provided a market-leading selection of color and brightness bins which are defined in great detail in Cree Application Bulletin CLD-AP22 rev 22 (2008 – 2014), Binning and Labeling, Cree® XLamp® XP Family LEDs. Exhibit 2088 (Cree 2008-2014 Binning Standards). (from <https://www.mouser.com/pdfdocs/xlampxpbinlabel.pdf>). Even Cree’s extensive binning selections provided only the following cool white LED bins, which shown in comparison to the ANSI cool white bins below, provides no sub-binning even

remotely similar to that misleadingly proffered by Holmes as being an option, whereas it was merely a hypothetical, aspirational commercial advertisement.

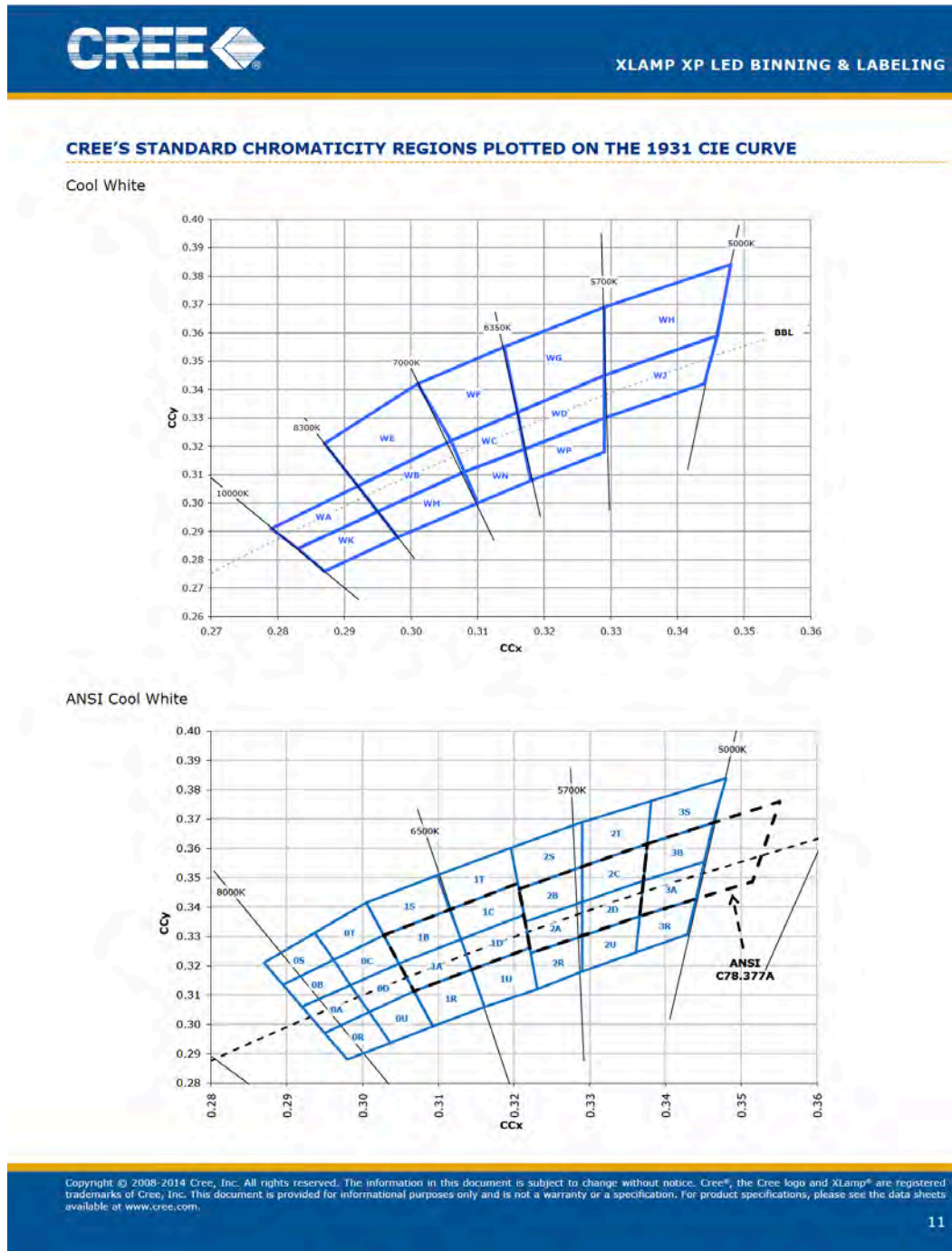


Exhibit 2088 (Cree 2008-2014 Binning Standards), p. 11. In addition to use of a hypothetical binning diagram which was not available to a POSITA in 2013 nor COLT INTERNATIONAL CLOTHING, INC. **EXHIBIT 2080**_Page 52 of 81

even now, Holmes’ statements regarding selection from “bin 573” (which does not exist anywhere to my knowledge) is incorrect. Holmes asserts as follows:

One wishing to produce a lamp producing 5600K output with very little shift towards green or magenta could simply specify LEDs binned in the right half of bin 573.

Exhibit 1003, ¶51 (on p. 22, below MADPCB diagram). The “right half” of bin 573 simply describes a CCT range > 5700 K, in contrast to the left half of bin 573 pertaining to a CCT range > 5700 K, irrespective of Green or Magenta shift, i.e., vertical deviation from the BBL.

73. In May’13, the ANSI standard (which is the only recognized industry standard in the US) for binning was ANSI c78.377-**2008**, which is shown below from ANSI_NEMA_ANSLG C78.377-2008:

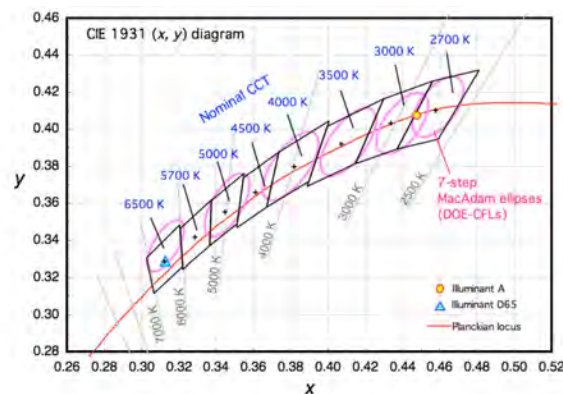


Figure A1, Part 1
Graphical representation of the chromaticity specification of SSL products in Table 1, on the CIE (x,y) chromaticity diagram

Exhibit 2089 (2008 ANSI Standards), p. 12 (PDF 14). Note that the binning for “cool” white ($> 5,000$ K) consists of two very broad bins (7-step MacAdam

ellipses, as labelled) – one for 5,000 K and one for 6,500 K, with no sub-bins internal to either of those two bins. Similarly, “warm” white (< 3,500 K) consists of three very broad bins – 3,500 K, 3,000 K, and 2,700 K - with no sub-bins. A POSITA would have been unlikely to try to get better selections than the existing binning per the ANSI 2008 standards and therefore it would not have been obvious to obtain or design for LEDs within the G/M 5 Point Limit of 1[j](ii). Accordingly, a POSITA at the Time of the Invention would also not have a reasonable expectation of success of any such design.

V. KIT WOULD NOT TEACH A POSITA TO USE A 28 WATT INPUT AND WOULD NOT ACHIEVE 1000 LUMENS

74. **Issue 5:** Is Kit’s disclosure of a 28-Watt T8 at Col. 4, line 63 to Col. 5, line 4 and Col. 6, lines 24 to 40 an actual LED lamp or is this a theoretical fictional construct?

75. My opinion on Issue No. 5: Kit’s description of the LED tube lamp photometric performance is a proposed LED lamp which is incorrect at least concerning lumen output, CRI, CCT, M/G color point, and luminaire lifetime. Accordingly, a POSITA would disregard it.

76. Here are the steps in Kit's logic to compare his proposed 4' T8 LED tube lamp with a 4' T8 fluorescent lamp.

77. First, Kit asserts a starting point as a 4' T8 fluorescent lamp, circa 2005 operating at 32 W with 2700 lumens for 360 degree output at a high color temperature (CCT) and 82 CRI. Exhibit 2004 (Kit) at 4:34-64. Kit then proposes a 4' T8 LED tube lamp powered by Cree LEDs having a 100° "beam output distribution" and further proposes that this hypothetical model "should produce 1040 (20 x 52) lumens...." Id. at 4:64-67. Moreover, Kit is using the entire luminaire to produce 1000 lumens.

78. Second, Kit asserts that twenty Cree X-Lamp 7090 white LEDs operate at 350 mA each, 1.4 electrical input watts, producing 52 lumens output at high CCT of 4500 – 8000 K, so that an assembly of twenty such Cree LEDs will provide 1040 (20 x 52) lumen output into a 100° beam output distribution. Id. at 4:63-64. This proposal ignores the lumen losses (except CRI) discussed in Section I above that must be considered when estimating the performance of an LED luminaire, based on the performance of the LEDs themselves. Following the analysis in this Declaration pertaining to Hasnains' assertions of LED luminaire performance, there are four correction factors to be made to the LED output to

convert it to expected luminaire output: optical losses, electrical losses, current droop and thermal droop of the lumen output of LEDs when operating at the elevated temperature inside a luminaire, which are substantial but indeterminate from Kit's proposed luminaire. See Section I above. Even if Kit's luminaire were as efficient as the GE Energy Star winning LED bulb (67%)(which I designed with others while at GE and which was in a bulb format, not T12), the net luminaire output would be $1040 - 0.33 \times (1040) = 697$ lumens, before any Color Correction and CRI Losses, which as noted in Section I above are substantial. There is also no accounting in Kit for drive current droop.

79. Holmes further presents an analysis referring to Kit that postulates an input of 42 watts, over 90 CRI and over 1000 lumens. Holmes sets forth his proposed luminaire in paragraphs 141-142 copied below for reference:

141. The LED lighting device disclosed in Kit can produce light that is at least 1000 lumens, both when the first LEDs are lit and when the second LEDs are lit. In support, Kit provides examples of LEDs capable of reaching 1,040 and 1,200 lumens. Id. at, e.g., 4:63–5:4 (“The tubular 4-foot LED lamp model should product [*sic*, produce] 1040 (20x52) lumens in a vertical direction beam output distribution over 100-degrees...”)(emphasis added), see also, e.g., 12:21–32. In addition, Kit discusses certain LED

lights of the time, e.g., from Luxeon, capable of achieving 17 lumens per LED (well over 1,000 lumens on a four-foot system), or “high flux 120 lumens 5-Watt white LED” lights. Id. at 21:20–34. The desired lumens can easily be calculated by taking the lumens per LED multiplied by the number of LEDs.

Exhibit 1003 (Holmes), ¶141.

80. Using the same analysis as above regarding Kit’s assertion of 1040 lumen output with 82 CRI for a 4’ T8 LED luminaire, it is clear that a POSITA would not consider Kit to teach a luminaire with the claimed 1000 Lumen Minimum, the G/M 5 Point Limit and the CRI > 90 per 1[j](i)-(iii). As noted above, Kit’s luminaire at best is 697 lumens and that is without consideration of all losses to get the claimed G/M 5 Point Limit and the CRI > 90, which add over 35% more losses, leaving Kit with an efficiency of about 44% (i.e., 0.67×0.65) in an absolute best-case scenario, i.e., under 458 lumens (under 44% x 1040 lumens) and even if Holmes’ assertions of a 1200 lumen luminaire from Kit were assumed, luminaire output would be under 44% of 1200, i.e., under 528 lumens. Typically, the type of LED fluorescent replacement that Kit is discussing for a residential or office setting and likely would have no more than a 70 CRI for a cool white LED. Accordingly, the losses would be significantly more than 56% (i.e., $1.00 - 0.44$).

81. In Paragraph 142 (and elsewhere), Holmes asserts a hypothetical luminaire:

142. By way of example, Kit suggests that a Lumileds Luxeon K2 series LED can overcome the low light output per unit barrier. Id. at 3:39–41. The K2 LED was available in a gull-wing package with overall mounting dimensions of about 14mm by 10mm. For a T12 four-foot fluorescent tube, a POSITA could conservatively use 64 K2 LEDs per row in the longitudinal direction and three rows across the width of Kit's support structure. Dividing the LEDs into two arrays, means a POSITA could easily have two arrays of LEDs with 96 LEDs per array.... The K2 gull-wing parts were rated for an absolute maximum power of about five watts per package; however, the LEDs were significantly more efficient at lower power levels. At one watt, a cool white K2 LED could yield about 60 lumens, while a warm white could yield about 45 lumens. Even discounting the lumen yield for high CRI, the output would have been well over 1000 lumens and capable of well over 42 watts while maintaining a greater than 90 CRI.

Exhibit 1003 (Holmes), ¶142.

82. This proposed luminaire is not taught anywhere in any of the references in Grounds 1 and 2. Specifically it is not taught in Katzir and particularly not a 42-watt input. Katzir is targeting efficiency and hoping to design a luminaire with a 14-watt input. Exhibit 1006 (Katzir) at [0026]. None of the

references in Grounds 1 and 2 mention anything near a 42-watt input to an LED luminaire. Furthermore, Holmes' assertions ignore the thermal loading accrued by operating 96 LEDs per array, presumably at 1 Watt per LED (Holmes omits any details), creating a thermal load of about 96 Watts in the 4' LED tube. He's merely describing geometrically how many LEDs he can squeeze into an LED tube in order to provide at least 1000 lumens output, without any consideration for the thermal environment which would overheat the LEDs by $> 100^{\circ}\text{C}$ beyond their rated temperature.

83. Combining Katzir's disclosure with Kit, Ducharme and Ianiro to try to get to 1000 lumens would not achieve that. In paragraphs 143-144 of the Holmes Declaration, Holmes asserts that Katzir "allows for a much higher lumen output":

143. A POSITA could fit hundreds of LEDs on a four-foot linear support structure. Id. [Ex. 1004] at 4:13-26 (disclosing 5 mm LEDs). In fact, Katzir discloses that, while 225 LEDs is preferred, upwards of 400 LEDs may be placed in a fluorescent tube form factor. Ex. 1006 at [0029]. **This allows for a much higher lumen output than 1000 lumens** when the first or second LED lights are lit.

144. A POSITA would have been motivated to achieve a higher CRI when using Kit's LED lighting device to

accomplish high quality image capturing. Ducharme teaches that a POSITA would have “appreciated that the color temperature and/or CRI of light is critical to creators of images, such as photographers, film and television producers . . .” Ex. 1005 at 4:1–5. A light with poor CRI “may cause colored surfaces to appear distorted.” Id. at 3:60–67. Typically, LEDs having lower CRI values under light red objects, making them appear darker, and having less detail, than real life, while over lighting blue and green objects. Ducharme teaches that to achieve a high-quality LED light for image capturing, you want “CRIs measure[d] in the high 90s.” Id. at 25:37–43. This disclosure teaches a CRI greater than 90.

Exhibit 1003 (Holmes), ¶s143-144.

84. Paragraph [0029] of Katzir says nothing about 1000 lumens. In fact, quite surprisingly, Katzir does not use the terms “lumens” or “LPW” or “efficacy” anywhere. There is no quantification of the light output anywhere in Katzir. The closest mention is in paragraph [0026] where he asserts without explanation that: “A lighting assembly 100 may be designed to consume approximately 14 watts of electricity, while outputting as much light as a fluorescent light that consumes approximately 32 watts.” Exhibit 1006 (Katzir) at [0026]. If a fluorescent lamp is taken at about 3100 lumens, a POSITA would then understand Katzir to be claiming LEDs (**even before any losses of Section I above**) to produce 3,100

lumens divided by 14 watts, or about 221 LPW. Obviously a POSITA would disregard this “teaching” as impossible (over three times the lower end of Hasnain’s 70 – 100 LPW LEDs).

85. Regardless of how many LEDs Katzir may teach (225 to 400) the idea that a POSITA could use his teachings to design a luminaire that can produce 1000 lumens with one half of the LEDs is unsupported and again fails to take into account significant lumen losses such as any of the Luminaire Losses and any of the Color Correction and CRI Losses and significant thermal issues.

86. In view of the above, Kit whether taken alone or in combination with Ducharme, Katzir and Ianiro as proposed in Ground I has not been shown to reach the 1000 Lumen Minimum of claim 1, in the lighting device of claim 1 with elements 1[b], 1[c], 1[d], 1[e] and 1[j](i)-(iii) as explained above. And, a POSITA would not have a reasonable expectation of success trying to create a luminaire as in claim 1 including the 1000 Lumen Minimum.

87. CLAIMS 16 and 23: Because independent claims 16 and 23 recite all the above discussed elements present in Claim 1, the reasoning set forth above applies equally to these claims.

VI. A POSITA WOULD IGNORE KIT'S REFERENCE TO GE LIGHTING'S OLED PANEL

88. Issue No. 6: Would Kit's disclosure of GE Lighting's 24-square-inch OLED panel driven by 80 watts suggest to a POSITA that anywhere near that wattage may be applied to a luminaire such as that of claim 1?

89. Opinion: The thermal issues involved in using an OLED in an open air panel are much different from those of an LED tube light such as in claim 1 with a Diffusion Cover and a housing as in 1[d] and 1[e]. GE Lighting's OLED panel was an experimental, uncovered panel which therefore was subject to open air cooling conditions while the claimed invention has a Diffusion Cover which presents significant thermal issues as discussed above in Section II. Therefore, a POSITA would not take Kit's discussion of GE Lighting's OLED panel as a suggestion to use 80 watts or anywhere near that.

90. Kit's reference to GE Lighting's OLED panel is as follows: "GE Lighting in the first quarter of 2004 ... produced a very bright 24 square inch OLED panel producing well over 1200 lumens of light with an efficacy of 15 lumens per watt and a power consumption of about 80-watts." Exhibit 1004 (Kit) at 12:22-26. Kit's reference to the 2004 GE OLED provides no description of the

thermal management of that OLED. Kit also misinterprets the size of the GE OLED panel by a factor of 24x, by calling it a “24 square inch OLED panel”, whereas the GE publication (Exhibit 2082) clearly identifies it as a “24-inch by 24-inch panel”. So, the GE OLED had 576 square inches of surface area for thermal management. From having worked on the early GE OLEDs myself, I know that they were not commercially viable product embodiments, but rather experimental laboratory devices, where we provided whatever thermal management was required to maintain the OLED at a low enough temperature to enable benchtop measurements of photometric (not thermal, nor lifetime) performance, typically involving the use of heat sinks and fans, if necessary. The inference made by Kit that a 24 square inch OLED, embodying extreme measures to manage the heat load of 80 watts of input electrical power, is misleading, and skewed by the 24x error in surface area. Holmes’s analysis carries through Kit’s huge error. Specifically, Holmes relies on Kit’s reference to GE Lighting’s experimental OLED to imply (that since the OLED product was only 24 square inches and could produce 1200 lumens of light) that one can thermally manage 80 watts of input power to a four-foot T12 luminaire. Holmes asserts that “a four-foot T12 form factor provides 72 square inches of mounting for LEDs”, but such assertion overlooks that this GE OLED provided 8 times as much surface area for cooling the device. But, for reasons as noted above, the 24 square inch number is wrong according to Exhibit

2082 and moreover, extrapolation based on or comparison between GE Lighting's experimental OLED device using a large surface area and a four-foot T12 would be summarily dismissed by a POSITA.

91. Kit's reference to GE Lighting's OLED panel would be disregarded by a POSITA trying to design a tubular LED luminaire with a diffusion cover as recited in claim 1. Moreover, Kit's reference to a 24 square inch panel is contradicted by an announcement of the OLED feat by GE Lighting, which states that the "demonstration OLED device [was] a 24-inch x 24-inch panel..." Exhibit 2082 (GE Global Research OLED), p. 1 (second paragraph).

92. In addition, while Holmes asserts that a T12 has 72 square inches of mounting space for LEDs, this is not correct. Holmes has not accounted for the Diffusion Cover of Claim 1 and the housing (1[d], 1[e]). In a covered T12 LED luminaire, the cover and its attachment to the housing take up some space and it is poor design to mount LEDs up to the edges. In addition, the luminaire has an end or ends for receiving power. Typically, there is no more than $1.5'' * 44'' = 66$ square inches of LED mounting space. Nonetheless, the comparison between an aggressively cooled benchtop OLED and a commercially viable LED T8 or T12 luminaire is overly optimistic by about an order of magnitude ($\sim 10 \times$). Moreover,

given that the OLED was 24" x 24" per Exhibit 2082, the 80 watt input was spread over 576 square inches, not 24 square inches.

93. CLAIMS 16 and 23: Because independent claims 18 and 23 recite all the above discussed elements present in Claim 1, the reasoning set forth above applies equally to these claims.

VII. DUCHARME'S PROPOSED HIGH CRI EMBODIMENT OF FIG. 16 IS A FICTIONAL CONSTRUCT BECAUSE THE PROPOSED LEDs DO NOT EXIST

94. Issue No. 7: Is it possible to get a CRI over 90 by using the embodiment of Fig. 16 of Ducharme?

95. My Opinion on Issue 6 is explained below. Conclusion: Ducharme does not teach a POSITA at the Time of the Invention how to find such LEDs as in Figure 16 as they do not exist and therefore a POSITA would not have a reasonable expectation of successfully constructing a luminaire with three or fewer such nonexistent LEDs.

96. Ducharme asserts that high CRI can be achieved from an RGB LED tube using at least three different LEDs with different peak wavelengths chosen far

enough apart. This three-LED embodiment of Ducharme is a fictional construct for high CRI because it requires red, green and blue emission spectra that are unattainable, and therefore cannot be replicated by a POSITA. Accordingly, any fewer LEDs than three, e.g., two-LED embodiment, would also be a fictional construct.

97. The graphic provided below shows a complete range of 17 “monochromatic” colored LEDs (plus 5 phosphor-coated white LEDs) from violet through red that were used in LED color research at NIST, showing that a complete range of LEDs was available in 2009 providing any color of interest, and yet none have a spectral width nearly wide enough to satisfy Ducharme’s Fig. 16. The width of colored LEDs is a fundamental attribute, not adjustable by design, so that the widths shown here in 2009 would be the same as available in 2013, as confirmed by a similar graphic below from LED color research published in 2019.

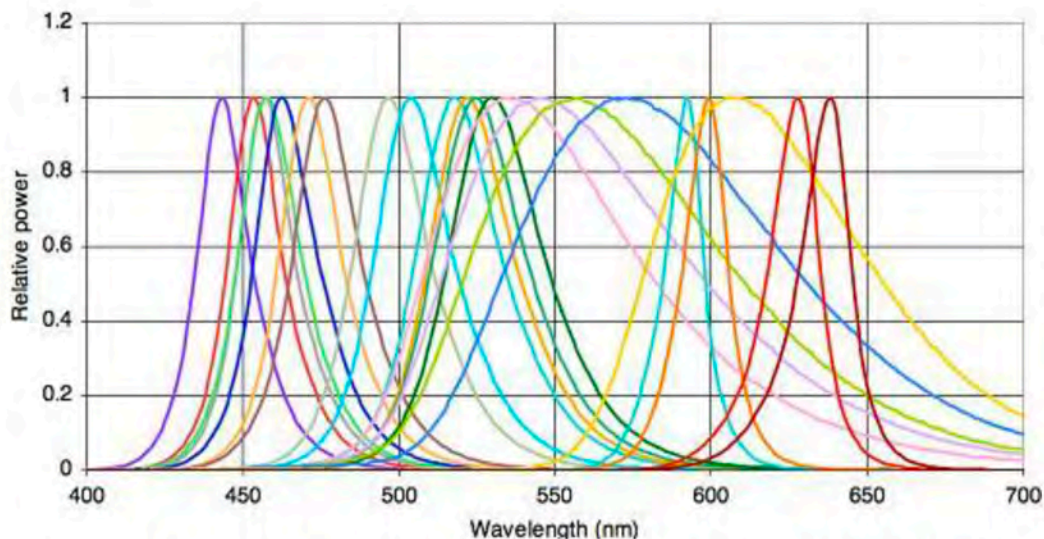


Figure 2. The spectra of the 22 color channels of LEDs currently installed in STLS.

Exhibit 2090 (Miller NIST Paper), p. 2, Figs. 1-2.

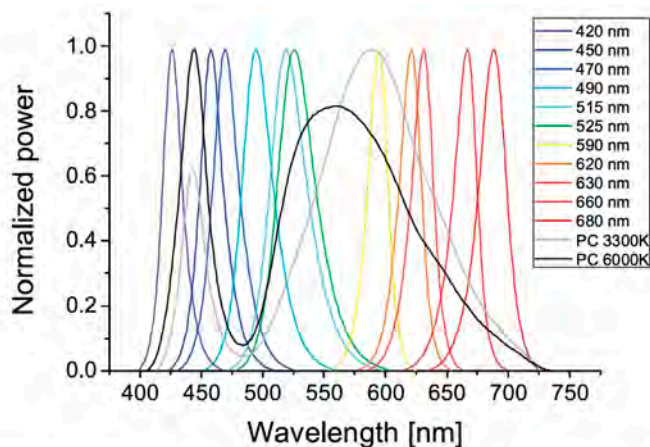


Fig. 1. Relative spectral power distributions of LED components of the source; LEDs were power-supplied with a maximum current.

Exhibit 2091 (Blaszczak Tunable LED Source), Fig. 1 at p. 155 (PDF 3).

98. There is a description in Ducharme of a high CRI embodiment in Fig. 16, reproduced below for reference.

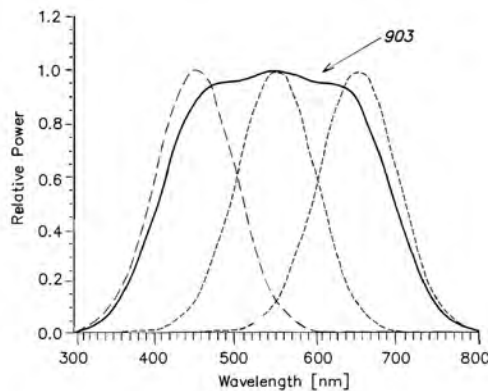


FIG. 16

Exhibit 2005 (Ducharme), Fig. 16.

99. At Column 25, lines 16-35, Ducharme states that a POSITA would only understand Ducharme to be saying that two different CCTs may be achieved by adding the spectra from three LEDs, e.g., red, green and blue LEDs which allow for a two dimensional area (a triangle) to be available as the spectrum for the resultant fixture; that two dimensional area including the Black Body Locus on which the two desired CCTs lie, and that a POSITA may generate alternate CCTs:

One embodiment of the current invention includes three different colored LEDs. Three LEDs allow for a two dimensional area (a triangle) to be available as the spectrum for the resultant fixture. One embodiment of a three LED source is shown in FIG. 16.

The additive spectrum of the three LEDs (903) offers less control than the nine LED lighting fixture, but may meet the

criteria for a high-quality white light source as discussed above. The spectrum may be continuous without dramatic peaks. It is also controllable, since the triangle of available white light encloses the black body curve. This source may lose fine control over certain colors or temperatures that were obtained with a greater number of LEDs as the area enclosed on the CIE diagram is a triangle, but the power of these LEDs can still be controlled to simulate sources of different color temperatures. Such an alteration is shown in FIGS. 17a and 17b for 5000K (1001) and 2500K (1003) sources. One skilled in the art would see that alternative temperatures may also be generated.

Exhibit 2005 (Ducharme), Col. 25, lines 16-35 (added).

100. However, Ducharme is NOT asserting that the three LEDs used in Fig. 16 are available, or even possible. Rather the three LEDs represent hypothetical spectral power distributions (“SPDs”) from which certain desirable CCTs along the black body locus may be obtained. However, in fact, the three red, green and blue LED SPDs shown in Fig. 16 were not available in November 1999 (Ducharme’s priority date), nor in March 2013 (Time of the Invention), nor even today – not with red, green and blue LEDs, nor with any phosphor emission excited by a blue LED or any other phosphor-coated LED.

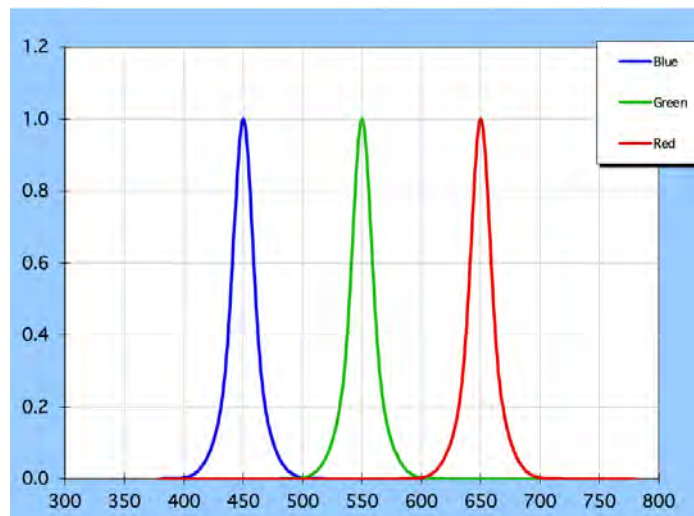
101. At the Time of the Invention, there were no commercially available white phosphor-coated LEDs having CRI > 90 by virtue of the combination of three LED phosphors. Only recently (years after 2013) have the requisite LED phosphors been available.

102. It may be reasonably assumed by a POSITA that Ducharme's LED spectra may be represented by gaussian distributions, which are typical of most visible LEDs. A chromaticity calculator is available from the National Institute of Standards and Technology (NIST) which calculates CCT, CRI, and other photometric outputs for any given input Spectral Power Distribution (SPD). Exhibit 2090 (see e.g., p. 3, section 3); Exhibit 2092 ("Rationale of Color Quality Scale").

103. A peer-reviewed chromaticity calculator is available from the National Institute of Standards and Technology (NIST) which calculates CCT, CRI, and other photometric outputs for any given input SPD (spectral power distribution). See, generally, Exhibit 2090 (and Abstract).

104. The NIST calculator has been used herein with input SPDs with the same peak wavelengths (same "color") as those depicted in the fictional

mathematical construct of Ducharme's Fig. 16, peaking at 450, 550, and 650 nm as shown in Ducharme's Fig. 16. However, since LEDs with SPDs as broad as Ducharme's Fig. 16 do not exist, the chromaticity calculation with NIST calculator includes realistic widths of about 10 nm Full-Width at Half-Maximum (FWHM) for the three LED SPDs, as depicted in the graphic below excerpted from the NIST calculator. The result from the NIST calculator provides a CRI of only 49, far short of the requisite $\text{CRI} > 90$ for Commercial Imaging Recording. Accordingly, Ducharme's high-CRI fictional construct will only achieve about half his target CRI. The result of my calculation is shown below:



VIII. 2013 LED LUMINAIRE DESIGN

105. In 2013, design of LED luminaires was focused on efficiency of lumen output and on achieving lumen output to try to match legacy luminaires such as fluorescent and metal halide discharge lamps. LED luminaire design was also at

least somewhat unpredictable relative to the impact of the thermal management design and the ambient thermal environment of the application on luminaire maintenance of lumens and color shift, as well as lifetime; and in the photometric specifications of the LED and the resultant LED luminaire even when specified from a selected manufacturer's chromaticity bin.

106. When designing an LED luminaire at the Time of the Invention and indeed even today, there were and are numerous tradeoffs. In contrast to the Petitioner's assertions, one cannot simply cherry pick desirable LED qualities and desirable luminaire qualities and expect to successfully design a luminaire.

108. As explained above, the calculations and factors presented herein are exemplary since Petitioner and the cited references have not provided complete specifications. There may be other factors that become relevant.

109. The conclusion, to one skilled in the art, is that at the Time of the Invention of the '895 Patent, the simultaneous achievement of these three critical claim elements related to green, CRI and lumens were technically achievable, but that the usual design approach of maximizing lumens from then-inefficient LEDs would have likely resulted and be expected to result in unacceptable levels of green

or CRI. In my opinion, one point of novelty and nonobviousness of the claims of the '895 Patent is the focus on the challenging aspects of color quality (green and CRI) in the given application along with at least a 1000 lumen output in each color temperature, when the primary focus in the LED industry was on efficacy and lumen output and also when taking into account thermal issues. In addition, the specific G/M 5 Point Limit on color deviation, when in combination with the other elements of the claims, is novel and would not have been obvious particularly given that the standard LED binning at the time was within a seven-step ellipse.

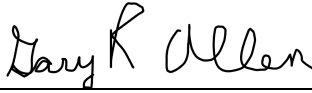
I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

In signing this Declaration, I understand that the Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge 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.

I declare under penalty of perjury that the foregoing is true and correct.

Executed this 4th day of February 2024 at Aurora, Colorado.



Gary R. Allen

APPENDIX A

Gary R Allen, PhD

Cleveland, OH

APPLIED PHYSICIST, LIGHTING

*Developing Innovative Lighting Technology and Products for 33 years
Available for Nationwide, International, or Remote Consulting*

*LED Lamps and Luminaires - Optics - Thermals - Systems
Spectral Tailoring - Human Centric Lighting, Circadian, Disinfection, Algae cultivation
Legacy lamp technologies: Metal Halide, CMH, LFL, Halogen, Automotive
Patent & Infringement Analysis*

Education

Princeton University – Princeton, NJ

PhD in Astrophysical Sciences, Plasma Physics Division, 1980

MS in Astrophysical Sciences, 1977

Pennsylvania State University – State College, PA

MS in Nuclear Engineering, 1975

BS in Nuclear Engineering, 1974

BS in Engineering Science, 1974

Experience

Expert Witness – see below

Executive Scientist with Aeroclenz, Inc. 2020 to present

Develop technology, products and IP for Disinfection Lighting using ultraviolet and other light sources, driving FAA approval to install UV-C Disinfection on all US commercial aircraft.

Consulting Scientist with GE Current 2020 to 2023

Develop technology, products and IP for Disinfection Lighting using ultraviolet and other light sources.

Chief Technology Officer, PHYCO2 LLC 2018 to present

Create sustainable commercial algae production while sequestering carbon dioxide (CO₂) emissions as part of carbon capture and utilization operations.

President, Wellness Lighting, LLC 2017 to present

Wellness Lighting's mission is to provide innovative lighting products that are based on recent scientific and medical breakthroughs to improve health and wellbeing, but that are not yet available to the public.

President, Gary Allen Consulting, Inc. 2016 to present

Gary Allen Consulting, Inc. provides consulting and expert witness services related to lighting technology, products, and intellectual property.

- Lighting Technology services include consulting or co-development of innovative technologies to enable your company to create first-to-market, value-added products, applications, and associated intellectual property.
- Lighting Product services include consulting or co-development of new products based on LED, and other SSL sources, for novel lighting applications, especially for the rapidly emerging applications of Spectrally Enhanced, Circadian, Horticultural, Algae, Disinfection, and Bio-active Lighting.
- IP services include Expert Witness for litigation; Prior Art and IP Landscape analysis; Patent and Claim Strategy; IP training for your staff.
 - Expert Witness in one Arbitration case including Trial 2018; one Consulting case 2017
- Available for Nationwide, International, or Remote Consulting

Principal Engineer, Engineering Manager, 1987 to 2016 GE Lighting Cleveland, OH

- 2013 Presented the first ever TED talk on a Lighting Tech topic "A Lighting Revolution"
https://www.youtube.com/watch?reload=9&v=ghwxAlmZF_A
- 2015 GE's highest corporate award for Distinguished Community Service – see Edutopia video: <https://www.edutopia.org/video/real-world-internships-lead-college-and-career-readiness>
- 2008-2016 Conceived product designs, and led concept development, of several of GE Lighting's flagship LED lamp product lines. Novel optical, thermal, system, and aesthetic breakthroughs resulted in \$10's MM sales, including
 - world's first PAR LED replacement lamp to meet or exceed the performance and aesthetic of Halogen lamps, enabled by a low-glare optic with a smooth beam and beautiful lit appearance (Visual Comfort Lens brand)
 - world's first Energy Star qualified A-line LED replacement lamp (Energy Smart brand), enabled by breakthrough optical and thermal designs, also resulting in the world's first LED replacement lamp to achieve 100 LPW
 - GE's first BR30 LED replacement lamp
 - world's first color-preference-enhanced LED replacement lamps (reveal® brand) A19 and BR30 lamps, and luminaires (reveal® TriGain™ brand), enabled by my co-development of a new state-of-the-art color preference metric, the Lighting Preference Index (LPI)
 - world's first LED display lighting that meets or exceeds all visual and performance attributes of the incumbent Low-watt Ceramic Metal Halide lamps (reveal® Whiter White brand) combining optical brightening for whiter whites with reveal® technology for enhanced colors
 - GE's first lighting to promote circadian health (Align™ & C-sleep brands); primary author of White Paper titled "GE Lighting - Lighting and Sleep"
- 1987-2008 Conceived new technologies and product designs; led concept development; managed programs and teams across every major legacy lamp technology within GE Lighting including Automotive; High Intensity Discharge (MH and CMH); Fluorescent; Halogen Thin Films; Incandescent.
 - As a program manager and team leader, established and led a lamp development team, and a production and sales operation of 7 engineers and technicians from 5/91 to 8/94. In 1996-7, as engineering team leader, led the growth of that engineering and production operation to 20+ people and \$2MM sales.

- o As an applied physicist, developed advanced, innovative new lamp products through the invention, engineering, and production phases, in the areas of metal-halide lamps, halogen lamps, and thin film technology.
- o Provided innovative leadership in the technical training of GE employees, in corporate volunteer activities, and in the recruiting and hiring of new employees.

Research Physicist, 1985 to 1987

Sylvania Lighting Danvers, MA

Independently developed laser-based diagnostics for arc discharge and halogen lamps. These included laser absorption, laser-induced fluorescence, and Rayleigh scattering measurements of gas and plasma parameters. Conceived and initiated the development of several novel concepts for new lamp products.

Member of Technical Staff, 1980 to 1985

Sandia National Labs Albuquerque, NM

Independently developed and implemented several novel, advanced, laser-based diagnostics on terawatt pulsed-power accelerator experiments in the Ion Beam Nuclear Fusion program. These were nanosecond-resolution techniques using Ruby, Nd:YAG, and HeNe lasers.

Ph.D. Research Associate, 1977 to 1980

Princeton University Princeton, NJ

Independently discovered and investigated a new plasma instability in a Q-machine plasma. Published all the essential linear and non-linear, experimental and theoretical properties of the instability as it related to plasma transport in Tokamak nuclear fusion reactors.

Issued U.S. Patents (92 count)

11,541,136	Light Disinfection System and Method
11,666,674	Light Disinfection System and Method
10,960,090	Light Disinfection System and Method
10,890,301	LED Lamp with Encapsulated Driver and Safety Circuit
10,862,009	Encapsulant modification in heavily phosphor loaded LED packages
10,861,690	LED apparatus employing neodymium-fluorine materials
10,833,228	Enhanced color-preference LED light sources using YAG, nitride, and PFS phosphors
10,648,642	LED Apparatus Employing Tunable Color Filtering using Multiple Nd and Fl Compounds
10,422,484	LED lamp with uniform omnidirectional light intensity output
10,381,527	Enhanced color-preference LED light sources using YAG, nitride, and PFS phosphors
10,240,772	Lightweight heat sinks and LED lamps employing same
10,240,087	Enhanced color-preference LED light sources using lag, nitride, and PFS phosphors
10,208,943	Lamps for enhanced optical brightening and color preference
10,197,230	LED lamp with internal mirror
10,196,565	Enhanced color-preference light sources
10,001,256	Structures subjected to thermal energy and thermal management methods therefor
9,981,052	Light disinfection system and method
9,974,138	Multi - channel lamp system and method with mixed spectrum
9,951,938	LED lamp
9,937,274	Light Disinfection System and Method
9,933,308	Method for determining spectrally tuned mixed-color LED light engines
9,680,067	Heavily phosphor loaded LED packages having higher stability
9,676,000	Lighting system w/ reflective coating having cross-linked polymeric powder and a pigment

9,618,165	LED lamp with uniform omnidirectional light intensity output
9,612,002	LED lamp with Nd-glass bulb
9,590,148	Encapsulant modification in heavily phosphor loaded LED packages for improved stability
9,534,743	Directional lamp with beam forming optical system including a lens and collecting reflector
9,416,952	Lighting apparatus with a light source comprising light emitting diodes
9,360,166	LED lamp with uniform omnidirectional light intensity output
9,327,309	Process for reclaiming inorganic powders from polymer-based coating compositions
9,233,510	Lenses for cosine cubed, typical batwing, flat batwing distributions
9,127,816	LED light engine/heat sink assembly
9,103,507	LED lamp with uniform omnidirectional light intensity output
8,864,346	Lens-reflector combination for batwing light distribution
8,864,339	Thermal solution for LED candelabra lamps
8,829,556	Thermal management in large area flexible OLED assembly
8,789,969	Compact LED light engine with reflector cups and highly directional lamps using same
8,757,836	Omnidirectional LED based solid state lamp
8,672,516	Lightweight heat sinks and LED lamps employing same
8,668,356	Lightweight heat sinks and LED lamps employing same
8,613,530	Compact light-mixing LED light engine and white LED lamp with narrow beam and ...
8,608,347	Lighting apparatus with a light source comprising light emitting diodes
8,593,040	LED lamp with surface area enhancing fins
8,541,933	Transparent thermally conductive polymer composites for light source thermal management
8,506,105	Thermal management systems for solid state lighting and other electronic systems
8,415,883	Miniature ceramic metal halide lamp having a thin leg
8,414,151	Light emitting diode (LED) based lamp
8,356,918	Compact beam former for induction HID lamp
8,247,959	Solid state illumination system with improved color quality
8,049,425	Gas-filled shroud to provide cooler arc tube
7,901,110	System and method for forced cooling of lamp
7,800,291	Low wattage fluorescent lamp
7,786,673	Gas-filled shroud to provide cooler arc tube
7,768,207	Highly emissive material, structure made from highly emissive material, and method of ...
7,642,719	Energy efficient fluorescent lamp having an improved starting assembly and preferred ...
7,443,103	High pressure lamp with lamp flicker suppression and lamp voltage control
7,394,200	Ceramic automotive high intensity discharge lamp
7,378,797	Fluorescent lamp with conductive coating
7,352,118	Optimized ultraviolet reflecting multi-layer coating for energy efficient lamps
6,621,219	Thermally insulating lead wire for ceramic metal halide electrodes
6,400,076	Xenon metal halide lamp having improved thermal gradient characteristics for longer ...
5,952,768	Transparent heat conserving coating for metal halide arc tubes
5,896,004	Double ended quartz lamp with end bend control
5,812,713	Optical coupling system with bend
5,774,608	Optical coupling systems with bend
5,676,579	Patterned optical interference coatings for electric lamps

5,675,677	Lamp-to-light guide coupling arrangement for an electrodeless high intensity
discharge ...	
5,587,626	Patterned optical interference coatings for only a portion of a high intensity lamp
envelope	
5,569,979	UV absorbing fused quartz and its use for lamp envelopes
5,552,671	UV Radiation-absorbing coatings and their use in lamps
5,526,237	Lighting system for increasing brightness to a light guide
5,420,769	High temperature lamp assembly with improved thermal management properties
5,388,034	Vehicle headlamp comprising a discharge lamp including an inner envelope and a ...
5,387,839	Electrode-inlead assembly for electrical lamps
5,357,167	High pressure discharge lamp with a thermally improved anode
5,283,563	Backlighting of nematic curvilinear aligned phase liquid crystal display panels
5,258,691	Metal halide lamp having improved operation acoustic frequencies
5,253,153	Vehicle headlamp comprising a metal-halide discharge lamp including an inner
envelope ...	
5,239,230	High brightness discharge light source
5,204,578	Heat sink means for metal halide lamp
5,198,727	Acoustic resonance operation of xenon-metal halide lamps on unidirectional current
5,196,759	High temperature lamps having UV absorbing quartz envelope
5,121,034	Acoustic resonance operation of xenon-metal halide lamps
5,107,165	Initial light output for metal halide lamp
5,047,695	Direct current (DC) acoustic operation of xenon-metal halide lamps using high-
frequency ...	
5,023,758	Single arc discharge headlamp with light switch for high/low beam operation
4,912,529	Apparatus and method to compensate for refraction of radiation
D732,709	LED lamp with an elevated light unit
D668,362	Lamp
D660,991	Lamp
D658,788	Light emitting diode (LED)-based light bulb
D646,409	Light bulb

Publications

1 invited chapter in a book; 10+ refereed journal articles; 20+ conference papers

Publications from the past 10 years:

Allen GR (2023) Continuous Disinfection of Cabin Air Using Safe and Controlled Levels of Ultraviolet Light, 93rd Annual Scientific Meeting of the Aerospace Medical Association, New Orleans, LA

Allen GR, Benner KJ, Bahnfleth WP (2022) Inactivation of Pathogens in Air Using Ultraviolet Direct Irradiation Below Exposure Limits. J Res Natl Inst Stan 126:126052.
<https://doi.org/10.6028/jres.126.052>

TEDxCLE presentation, “A Lighting Revolution”, April 2013

“Landmark Paper, Thermal design of integral LED replacement lamps” at the 13th International Symposium on the Science and Technology of Lighting (LS13), June 26, 2012

TEDxCLE presentation, “A Lighting Revolution”, April 2013
Expert Witness Experience

Start - End	Type of Case	Law Firm; Client	Case Name	Services Provided	Disposition
2/10/21 ongoing	Class Action Complaint	The Sultzer Law Group, P.C	Civil Action Wedra et. al v. Cree Inc.	Expert Witness Report; Deposition	Ongoing
3/29/21	Patent Infringement	Rothwell, Figg, Ernst & Manbeck, P.C., Plaintiff	Nichia v. GVL	Analysis	Settled out of court
1/6/21 1/18/23	Patent Infringement	Rothwell, Figg, Ernst & Manbeck, P.C., Plaintiff	Nichia v. Feit	2 Expert Reports; Deposition; Testimony in Jury Trial	Verdict favored Defendant
11/11/20	Patent Infringement	KIM IP, Defendant	Wangs Alliance Corporation v. CAST Lighting LLC	3 Expert Reports, one for each of 3 Exparte Challenges	Settled out of court
11/4/20	Class Action Complaint	Bursor & Fisher, PA	TBD	TBD	Product testing in progress
10/18/20	Patent Infringement	Ulmer & Berne; Plaintiff	HGCI, Inc. v. Luxx Lighting	Expert Witness Report prepared, not submitted	Settled out of court
10/16/20	Warranty Claims	Levin Ginsburg; Defendant	North American Lighting v. General Motors	Expert Witness Report; Testimony at Mediation	Mediation Settlement
4/1/20 7/3/20	Patent Infringement	Baker Botts LLP; Plaintiff	Autronics Plastics & Clearview v. Apogee & Smalls	Reviewed Infringement Claims	Pending
10/15/19 1/22/20	Class Action Complaint	Pearson, Simon & Warshaw, LLP; Plaintiff	Civil Action No. 4:17-cv-06252-YGR; Young et. al. v. CREE Inc.	Expert Witness Report; Deposition	Renewed Motion to Certify Class Denied; Daubert in Appeal
6/24/19 1/22/20	Patent Infringement	Steptoe & Johnson LLP; Defendant	ITC No. 337-TA-1164 (Lighting Science Group v. Leedarson	Expert Witness Report & Deposition	Closed
6/24/19 9/23/19	Patent Infringement	Steptoe & Johnson LLP; Defendant	ITC No. 337-TA-1163 (Lighting Science Group v. Leedarson	Analysis of Accused Products and Prior Art	Complaint withdrawn in favor of Defendant
1/6/19 2/20/19	Patent Infringement	Hoffman Patent Group; Plaintiff	USPTO Docket No.: 12-10060-CON-REEXAM	Expert Witness Declaration submitted to USPTO	key Patent Claims allowed to Plaintiff
5/1/18 8/30/18	Breach of NDA	Terpening, Wilder, Moors PLLC; Plaintiff	TVL International LLC v. Zhejiang Shenghui Lighting Co., Ltd. and Sengled USA, Inc.	2 Expert Reports; 4-day Testimony at AAA Arbitration	Plaintiff Awarded \$3,000,000
1/6/17 3/1/17	Patent Infringement	Wolf & Wolf, LLC; Plaintiff	Aamsco Lighting, Inc. v. Bulbrite Industries, Inc.	Consulting	Settled out of court

