GRAND CENTRAL TERMINAL’S ORIGINAL LIGHTING
ITS SIGNIFICANCE, ITS RELATIONSHIP WITH THE CURRENT SCHEME, AND RECOMMENDATIONS FOR ALTERNATE CONSIDERATIONS

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“If I have seen further it is by standing upon the shoulders of giants.”

You will never see Grand Central Terminal the same way, ever again.

---

1 Isaac Newton; adaptation from Bernard of Chartres's original quote, circa 1130.
ACKNOWLEDGEMENTS

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CHAPTER 1 - INTRODUCTION

SIGNIFICANCE

Grand Central Terminal's original lighting is an essential feature and constitutes a fundamental component of the station's interiors because its planning corresponds with the functional paradigm of coherence and clarity by visually distinguishing spaces, it is as important as architectural form in the main concourse in establishing the aesthetics character and style of the building, and it represents chief principles of the role of artificial lighting in the early the twentieth century. For these reasons, lighting should be considered an important part of what gets preserved in the building as it relates to architecture.

The lighting analysis will provide information to expand on the designation report from the Landmarks Preservation Commission (LPC) of the City of New York. On May 10, 1966, the commission held a public hearing on the proposed designation of Grand Central Terminal and its site as a landmark. The document stated the building's historical significance as follows:

Grand Central Terminal has a special character, special historical and aesthetic interest and value as part of the development, heritage, and cultural characteristics of New York City…. The Commission further finds that, among its important qualities... it is a magnificent example of French Beaux-Arts architecture; that it is one of the great buildings of America, that it represents a creative engineering solution of a very difficult problem, combined with artistic splendor; that as an American Railroad Station it is unique in quality, distinction, and character; and that this building plays a significant role in the life and development of New York City.²

A few years later the commission expanded the designation to include the terminal’s interiors on September 11, 1979:

The Interior of Grand Central Terminal is one of the finest examples of railroad station interior design in the world, it is a truly impressive, richly detailed, and grandly scaled example of the beaux-Arts style, its planning is a paradigm of coherence and clarity (Figure 1.1), allowing for exceptional ease of circulation and maximum passenger comfort, the use of ramps was an innovative concept, the Main Concourse (Figure 1.3) constitutes one of “the classic interior spaces in America,” the interior was designed by two notable architectural firms working in association, the beauty of style and plan of the interior (Figure 1.2) were predicated upon pioneering engineering and urban planning concepts, the interior continues to serve the city’s transportation needs effectively, it is also a vital civic
center, it is a treasured symbol of Manhattan, cherished not only by New Yorkers, but by visitors from all over the world.³

The following pages will demonstrate how lighting terminology defined the methods included in the original design and how they correspond with engineering principles and architecture. Illuminating engineers of the time fine-tuned a number of qualities of light and defined tasks, “solving the problem of more or less light, but also to create character in architecture.”⁴ Each space has one or more different approaches to solve practical problems. Engineers also stimulated sensitivity establishing relationships between use and experience. Those notions were already part of the practice when illumination science started developing. In this way, the lighting of the terminal surpasses the functional and technical aspects by establishing its own principles, opposing general trends and pre-established recommendations.

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³ Ibid.
HISTORICAL REVIEW

This historical account provides the necessary background to understand the significance of the terminal’s interiors and original lighting. This section also refers to secondary sources because it builds on statements of significance constructed well after the inauguration of the terminal and they evaluate the building’s influence and relevance throughout history.

“The first Manhattan terminal was opened in 1832 at Centre Street, near City Hall…. Trains were run by steam as far south as Fourteenth Street and pulled from there by horses.” Grand Central Depot opened in 1871 on Forty-second Street.

Between 1898 and 1900 it was enlarged; but it was soon inadequate; the discomfort and danger of running trains through the Park Avenue tunnel grew intolerable; and plans for rebuilding the terminal and electrifying south of the Harlem were well advanced when, in 1903, a State law required electrification and authorized the city to arrange for the use by the railway of the subsurface of streets near the station. The following extensive and expensive reconstruction process ensued. It involved the electrification, rearrangement, enlargement and rebuilding of yards and stations.

William J. Wilgus, chief engineer and later vice-president of the New York Central, presented his scheme in 1903 for a new project that included an urban development plan, the utilization of air rights above railroads, a hotel, and a complete re-systematization of levels to optimize train and passenger traffic. He described the existing depot’s “unattractive architectural design” and “unfortunate exterior color treatment,” as well as the “great blunder” of dividing the city for 14 blocks and obstructing Fourth Avenue. Shortly after, he requested architectural studies from four architectural firms, including Daniel H. Burnham of Chicago; McKim, Mead and White

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6 Ibid.
7 Ibid.
of New York; Samuel Huckel of Philadelphia; and Reed & Stem of St. Paul; to participate in a competition.¹⁰

Reed and Stem’s firm was selected initially for its experience in the design of stations for the New York Central Railroad, but mostly because of their “novel suggestion of an elevated exterior circumferential driveway with a bridge over Forty-Second Street connecting Park Avenue on the north with Fourth Avenue on the south in such a manner as to unite a striking architectural effect with convenience of access to the station.”¹¹ Contemporary author Sam Roberts suggests the decision was influenced by the fact that Allen H. Stem was Wilgus’s brother-in-law.¹² Yet, Charles Wetmore and the well-connected Whitney Warren, who was William K. Vanderbilt’s cousin, submitted an alternative design without consulting Reed & Stem.¹³¹⁴ After considering both proposals, the two firms constituted an organization known as the “Associated Architects of Grand Central Terminal” led by Charles A. Reed. Under those circumstances, “the partnership would be fraught with dissension, design changes and acrimony and would climax two decades later in a spectacular lawsuit and an appropriately monumental settlement.”¹⁵ Regardless, the terminal’s central feature, which was a system of public spaces to handle incoming and departing passengers, remained as a model of coherence and clarity, constituting a major gateway to the city.¹⁶

Architect and preservationist James Marston Fitch referred to railroad terminals as mechanisms, instead of gateways, considering the flow of pedestrian traffic and the different sorts of connecting systems.¹⁷ Certainly, the role of the Associated Architects would present an efficient architectural plan that would solve the difficulties previously encountered at the Depot by the elimination of stairs and smart use of connecting ramps. Widely used during the Roman Empire, ramps allowed chariot movement within

¹⁰ Stem and Fellheimer, *Inception and Creation of the Grand Central Terminal.*
¹¹ Ibid.
¹² Roberts, “100 Years of Grandeur: The Birth of Grand Central Terminal.”
¹³ Ibid.
¹⁴ Ibid.
¹⁵ Ibid.
¹⁷ Ibid.
fortified camps, but Grand Central Terminal would be the first railway terminal to use them in such a large scale (Figure 1.4). The Town Planning Review of Liverpool hailed the terminal as “the greatest railway terminal in the world” and stated the ease with which any person would use it “with the least possible confusion and the utmost tranquility and peace of mind.” The waiting areas and connecting rooms evolved and expanded as a consequence of increasing demands for useful space and improved comfort levels, along with a desire to make better use of air and light.

Figure 1.4 Sectional View Drawing of 1912
(General Sectional View of The Grand Central Terminal, Scientific American December 7, 1912, William J. Wilgus Papers, Manuscripts and Archives, New York Public Library)

A last-minute substitution replaced a skylight in the main concourse that would have allowed natural light to enter from above (Figure 1.5), but the architects opted for a symbolic representation and benefited from alternative design considerations Glass apertures would divide the vaulted surface, affecting the apparent endless space of the

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19 Fitch, Grand Central Terminal and Rockefeller Center: A Historic-Critical Estimate Of Their Significance.
interior. This change also conforms to the overall plan for the terminal building. Eight-hundred-thousand dollars of 1910 were spent on steel reinforcement to support a skyscraper whose floor loads averaged about one thousand eight-hundred pounds per square foot over the concourse and the average load from building walls was calculated to be about forty five thousand pounds per linear foot of the building wall (Figure 1.6).²¹ Engineers used the building code of the City of New York to calculate the loads for columns carrying buildings, and made complete structural studies to include a tall building in the future.²³ In addition, the average dead load per square foot of the roof construction was calculated to be around 540lbs, a large number due to the extent of void to cover below.²⁴

²² Roberts, “100 Years of Grandeur: The Birth of Grand Central Terminal.” 2013
²³ “The Grand Central Terminal Building: Warren & Wetmore and Reed & Stem, Architects.” 1913
²⁴ Ibid.
Despite the terminal's massive structure designed to support a skyscraper above encouraged the Associated Architects to provide as much natural light as possible. The National Ventilating Company installed puttyless-type skylights over extensive portions of the building, such as the “light courts” on the north and south sides of the concourse.\(^{25}\) This provided overhead natural lighting to the main concourse and surrounding spaces, and during the night, artificial lighting methods, explained in the following chapter, provided a similar type of light.

The designation report from the LPC established the significance of the terminal's interiors but does not refer to lighting specifically. The following terminology will establish the framework to understand how illuminating engineers included lighting ideas in the building.

\(^{25}\) Ibid.
This section establishes a parallel between terminologies used in the period of Grand Central Terminal’s construction and today. The purpose is to present the chief principles of theory and practice of artificial lighting after the first decade of the twentieth century. Some words changed with time, but their concepts remain the same.

The craft of electric lighting began before scientists could provide the required measurement tools. People first experienced electric light with lightning and static electricity.26 Similarly, Newton suggested “cohesion, light, heat, and the communication of the brain with the muscles were to be referred to the same cause: an electric fluid, which, as an ether or spiritus, pervades all bodies.”27 The Edison Electric Illuminating Company established the first electric district in lower Manhattan when Pearl Street Central Station started generating power on September 4, 1882.28 More than a decade later, illuminating engineers constituted their profession in America.29 In 1907 Clayton S. Sharp, president of the Illuminating Engineering Society (IES) described the challenges of the field at the time: “In the infancy of a science the concepts regarding it are necessarily neither very clear nor definite.”30 The profession would soon shift from a qualitative to a quantitative discipline the following years.

Illumination is a synonym of lighting, but historically it was also a quantitative term to measure light. The Illuminating Engineering Society of North America (IESNA) regards the term illumination as an alternative or inadequate term for illuminance.31 Louis Bell, consulting engineer and former president of the IES, presented a summary of artificial light characteristics and a range of technical applications in the Electrical

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28 Association of Edison Illuminating Companies, Edisonia (New York, 1904).
Engineers’ Standard Handbook of 1910. He defines Illumination as “a multiple of light emitted from a source in a unit distance, measured in foot-candles.” Today we call this illuminance, or the amount of light that falls on a surface. The society further indicates illumination is commonly used in a general sense to designate the act of “illuminating” or the state of “being illuminated.” This paper assumes the IESNA’s current use of the term illumination in its qualitative or common form, and illuminance as the quantitative term.

Consequently, illuminating engineering referred to the field of electrical engineering that dealt with artificial lighting, now called lighting design. The old term is not commonly used, except to indicate lighting design in its initial phase. In 1907, one year after the formation of the IES, member Charles Steinmetz described the spirit of their profession:

“Compared with other branches of engineering … we are at a disadvantage when dealing with light and illumination, because we have not to do so strictly with a problem of physics, but are on the borderline between applied physics, that is engineering, and physiology. Light is not a physical quantity, but is the physiological effect exerted on the eye by certain radiations.”

In addition to illuminance, Mr. Bell identified two other fundamental qualities of light, which were intensity and intrinsic brilliancy. He defined the term intensity as the amount of luminous energy given by any source with relation to the standard SI unit (International System of Units) or candela. This measuring unit is still in use today for...
luminous intensity, which is the radiant energy emitted by a source.\textsuperscript{40} The concept is analogous to water pressure in a hose.\textsuperscript{41} Intrinsic brilliancy measures luminous intensity per unit area of radiant surface.\textsuperscript{42} The current term, luminance, is the intensity of light emitted by a surface.\textsuperscript{43} This is the quality of light that allows the eye and the brain to perceive matter and space.

Given the looseness of definitions in early lighting literature as Mr. Sharp points out, this analysis takes the terms luminous intensity, illuminance, and luminance to replace the words intensity, illumination, and intrinsic brilliancy, respectively and as seen above. To better explain their relationship, the brain can discern from different luminous intensities but not measure them, and the eye can see luminance but not illuminance.\textsuperscript{44}

Lighting literature at the turn of the century also used concepts like light color, color value, distribution, direction, reflected illumination, and glare, but the terminology has changed.\textsuperscript{45,46}

Light color is now color temperature.\textsuperscript{47} It’s a numerical measurement of color appearance; technically “the absolute temperature on degrees Kelvin required for a blackbody to radiate a color spectrum most similar to that of a given light source.”\textsuperscript{48,49} Mr. Steinmetz considered color temperature to be an important subject in 1907 as new high efficiency light sources became available. He explains the light temperature phenomenon for incandescent lamps as follows:

The higher temperature reached by an incandescent body, the higher is the average frequency of radiation, and so a larger percentage of the total energy of

\textsuperscript{40} Descottes and Ramos, \textit{Architectural Lighting}. 2011
\textsuperscript{42} Bell, “Section 12: Illumination.” 1910
\textsuperscript{43} Descottes and Ramos, \textit{Architectural Lighting}. 2011
\textsuperscript{44} Malcolm Innes, \textit{Lighting for Interior Design} (London: Laurence King Publishing Ltd, 2012).
\textsuperscript{45} Bell, “Section 12: Illumination.” 1910
\textsuperscript{47} Bell, “Section 12: Illumination.” 1910
\textsuperscript{48} American Institute of Architects, \textit{Architectural Graphic Standards}. 2007
\textsuperscript{49} Rea, \textit{The IESNA Lighting Handbook: Reference & Application}. 2000
radiation is within the visible range, and is light. Thus the problem of efficient light production by incandescence is the problem of reaching as high a temperature as possible with the luminous body.\textsuperscript{50} However, incandescent material would burn with higher temperatures, and higher temperatures would reduce lamp life. According to 1907 standards, the carbon arc lamp emitted the whitest light while the incandescent lamp emitted an orange or yellow light.\textsuperscript{51} The recommendations for practical uses also depended on the way colors would appear under each of those lights.

*Color value* was the earliest term for *color rendering index* (CRI). CRI is “the degree of color shift a defined set of objects undergo when comparing their color illuminated by the light source to the color of those same objects when illuminated by a reference source of comparable color temperature.”\textsuperscript{52} It uses a scale from 1 to 100, where 100 indicate true colors. In other words, it establishes a comparison between colors under a specific light against a standard reference. Early experiments examined this quality with a spectroscope and employed analysis on aniline dyestuffs, a material that showed “curious selective absorption and reflection patterns.”\textsuperscript{53} According to Mr. Bell any light technology, except the enclosed arc and the mercury arc, was white enough and allowed the eyes to work comfortably and recognize true colors (by the standards of 1908). Experts established color rendering depended on the intensity of color emissions from the source. Even today, the modern system measures a wide range of colors depending on their technology.

Under those circumstances, engineers adopted photometric technology to measure light more accurately and soon developed their own methods to quantify light. These advances had made their way into the practice by 1913, and they included terms like *coefficient of reflection*, *normal brightness*, and *contrast*.\textsuperscript{54} This suggests the early stage of lighting design would inform and transform architecture. “It is, however, not

\textsuperscript{50} Steinmetz, “Light and Illumination." 1907
\textsuperscript{51} Ibid.
\textsuperscript{53} Bell, “Section 12: Illumination.” 1910
even the actual amount of light which enters the eye which is of importance in illumination, but the differences in this light.”  

Similarly, Mr. Steinmetz explains “Seeing takes place by the recognition of differences in color and in intensity. Seeing in intensity includes shadows. Shadows are thus an essential feature in seeing things.” And he adds,

... A mistake has been made for many years, by the gas industry, as well as the electric lighting industry, by devoting all energy to the production of light, to the development of the lamp, while it was left almost entirely out of consideration that the production of an efficient light is not the only important problem, but of equal importance is the arrangement of the light so as to get the efficient illumination, that is to get the greatest benefit from the light produced. This feature has been usually left to the tender mercies of the architect or the decorator, who placed the lights wherever he thought they would look artistic, everywhere there are cases of artificial illumination where the lamps have been arranged so that they give a very poor illumination from a large amount of light.”

Nonetheless, the professional discipline developed quickly after the creation of the IES.

The new technologies generating light by artificial means presented technical difficulties that encouraged the building industry to develop improved alternatives focusing on the artistic and aesthetic aspects of lighting. The National Electric Lamp Association recognized two primary methods of lighting a room within their parameters in the Railway Electrical Engineers’ 1912 Handbook. The direct method involved the use of ceiling, stud, frieze, chandelier, and bracket lights. In the simplest arrangement, illuminating specialists would locate lights near the ceiling with globes or reflectors to throw the light downward as specified in the handbook. A second practice involved embedded stud or frieze installations using frosted lamps in the absence of shades. The document indicated this form of lighting required a large number of outlets and was inefficient and expensive to operate. A third practice incorporated chandeliers and wall brackets to add decorative value in a room, but using

55 Steinmetz, “Light and Illumination.” 1907
56 Ibid.
57 Ibid.
58 Bender, Railway Electrical Engineers’ Handbook: Electric Light and Illumination. 1912
59 Ibid.
60 Ibid.
alternative diffusing techniques to conceal and distribute light in a different manner.\textsuperscript{61} The last practice presented involved table or desk lights to provide local illumination for reading and writing, an arrangement that could also enhance aesthetics.\textsuperscript{62} Nonetheless, by 1912 specialists in the practice of lighting were observing the increase in the “intrinsic brilliancy of common illuminants” (or luminance of common light sources) and recommended shades and reflectors to distribute light differently and protect the eye.\textsuperscript{63} Improved alternatives would adapt those technologies to a practical and sensible integrated design. As scientists developed technologies to furnish light sources with higher luminance levels, architects devised subtractive efforts alongside illuminating engineers to ensure visual comfort in their plans.\textsuperscript{64}

This document adopts a simplified system of classification using the most important attributes, of both historic and current sources, on lighting and presents a comparative scale to qualify and quantify light. This strategy does not disclose absolute light levels, but establishes a correspondence between all lighting methods in Grand Central’s Interiors using applicable standards.

**Simple, common, and special** illuminance levels quantify the density of light on a surface with relation to the type of task. Different activities require different illuminance values. Illuminance establishes a relation between light and matter, a concept that is specifically applicable to the purpose of this study, as opposed to luminous intensity or flux. It is important to realize that quantifying this value involves solving complex mathematical equations that modern software could render using bulb specifications, but it is an exercise that lies outside the scope of this thesis. Photography provides unreliable values to measure illuminance because exposure times alter those values. The length of this document explores the importance of illuminance, its relationship with luminance, and its relevance in preservation of historic interiors. Consequently, **High, medium, and low** luminance levels quantify light intensity emitted by surfaces. **Very**

\textsuperscript{61} Ibid.
\textsuperscript{62} Ibid.
\textsuperscript{63} Bell, *The Art of Illumination*. 1912
warm, warm, mid, and cool tones quality color temperature. Tall, average, and low height levels quantify the elevation of light sources and fixtures in relation to the ground plane. It is important to point out that the variable height used in lighting usually refers to the public or private character of a space. Linear and clustered describe distribution, while uplight, downlight and omnidirectional describe direction. Diffuse is soft light that produces soft shadows, where directed produces hard light and sharp shadows. Glare is the sensation produced by luminance within the visual field that is sufficiently greater than that which the eyes are adapted. Glare causes annoyance, discomfort or loss of visual performance and visibility. Intense light from lamps can produce direct glare, while their reflections – usually on specular or mirrored surfaces – can produce reflected glare.

The following section will demonstrate how illuminating engineers included ideas from their profession in the construction of the terminal for the benefit of transportation in New York.

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65 Descottes and Ramos, Architectural Lighting. 2011
CHAPTER 2 - CHAPTER 2: THE ORIGINAL LIGHTING

GENERAL FEATURES

This chapter will demonstrate how the original lighting scheme represents chief principles of artificial lighting at the time of Grand Central Terminal’s construction. The graph below (Figure 2.1) represents the role of electricity at the urban scale, affecting the physical configuration of the city. Light shaped people’s lives as a result of improved electrical systems to deliver light away from the power generators and into exteriors and interiors. Illuminating engineering was part of a larger subject in the realm of applied sciences, providing extended hours for transportation and urban life. Architects and engineers used train terminals and stations as advertisements to attract users, and helped establish new technologies by including and displaying them in their architecture. Grand Central was one of those terminals.

![Figure 2.1 Electricity Connecting New York to the North](Express Level, Grand Central Terminal: New York City, 1913, drafting, Electricity on the New York Central, The General Electric Company)

Metro-North could not provide access to the archive, which contains the original plans and building specifications. For this reason, this thesis does not present first-hand evidence of the original electric lamps used throughout the terminal. However, other primary sources revealed key information on recommendations and general specifications.

The General Electric Company included a section on illumination regarding Grand Central Terminal's interiors in the book *Electricity on the New York Central*
published in 1913. The book specifies a range of lamps within a general description of lighting methods; “Edison Mazda lamps equipped with various diffusing and reflecting devices are used throughout the terminal in sizes ranging from 25 to 250 watts, or from 20 to 200 candle-power each.” It also explains that the cornice of the main concourse had 150-watt frosted lamps within the cylindrical recesses below, and half as many 150-watt unfrosted lamps above it. Correspondingly, the 1912 *Railway Electrical Engineers’ Handbook* provides the same specification for high efficiency Mazda lamps, favoring their use in good railway uses over Carbon, Gem and Tantalum alternatives. *Mazda* was the trade name for the incandescent lamp with a tungsten filament. These lamps emitted light that “compared very favorably with actual daylight and the fundamental colors of red, blue, and green were such that colors and their shades appeared to be in their proper relationship with each other.” As seen in Table A, S-35-A specifications match all the descriptions presented above.

<table>
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<th><strong>MAZDA—STRAIGHT SIDE (200-260 VOLTS)</strong></th>
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**Table A Table Of Mazda – Straight Side Lamp Recommendations**


The S-35-A lamp lasted 1000 hours, surpassing the minimum of 700 hours indicated in New York Central’s engineering and equipment manual. The total lumen

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68 Ibid.
69 Ibid.
70 Ibid.
71 Ibid.
72 Ibid.
73 Ibid.
output was 1137, which was among the highest values within the efficiency range selected for the terminal.\textsuperscript{75} Comparatively, higher wattage elevated operating costs and rendered a whiter light, while lower wattage rendered insufficient illuminance. For this reason and with a relatively medium to high candlepower specification, frosting lamp was necessary to protect the eye from excessive luminous intensity. The 1912 publication includes a drawing of the lamp (Figure 2.2) that resembles the lamps from photographs of the fixtures (Figure 2.3). However, even though the correspondence between these sources might document the exact specification of the lamp, we cannot be certain that they are absolute evidence. Moreover, architects and engineers can change lighting guidelines during the last stage of construction if they decide to make adjustments and control excessive or insufficient light. In the future, researchers with an interest on the original lighting should consult maintenance records from the first years of the terminal’s operation.

\textsuperscript{74} Authors The New York Central and Hudson River Railroad Company, \textit{The Mechanical, Electrical, and Sanitary Equipment of the Grand Central Terminal, New York City - To the American Society of Mechanical Engineers / With Compliments of the New York Central Lines} (New York: The Company, 1912).

\textsuperscript{75} Bender, Railway Electrical Engineers’ Handbook: Electric Light and Illumination. 1912
All historic records, including photographs, indicate the use of “frosted lamps” throughout the main concourse and its surrounding spaces. *Frosting* was an alteration to the finish of the surface of globe glass. It was recommended to dissipate light, diffusing it in a uniform manner as opposed to clear glass. Engineers recommended this type for direct lighting methods to reduce glare. Lamp frosting in 1913 involved either sandblasting or acid etching and both processes provided almost indistinguishable results.76 Lamp manufacturers employed two methods with acid to adjust the glass surface of Edison lamps.77 One method involved applying acid frosting, while the other consisted in dipping lamps in paste, letting them stand for some time, and finally rinsing them with water. The latter finish was smooth and satin-like and was frequently used on regular Mazda lamp types.78 Other finish alternatives allowed designers to incorporate partially treated lamps using methods like “bowl-frosting” or “bull’s-eye-frosting,”

77 Ibid.
78 Ibid.
increasing lamp illuminance. Frosting was an important design consideration within the lighting methods introduced throughout the interiors of the terminal because it was a strategy to control luminance, as explained in the following section.

![Image 1](image1.png)

Figure 2.4 “The Midnight Sun” (General Electric Company, *Edison Mazda Lamp*, 1913, print advertisement, Ebay Seller, Courtesy eBay)

The following analysis uses the definitions established earlier to describe light quality of the original lighting design of Grand Central, specifically in the main concourse and its surrounding spaces.

**THE LIGHTING SCHEME**

The LPC’s designation report states “the beauty of style and plan of the interior were predicated upon pioneering engineering and urban planning concepts.”\(^{79}\) The statement of significance could expand on those concepts because the lighting design of the terminal fits in the category of “engineering concepts” and adds to the importance of the plan of coherence and clarity to serve the city’s transportation needs effectively because it defines those activities through lighting.

\(^{79}\) “Grand Central Terminal Interior (Designation List 137).”
The layout of the building corresponds to the logical arrangement of the different processes in a railroad terminal (Figure 2.6). Following Wilgus’s tentative plans, Reed & Stem introduced levels to “minimize cost, retard incoming and accelerate outgoing trains, and permit the use of ramps instead of stairways to train platforms.” The building operates as a buffer between the train tracks and the street, and the architecture filters flows and activities. As John Belle from Beyer Blinder Belle points out, “The terminal’s seemingly limitless capacity is the result not only of the superb pedestrian spaces but also of the railroad engineering technology that designed and built two loop tracks to service the upper and suburban levels of tracks.” The sequence of pedestrian spaces allows people to move easily, while the unobstructed architecture indicates the path to follow. For example, the ramp that descends from Forty-Second Street arrives in a passageway that provides direct access either to the main concourse or the suburban concourse below (labeled “Concourse” and “to Sub.Level” in plan). The proximity and perpendicular location of the ramp with relation to the adjacent spaces establishes a natural flow that allows people to see and know where they should go. According to author Kurt Schlichting, “Interior rooms, regardless of their size, had to lead logically from the entrance to the ‘main element.’ At the heart of a Beaux-Arts building, the central space, where the primary function of the building took place, provided the focal point for the entire design.” In the final proposal, the Associated Architects designed a terminal in which all paths followed a logical sequence in an organized hierarchy of spaces.

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80 Stem and Fellheimer, *Inception and Creation of the Grand Central Terminal*.
83 Stem and Fellheimer, *Inception and Creation of the Grand Central Terminal*. 
The main concourse is the largest space because it is the core of the building and it belongs in a number of processes within the terminal. This space is “275 feet long, 120 feet wide, and 125 feet high, framed at its eastern and western ends by 90-foot-high double-glazed walls with glass-floored walkways between them.” It has ticket booths on one side, train gates on the other, a clock and information booth in the middle, and a system of connecting stairs and passageways on the east and west ends. With a great number of access points, the main concourse has surrounding spaces (labeled “To Sub.Level” in plan) that expand the core of the building visually and spatially between robust spaced columns. The upper arched windows on the base of the barrel-vaulted ceiling of the main concourse and the skylights over the north and south galleries provide natural light that reflects on light colored surfaces (Figure 2.7). The monochromatic scheme echoes the 42nd Street façade, combining a pale yellowish color from Botticino marble on stairs; a sandy, tooled finish from imitation Caen Stone on walls; the pink tan color of Tennessee marble on floors; and the off-white colored

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84 Belle, *Grand Central: Gateway to a Million Lives*. 
plaster on lunette window decoration. The entire room has an appearance of natural stone that reflects light throughout. The original lighting scheme that used incandescent lamps provided the same general lighting, but added effects with a number of different methods to improve the efficiency of the terminal and enhance the experience of visitors.

![Figure 2.7 Preliminary Rendering](image)
*The Beautiful and Spacious Outbound Concourse, Grand Central Terminal Brochure, circa 1912, print advertisement, William J. Wilgus Papers, Manuscripts and Archives at New York Public Library, New York*)

![Figure 2.8 Winged Characters over Lunette Windows](image)
*Digital alterations: increase contrast, crop (Original: Harvey, photographer, *Main Concourse*, 1914, photographic print, Avery Architectural and Fine Arts Library, Columbia University, New York)*

The architectural features of the main concourse constitute a representation of nature with the play of colors, materials, and the effects of light. For example, the lunette window design incorporated sculptural plaster reliefs of winged locomotive wheels, branches of foliage symbolizing transportation, caduceus, and clouds (Figure 2.8). Similarly, ornamental works on stone and light fixtures have acorn and oak leaves, both elements that represent the Vanderbilt family. Furthermore, ever since the terminal opened, visitors recognized the barrel-vaulted painted ceiling of the stars as one of the

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86 Roberts, “100 Years of Grandeur: The Birth of Grand Central Terminal.” 2013
most attractive features (Figure 2.9). After the architects were unable to include actual skylights, they asked Paul César Helleu to consult in the design of the entire vault above. During his three-month visit to New York, he sketched out a concept of the concourse ceiling.\textsuperscript{87, 88} J. Monroe Hewlett developed the designs and Charles Basing and his associates executed the job, ensuring there would be no variation in the blue tone selected for the entire surface (Figure 2.10).\textsuperscript{89} To add to the effect, the team added gold leaf and sixty-five eight-candle-power miniature lamps as stars in the great vaulted ceiling.\textsuperscript{90}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2_9.png}
\caption{Figure 2.9 Rendering After Completion}
\flushleft{(H. Finkelstein & Son, \textit{Main Concourse Grand Central Terminal}, 1918-1925, print postcard, American Art Publishing Co. Collection, Museum of the City of New York, New York)}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2_10.png}
\caption{Figure 2.10 The Original Ceiling}
\flushleft{(\textit{Ceiling Over Concourse of Grand Central Terminal}, 1913, print article, Architecture, Forbes & Company, Courtesy The Internet Archive)}
\end{figure}

Similarly, the installation of indirect concealed lighting over the cornice provides a graded tone of color on the ceiling.\textsuperscript{91} This lighting method simulates the effect of sunlight on the atmosphere, with the lightest tones near the horizon. Lastly, early photographs of the main concourse show topiaries on the north and west balconies like plants in a garden (Figure 2.11 and Figure 2.12). The combination of those five elements constitutes the original outdoor theme of the main concourse, which combined natural and artificial lighting at different times of the day to magnify the effect.

\begin{flushleft}
\textsuperscript{88} Roberts, “100 Years of Grandeur: The Birth of Grand Central Terminal.” 2013
\textsuperscript{89} “Central Terminal Opening on Sunday.” 1913
\textsuperscript{90} The General Electric Company, \textit{Electricity on the New York Central}.
\textsuperscript{91} Ibid.
\end{flushleft}
The New York Times article published on January 29, 1913 recognized the importance of the ceiling’s form and color in relation to the concourse. The reporter said, “The shape of the ceiling allows a gradation of tone that gives an effect of illimitable space. The view presented is a section of the heavens seen from October to March, from Aquarius to Cancer. Extending across the ceiling from east to west are two broad bands of gold, representing the Elliptic and the Equator.”\textsuperscript{92} Additionally, according to the description of the New York Tribune article published in 1913, the ceiling was painted a “lovely blue; a light and airy scheme, fragile as it is essential in quality, of delicate and distinguished beauty.”\textsuperscript{93} This description is no scientific evidence of color, but it defines the type of tone they used and corresponds with the rest of the outdoor theme.

\textsuperscript{92} “Central Terminal Opening on Sunday.”
\textsuperscript{93} “M. Helleu’s Ceiling for the Grand Central Station (Matters of Art),” \textit{New York Tribune}, February 16, 1913.
Consequently, the drawings, colors, and shape of the ceiling represent the heavens and they combine by reflecting light in such a way to give the impression of an actual sky.

Illuminating engineers introduced light to visually distinguish spaces. A typical sequence would involve all lighting methods of the original scheme to connect the street and the trains. First, directed sharp light in low ceiling passageways and corridors guarantees safe and fast movement inside the terminal. Second, directed diffuse light in ramps and galleries indicates a transition between high and medium luminance areas. Third, diffuse light in the main concourse assists people in general activities. Fourth, concealed diffuse light on the ceiling of the concourse emphasizes spatial experience, affecting the mind and creating a memory. Fifth, directed sharp light in the distance attracts attention to ticket booths and signs. Sixth, directed sharp light on low ceiling passageways and corridors guarantees safe and fast movement to trains.

The following section demonstrates how those illuminating engineering concepts mentioned above constitute an important role in Grand Central Terminal. The purpose is also to show different ways to use incandescent lamps in a number of applications, how those methods enhance the aesthetics and style of the building, and how they contribute to establish the outdoor character of the main concourse.

METHOD 1

The first lighting method involves “general illumination,” also known as ambient lighting. 94 The approach exploited the functional aspects described earlier to amplify the experience. As Mr. Steinmetz pointed out in 1907, “Many places require general illumination where it is desired to see equally well everywhere ... to get the same intensity of illumination throughout the whole illuminated area.... This may be done by distributing a large number of small units around the cornices and reflect the light from white walls and ceilings, thus getting a very diffused illumination.” 95 Furthermore, illuminating engineer Luckiesh indicated the importance in the color of walls; “Perfect

94 Bell, The Art of Illumination. 1912
95 Steinmetz, “Light and Illumination.” 1907
diffusion is approached in a room with ceiling, walls and floor covered with the same light-reflecting material, with the direct light screened from the point in question.\textsuperscript{96}

Figure 2.13 METHOD 1: General Lighting

In the main concourse (Figure 2.13), approximately 300 high-efficiency frosted lamps shine under the cornice as \textit{direct diffuse downlights}.\textsuperscript{97} Located within white-painted cylindrical recesses between each modillion piece (Figure 2.15), these lamps deliver uniform light from the perimeter of a horizontal plane above.\textsuperscript{98} They define a hard


\textsuperscript{97} The General Electric Company, \textit{Electricity on the New York Central}. 1913

\textsuperscript{98} Ibid.
light over adjacent ornamental decoration organized in a linear arrangement. From their tall location (Figure 2.14), these frosted lamps render soft light on the horizontal ground plane below because, according to the law of inverse squares, as distance increases intensity decreases.  

Photometrical measurements from 1909 define the fundamental law of distances as “The quantity of light falling on a given surface varies inversely as the square of the distance from the source.”  

Illuminance levels of this arrangement would correspond today for simple tasks like orientation. Commuters can see from a distance and decide the path to follow, while visitors can linger. In addition, lamp height also expands the space and provides homogeneous light during the night in the same way as an overcast sky during the day. The effect is high luminance under the cornice, lighting the monochromatic palette of light-colored surfaces and distributing light in the most efficient manner. These surfaces shined under a “white light” according to 1913 industry standards that if compared with today’s temperature scale, would be classified as very warm-tone.

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99 Bender, Railway Electrical Engineers’ Handbook: Electric Light and Illumination. 1912
101 Descottes and Ramos, Architectural Lighting. 2011
102 Ibid.
Some lighting specialists of the time approved of the design, while others condemned it. Mr. Bell compared lighting immense closed spaces, such as exposition buildings, to the practice of outdoor lighting. He recognized the use of arc lights provided illuminance and luminance levels in these large spaces in relation to their use. However, he explains the reasons behind the choice of this kind of light source:

The work can, of course, be beautifully done with incandescent if enough are available, but at considerably lessened economy. (...) Incandescent lamps have a very high decorative value in connection with such work, but to be used effectively must be massed somewhere near the plane of illumination, lights in and about the roof being practically only for decorative purposes. Used in sufficient numbers, however, they give, in virtue of their complete subdivision of the illumination, a better artistic result than can be obtained with arcs.

In this way he describes the aesthetic qualities of the general lighting scheme of the main concourse. At the same time, the 1913 Railway Electrical Engineer’s Handbook mentioned the stud or frieze lighting form required a large number of outlets and it was

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103 Bell, *The Art of Illumination*. 1912
104 Ibid.
inefficient and expensive to operate, except with the use of a reflector.\textsuperscript{105} In terms of efficiency the best lamp was the one whose ultimate cost was the lowest; in other words, the combination of the cost of the lamp and the cost of power or longest useful life.\textsuperscript{106} With this in mind, engineers in charge of the lighting of Grand Central used Edison Mazda lamps, which surpassed others in those desirable qualities and were apparently the cheapest lamps to use.\textsuperscript{107, 108} Given these points, the engineers in charge of the terminal effectively introduced general lighting, as required for this space.

METHOD 2

The second lighting method involves direct lighting. The approach exploited the technical aspects of lamps for practical purposes, supplementing aesthetics in some of cases. With respect to proper lighting, Mr. Steinmetz explains that any method should “secure the correct distribution of light so as to give the desired amount of directed light used.”\textsuperscript{109} And he adds: “Light which is not used must be paid for.”\textsuperscript{110} Illuminating Engineers agreed the efficiency of lighting could improve using direct methods. While the direct method brought light to all spaces without interruption, indirect methods relied on reflection and refraction to redistribute light. With respect to the use of direct as opposed to indirect methods, “The proper place for the illuminant is outside of the field of vision. Where it cannot be so put, its intrinsic brilliancy should be reduced by diffusion.”\textsuperscript{111} Illuminating specialists recommended frosting the glass globes of lamps when used for the direct method to diffuse light. In Grand Central, a collection of hanging \textit{clustered} lamps bring light to surrounding areas in three distinct categories of distribution and direction.

\begin{flushleft}
\textsuperscript{105} Bender, \textit{Railway Electrical Engineers’ Handbook: Electric Light and Illumination}. 1912
\textsuperscript{106} The General Electric Company, “General Information on Incandescent Lamps.” 1913
\textsuperscript{107} Ibid.
\textsuperscript{108} The General Electric Company, \textit{Electricity on the New York Central}. 1913
\textsuperscript{109} Steinmetz, “Light and Illumination.” 1907
\textsuperscript{110} Ibid.
\textsuperscript{111} Ibid.
\end{flushleft}
The purpose of this method is to provide an efficient illuminance with the least amount of wasted energy, according to illuminating engineers of the time. J. Livingston and Co. Inc. carried out the electrical work using large amounts of material; there were approximately 6,500 outlets to control lights and other electrical equipment, including about nine hundred Metropolitan detachable mechanism push button switches.\textsuperscript{112} The Sterling Bronze Company designed and fabricated the chandeliers and Wm J. Kelly furnished the stamped metal ornaments that added decorative sparkle.\textsuperscript{113} While lighting experts recommended Mazda lamps for white light, they also opposed the use of dark

\begin{footnotesize}
\footnotesize{\textsuperscript{112} “The Grand Central Terminal Building: Warren & Wetmore and Reed & Stem, Architects.” 1913

\textsuperscript{113} Ibid.}
\end{footnotesize}
walls for interiors claiming they would diminish reflective efficiency.\textsuperscript{114} Engineers organized these fixtures in three categories (Figure 2.16).

One category is \textit{multidirectional diffuse}, which uses ten ellipsoidal fixtures (Figure 2.18) above the north balcony and south ramps (Figure 2.17). Another category is \textit{downlight diffuse}, which uses inverted cone chandeliers (Figure 2.20) to scatter light towards the ground plane of the waiting room (Figure 2.19).\textsuperscript{115} These chandeliers also included \textit{concealed uplight diffuse} on the top of the fixtures. The last category is \textit{direct concentrated downlight}, which locates suspended and surface mounted fixtures (Figure 2.22) to shine over passages, ramps and corridors (Figure 2.21). Even though all of them use bare frosted lamps, only the third category produces \textit{direct} and \textit{reflected glare} due to a relative \textit{low} height. Illuminance levels indicate \textit{simple and common} tasks. The effect is \textit{medium} luminance in the first category and \textit{high} luminance in the other two.

The monochromatic palette of light-colored surfaces shine under a 1913 “white light” classified today as \textit{very warm-tone}. The ellipsoidal fixtures add decorative value and its lamps provide enough light for passengers. The inverted cone chandeliers allow users in the waiting room to pause between the city and the trains and read in the benches. The illuminating engineers included directed light with chandeliers because it provided distinct ornamental character and their light was high enough it did not cause discomfort to the eyes. However, the suitability of exposed lamps in passageways is debatable. Incidence of high luminous intensity from artificial sources had the same effects of the sun’s rays, which have serious health consequences.

\textsuperscript{114} The General Electric Company, “General Information on Incandescent Lamps.” 1913
\textsuperscript{115} The General Electric Company, \textit{Electricity on the New York Central}. 1913
Figure 2.17 Category 1: North Balcony
(North Balcony, photographic print, 1913, Avery Architectural and Fine Arts Library, Columbia University, New York)

Figure 2.18 Ellipsoidal Fixtures - Detail
(North Balcony, photographic print, 1913, Avery Architectural and Fine Arts Library, Columbia University, New York)

Figure 2.19 Category 2: The Waiting Room
(Waiting Room, 1913, photographic print, Reed & Stem Archive at Wasa Studio, New York)

Figure 2.20 Inverted Cone Chandeliers - Detail
(Waiting Room, 1913, photographic print, Reed & Stem Archive at Wasa Studio, New York)
The direct lighting method received criticism a month after the inauguration of the terminal. The April issue of *Railway Electrical Engineer* in 1913 included a short opinion piece titled “Who Was Responsible.” The unnamed author brings attention to the exposed lamp or cluster of lamps glaring directly into the eyes comparing it with a slap in the face, calling it a “serious mistake”. This might suggest the reason behind the lack of technical literature in journals with respect to the terminal’s lighting. As stated, “it goes against a modern and rational way of handling artificial lighting, overlooking important lessons of a growing movement towards protecting the eye from injurious exposure.” However, this observation addressed just one aspect of Grand Central’s lighting scheme, claiming it deliberately opposed all recommended standards of the time of its construction. In the case of exposed lamps in the surface mounted fixtures over the passages, ramps, and corridors, designers were more concerned with luminance as

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117 Ibid.
118 Ibid.
opposed to illuminance, which means they associated functionality with efficiency. The fact that lamps became too bright seemed less important than *how efficiently* those lamps lit the spaces for movement.

**METHOD 3**

The third method involves indirect illumination, or cove lighting in this specific case. This method complements the former two and enhances the experience of the space, contributing to the significance and character of the main concourse. In broad terms, it consists in reflecting or refracting light by some attachment such as a reflector, or by reflecting light from the ceilings and walls on the objects of the room.\(^{119}\) “… It is obvious that white walls give the highest efficiency of reflected light. It is easy to observe that the same source of light in a room with white walls gives several times the intensity of illumination which it gives in a room with black or non-reflecting walls.”\(^{120}\) This way, the total amount of light is multiplied throughout a space and produces no glare if the reflecting surface is not specular. A modification of this is the “concealed lighting from cornices or special coves arranged near the ceiling whereby the lamps are completely concealed from the floor and act entirely by diffusion of light from the ceiling.”\(^{121}\)

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\(^{119}\) Steinmetz, “Light and Illumination.” 1907. p20

\(^{120}\) Ibid.

\(^{121}\) Bell, “Section 12: Illumination.” 1910
In Grand Central, the purpose of this method is to provide additional general lighting using a reflective surface to distribute diffuse light below (Figure 2.23). A linear concealed arrangement of unfrosted lamps above the cornice “furnish a brilliant illumination to the ceiling, bringing out in a most effective style the allegorical figures of the constellations, planets, and the Milky Way.”\(^{122}\) The indirect diffuse uplights remain fixed on silver reflectors, rendering a “white light,” classified today as very warm-tone. There are one-half as many lamps of the same size as those beneath the cornice, but with unfrosted globes.\(^ {123}\) Luminance dissipates from medium to low from the area near the light sources on the side of the ceiling to the center of the sky mural. The resulting

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\(^{122}\) The General Electric Company, *Electricity on the New York Central*. 1913  
\(^{123}\) Ibid.
effect simulates the effect of the sun on a clear sky (Figure 2.24). Additionally, clear glass lamps provide a bright luminance of hard light that shines on all ornament located above the cornice, giving it a very dramatic effect (Figure 2.25). The lighting method combined with the light surface above, the shining stars, and the vivid ornament of wings and clouds stimulates contemplation.

Most lighting specialists of the time thought indirect illumination was the most comfortable to the eye. Mr. Marks compares the direct and indirect methods for domestic interiors; “The tendency now is to compromise between these two extreme limits by the use of units in which the lamps are concealed by diffusing shades of glass or other material, the lighting thus being carried out partly by direct but mainly by indirect means.” 124 However, Mr. Bell considers that the efficiency of this method depends on each case. 125 Even though the majority of publications mention the vaulted ceiling’s design, none of them mention the indirect lighting method associated with it.

124 Marks, “Tendencies in Illuminating Engineering.” 1913
125 Bell, The Art of Illumination. 1912
Additionally, all photographs show a similar luminance between the different parts of the arched windows and the ceiling (Figure 2.26 and Figure 2.27). This means they would shine uniformly, but it does not mean they were the same color.\textsuperscript{126}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2-26.png}
\caption{Similar Luminance But Different Materials - Detail \newline \textit{(Ceiling and Ornament, 1913, photographic print, Reed & Stem Archive at WASA Studio, New York)}}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2-27.png}
\caption{Similar Luminance - Detail \newline \textit{(Main Concourse, looking south, Grand Central Terminal, 1900-1915, photographic print, Detroit Publishing Co., Library of Congress Online)}}
\end{figure}

METHOD 4

The fourth method involves local illumination, or task lighting. This type of concentrated lighting is necessary to accomplish a specific activity or task, usually seen in office desks, reading tables in a library, dining rooms, retail counters, and signs. Most cases require general lighting, but others need higher levels of light to accomplish specialized levels of tasks. “In such cases merely a general illumination would be sufficient if very intense, but this is uneconomical and to some extent objectionable on account of the blinding glare, which is disagreeable. Therefore, a combined general and local illumination is more efficient and more satisfactory.”\textsuperscript{127}

\textsuperscript{126} Appendix A
\textsuperscript{127} Steinmetz, “Light and Illumination.” 1907
Illuminating engineers included this lighting method in the main concourse and the rest of the terminal (Figure 2.28). This type of light is used for signals to indicate travellers where they should go. Additionally, this method provides directed light over the ticket and information booths. It uses direct concentrated downlights and shines a sharp light on the corresponding highlighted surfaces. This method might generate direct and reflected glare due to its relative low height. This special illuminance generates high luminance near those areas where the task occurs. The monochromatic palette of light-colored surfaces shine under a 1913 “white light” classified today as very warm-tone. No further specifications were found for this method.
The combination of lighting methods generates an appropriate environment and allows the terminal to function efficiently in the absence of natural light. The scheme represents chief principles of the role of artificial lighting in the early the twentieth century because it applies concepts from several lighting specialists of the time in four distinct methods. The original lighting scheme corresponds with the functional paradigm of coherence and clarity by visually distinguishing spaces and contributes to define the activities associated with them, as described at the beginning of this chapter. Additionally, the combination of light and surface characteristics also generates a distinct outdoor effect in the main concourse that is as important as architectural form because it establishes the character and style of the building.

The original lighting scheme of the main concourse and its surrounding spaces suggests illuminating engineers in the beginning of the twentieth century recognized the power of light. They established a practice that controlled practical, technical, and aesthetic factors in favor of experiences in architecture. It was a science between applied physics and physiology, which meant that engineers deemed lighting systems as important as perceptions. Engineer and lighting consultant Laurent Godinez believed better lighting was a cause and that “illuminators” were on a mission of great importance. In his publication *Lighting Book* of 1913 he faults an eminent authority on interior decoration who claimed engineers were only interested in the economic and utilitarian aspects of construction and says; “He has no appreciation for environment, knows naught of that consistent relationship between light and color which is the essence of decoration – or atmosphere.” In other words, lighting specialists can determine the character of a space. They can create an environment, which is the result of managing light and color. If the essence of “atmosphere” is light and color, then lamp and surface characteristics determine how that information reaches the eyes. For

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128 Ibid.
example, a room with white walls can seem dark if task lighting displays specific areas for different activities to happen.

Nonetheless, if perceptions are subjective, what is the role of this discipline? Just like architects shape buildings for different living beings, lighting designers shape light. Both manage specific needs and create a balance between relevant factors involved in each case. Illuminating engineers that represented the ideas of the IES said in the journal *Good Lighting and the Illuminating Engineer* their mission was to assist in making artificial light effective.\(^{131}\) They indicated, “By proper use you can get good illumination from any of these sources, but by misuse you are likely to get lighting that is bad, costly, and even dangerous to the eyesight.”\(^{132}\) Even though the problem of lighting seems obvious today, the profession only started as a quantifiable science after the institution of electric light in architecture. Technological developments encouraged the advancement of lighting. In this sense, the original lighting scheme relates to its architecture and engineering principles.


\(^{132}\) Ibid.
CHAPTER 3 - CHAPTER 3: COMPARATIVE ANALYSIS

RAILROAD STATIONS

This section provides information on railroad terminals built in the beginning of the twentieth century in America. The purpose is to understand the convenience in arrangement of terminal facilities and its relation with artificial lighting using two case studies: Buffalo Central Terminal and Union Station in Washington. This document establishes a possible method to evaluate the historical significance of artificial lighting in train terminals referring to the main ideas behind the significance of Grand Central Terminal's original lighting. In these and other cases, the researcher should reveal the design intent, analyzing the purpose, sequence, and arrangement of the original lighting scheme in relation to the use and configuration of the building; argue how it was an essential part of the experience of the building at the time of its construction; and demonstrate how it reflects prevailing science and technology principles when it was designed and built.\(^\text{133}\) There are many other ways to assess historical significance, but this method is specifically relevant to lighting, especially to train stations.

Architects worked with engineers to organize spaces according to the processes and activities that allow a train terminal to operate efficiently. They learned from older stations to improve conditions for changing demographics and increased travel patterns at the turn of the century. Sometimes the connection between function and aesthetics was not clear. Architectural critic John Albert Droege considered there was a problem with the design of “modern” railroad terminals; “This is a matter which is frequently subordinated to the necessities of architectural design, sometimes with reason, but more often because of lack of care or because the architects fail to realize that the terminal is not built primarily for a monument, but as a decidedly important railroad facility.”\(^\text{134}\) Just as ornament does not constitute the most important element of architecture, lighting fixtures are not the most important elements of lighting. A suitable

\(^{133}\) Paul Bentel (Partner at Bentel & Bentel Architects/Planners AIA) email message to author, May 4, 2015.

lighting scheme should include a combination of methods, as described in Chapter 1. For example, uniform intensity and method throughout the spaces of a train station might not correspond to the use and visual needs of the occupants.

When planning the construction of a terminal, designers had to determine location and required amount of space for each facility taking into account its use during the following twenty years. The program of a terminal should include: a waiting room, baggage and express rooms, a parcel check room, ticket offices, retiring rooms, and toilets. Designers could also include facilities like telephone booths, a bootblack stand, candy and news counter, a barbershop, and other services depending on the size of the building. An important consideration was all terminals had to handle peak loads, either every day or in a special occasion. For example, Union Station in Washington provided generous space and enough facilities for the stream of visitors during the president’s inauguration every four years. Additionally, some terminals would have space for railroad headquarters offices depending on their location. Terminals like Michigan Central Station in Detroit, the South Station in Boston, or the Broad Street Terminal in Philadelphia had office buildings next to the terminal building. New York Central Railroad and the Hudson River Railroad sold air rights above the tracks to increase revenue as part of Grand Central’s urban plan and included their own office spaces nearby.

Consequently, a train terminal should establish a rational flow of people. Inbound and outbound traffic could be separated for an efficient pattern of circulation. Architectural critic Symmes Richardson points out, “The chief lesson which we can learn from Europe in the operation of our great terminals lies in the constant effort to separate traffic along its logical lines, even at increased expense of operation, as against the tendency in this country to mass all of the people together; for instance those who are checking their luggage at the moment, quite irrespective to their destination.” The best layout would allow passengers to move freely and with no obstructions between

135 Ibid.
136 Ibid.
the streets and the trains. Facilities around those circulation spaces had to be as unobtrusive as possible as not to confuse passengers. Mr. Droege explains, “It is axiomatic that in the well-arranged station the necessity for signs is small, for the various facilities are placed as nearly as possible in a natural sequence along the routes from the entrances of the station to the platforms and trains.” 138 Any lighting that corresponds with these ideas of efficiency could be part of the significance of the building.

Figure 3.1 Buffalo Central Terminal Rendering
(Contemporary postcard view of the terminal, package & mail handling building, undated, Private Collection Western New York Heritage Website)

Figure 3.2 Washington Union Station Rendering
(Washington Union Station, c. 1907, chromolithograph, Breaker & Kessler Co.: Philadelphia, Library of Congress Online)

The room located between the waiting room and the train platforms is usually known as the concourse. In the case of Grand Central, the Associated Architects located most of the station facilities around this space in the most efficient manner possible. Mr. Droege points out, “It has been found by experience that the passengers are very likely to become nervous when at the windows if there is not a large clock in sight.” 139 In fact, the architects of Grand Central placed a clock at the very center the main concourse so it was visible to everyone coming at any angle. Similarly, in 1929 the Buffalo Central Terminal had a clock at the very center of the main concourse. Generally, the concourse or waiting rooms can also have ticket offices in full view of travellers, and some have separate rooms for men and women. Other train terminals had facilities surrounding the waiting room, which resembles a main concourse. A waiting room is a place of comfort usually separated from the main circulation spaces

138 Droege, Passenger Terminals and Trains.
139 Ibid.
and the draft of winds from nearby doors.\textsuperscript{140} The grand waiting room of Union Station in Washington, built in 1907, has no clock and the space is full of waiting benches. The activity is concentrated in this large space.

**NATURAL AND ARTIFICIAL LIGHT**

Studies also addressed color reflection and refraction and the benefits of using one material or the other for light efficiency in architecture. These were introduced in railroad terminals and train stations as early as 1907. Different configurations and different surfaces increased or decreased light levels of the spaces depending on their characteristics; “Finely ground surfaces, as of glass, for normal incidence of rays will diffusely reflect, while as the angle of incidence is increased or is made more oblique to the surface of reflection becomes more and more specular or mirror like, until at grazing incidences very little light is diffused.”\textsuperscript{141} The measurement of light would ultimately affect the choice of surface materials in construction.

The *Standard Handbook for Electrical Engineers* also addressed the effect of wall color on objects and their respective reflected tones, stating, “This may be turned to an advantage in softening and modifying the color effect due to the original illuminant.”\textsuperscript{142} The *Railway Electrical Engineers’ Handbook* provided photometric studies in its “Supplemental Data Sheet Supplement” to present tables and educate readers in this discipline of photometry. The journal also presented data with coefficients of reflection to demonstrate light-colored walls would give more useful reflected illumination than dark walls.\textsuperscript{143}

The use of general light in these spaces is crucial due to their size, so the selection of color and materials contribute to the reflected amount of light and the general luminance. High Ceilings allowed bringing light from above (Figure 3.3, Figure 3.4). While they provided ample space for air circulation, they also provided necessary

\textsuperscript{140} Ibid.
\textsuperscript{142} Bell, “Section 12: Illumination.” 1910
\textsuperscript{143} Bender, *Railway Electrical Engineers’ Handbook: Electric Light and Illumination*. 1912. p77
illuminance in the interiors during the day. While the grand lobby of Union Station in Washington DC makes full use of luminance with light colored tones, the main concourse of Buffalo Central Terminal has darker walls.

Interior lighting of train stations should have well diffused light throughout the spaces and the method should avoid any shadows. Platforms and stairs should be adequately lighted for safety reasons. With respect to the application of science and technology applied after the electrification of railroads and stations, experts consider “Lighting a station room, in common with other public rooms, is a problem in itself which is being most careful study, and to which specialists are giving their attention.” Ideal lighting reflects just enough light from the object to the eye and the walls don’t absorb all of the light. Sometimes the finish of walls will diminish the amount of light reflected and available for use; “An illuminant is powerless to light a room if the color of the walls absorb most of the light rays.” Diffuse light is possible with a number of methods.

Both main spaces of the terminals have adjacent spaces surrounding them (Figure 3.5, Figure 3.7). This means the use of high windows provides the most light

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144 Droege, *Passenger Terminals and Trains.*
145 Ibid.
146 Ibid.
during the day. Artificial lighting is different on both of the following cases, relying on direct and indirect methods in addition to task lighting. Union Station relied on indirect lighting under the arched surfaces near the windows to simulated natural daylight (Figure 3.6). During the night a group of uplights located on the columns next to the arches provided general indirect lighting, rendering a diffuse light throughout.
Figure 3.5 Washington Union Station Floor Plan
(Union Station, Wash., D.C.: Ground floor plan, Illustrations in Architectural Work of Anderson Graham, Architectural Drawings, Prints & Photographs Division, Library of Congress Online)

Figure 3.6 The Main Waiting Room Years Later

Figure 3.7 Buffalo Central Terminal Floor Plan
(Plaza level floor plan, 21 feet above track level, published in the Railway Age, May 18 1929, print article, Private Collection Western New York Heritage Website)

Figure 3.8 Lights in the concourse at Buffalo
(Luncheon in the concourse, print article, June 22 1929, Buffalo Evening News, Kalmbach Publishing, Western New York Heritage Website)
Buffalo Central Terminal’s main concourse relies on a combination of localized indirect fixtures on the columns and surface mounted downlight luminaires above, providing indirect and direct diffuse lighting (Figure 3.8). These methods provide low luminance below and add small spots of decorative light, just like in Grand Central’s interiors. Both functional and aesthetic considerations are part of this scheme. The higher contrast of light both in the day and in the night in Buffalo’s interior is balanced with a specular type of floor to reflect as much light from below. This feature does not solve luminance issues during the night and might require inefficient higher levels of light. In comparison, Union station’s interior makes full use of its surfaces to reflect light.

Some terminals were dark due to the amount of required spaces for terminals. Some of those stations relied on underground spaces. Grand Central has a main concourse level or express level, and a lower suburban concourse. This raises the issue of permanent general lighting for the underground portion that does not ever receive natural light. Directed lighting over ticket counters and platform numbers highlight all relevant information for travellers, making the problem of sequence a matter of higher light intensities. Because the brain distinguishes the differences between those intensities as seen in Chapter 1, lighting has a very important practical use that improve efficiency in a terminal. Without light contrasts, the whole space seems uniform and is difficult to know where to go. With an increased contrast, either the task of commuting or the task of reading signs becomes difficult. Thus, when there is a combination of those methods in a scheme, the problem of preservation is dealing not only with appearance but also with efficiency and use.

A PRESERVATION PRECEDENT

A recent restoration project relevant to preservation and the lighting profession is the Auditorium Theater. The firm of Adler and Sullivan designed the four thousand-seat theater in 1889 inside the Auditorium Building in Chicago (Figure 3.9). It was one of the first electrified buildings in America. Dan Coffey, a preservation expert, supervised the interior restoration of the theater, which consisted of retaining the basic and original
 lighting scheme. During an interview for this research, he explained that the team decided to reinstate a 95% accurate contemporary replica (Figure 3.10) of the original clear glass filament bulbs compared to the original.\textsuperscript{147} He explained the heated part of the bulb that produced light was the main aspect of the ornamented surfaces. Fortunately, the theater management had kept record of all replacements for a number of years, but he insisted on using the original hairline distance of the filament with a precision of only a fraction of an inch.

In his experience, the change of lighting schemes in preservation is a consequence of a variety of factors, including current standards and taste but not necessarily code requirements. The team also considered LEDs at the time, but because they emitted noise they were not appropriate for this space. For the Auditorium Theatre, “the filament bulbs are not very energy-efficient because they emit a high amount of heat.” This is usually a problem for temperature control and air conditioning systems, but as he clarified, the bulb was relatively long lasting in comparison with the original one and was part of the building interior’s significance.

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\textsuperscript{147} Dan P. Coffey (Daniel P. Coffey Associates) in discussion with autor. November 7, 2014.
Preservation efforts should consider the narrative of a lighting scheme as it relates to the use of the building. The spatial sequence usually establishes patterns of light. It’s important to understand how the technical instruments are not necessarily the main goal. After 20 years of neglect, a project to restore the Buffalo Central Terminal has started in the last few years. More research in this building could reveal modern lighting principles, but they are essentially the same for train terminals; general directed diffuse or indirect diffuse light for large rooms, directed diffuse light for passageways and corridors, and directed concentrated light for specific tasks.
CHAPTER 4 - THE CURRENT LIGHTING

This section will present a comparison between historic and current conditions, focusing on the evolution of lighting methods spanning more than one hundred years. The purpose is to learn from former and current projects and understand the challenges implicated in lighting the interior of the historic structure. The analysis takes each lighting method identified in Chapter 2 and explores how the current lighting scheme relates to the use of the terminal today. This section also refers to the significance of the original lighting of Grand Central Terminal, specifically about the main concourse and its surrounding spaces looking for answers to three main questions. First, does the current lighting scheme still correspond with the functional paradigm of coherence and clarity by visually distinguishing spaces? Second, does it establish the aesthetic character and style of the building in the same way as architectural form? And third, does it represent chief principles of the role of artificial lighting in the early twentieth century?

RESTORING GRAND CENTRAL

Today, the Metropolitan Transportation Authority and its subsidiary, Metro-North Railroad, pay annual rent on a lease that expires on February 28, 2274. Their efforts at improving the historic structure are broad and span a great number of years. Even though Grand Central Terminal recovered its most important features, there is an understated separation between the lighting scheme and the reflecting surfaces of the main concourse. The effect of limitless space no longer exists. Even though this seems like an aesthetic consideration, it provided the main concourse the “unique” character that critics celebrated in 1913.

During the 1920s they decided to improve the appearance of the interiors by altering the monochromatic scheme of the surfaces (Figure 4.1). This affected the amount of reflected light from the general lighting method by reducing luminance. The

alteration was probably trying to solve weathering and moisture problems, which were also responsible for the destruction of the original sky mural (Figure 4.2). Photographs from that period reveal considerable damage after less than two decades since the inauguration of the railroad terminal.

As damage continued, they decided to replace the sky mural in 1945 (Figure 4.3). Photographic records show the change in contrast of the curved surface above the main concourse. This changed the tone of the reflective surface. Further research could reveal the original color of the vaulted ceiling, which is an important part of the original lighting scheme. This chapter will address this issue in the section concerning the indirect lighting method.
In 1976, the MTA decided to update the lighting of the main concourse as part of the process to preserve and revitalize the terminal after years of deterioration. The purpose was to restore the building’s former grandeur as a public space of New York by introducing a new scheme that would respect the architectural integrity of the terminal. After years of disrepair, the building’s interiors had become dark, filthy and dangerous. In its efforts to save the building, the MTA initiated a plan to save energy and reduce the maintenance costs of the terminal, hiring The Rambusch Company to

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At the time, the firm had experience in lighting design for large architectural spaces, but when Rambusch engaged the architecture firm Poor, Swanke, Hayden & Connell, architect Der Scutt was able to contribute extensive lighting experience to the project.\textsuperscript{151}

In 1983, MTA Metro-North hired the firm Beyer Blinder Belle to carry out the project established in the Master Plan to restore the integrity of the original Grand Central and to conform to transportation terminal standards.\textsuperscript{152} The plan included a program to clean, conserve, and replicate missing light fixtures; install updated electrical systems; introduce the latest lighting technology; supplement light levels where necessary; and to remove inauthentic accent lights that affected the appearance of its interiors.\textsuperscript{153} In addition, Metro-North decided to end the lease with Kodak in 1987

\textsuperscript{150} Ibid.  
\textsuperscript{151} Ibid.  
\textsuperscript{153} Ibid.
because the “Colorama” was too large and it was taking over the entire east gallery (Figure 4.5).\textsuperscript{154} The advertising installation had occupied the east balcony of the main concourse since 1950.\textsuperscript{155} Consequently, they requested permission from the LPC to modify the landmarked interior and demolished the installation in 1989.\textsuperscript{156}

METHOD 1

The first lighting method involved ambient lighting.

Lighting specialist Viggo Rambusch explained during an interview they didn’t produce a conditions report when they started the analysis, but they were able to write a short document on lighting.\textsuperscript{157} He provided an article published in 1976 that summarized the analysis and execution, containing the only record of general specifications of the terminal’s lighting found for this report since 1913.

The project focused on a scheme that revealed architectural features, but did not associate the lighting to the main activities of the terminal. The 1976 report documented a number of tall buildings surrounding the terminal had blocked most of the sun’s rays that entered directly through the lunette windows above. They indicated the recessed reflectors on the cornice had 200-watt A-lamps before their intervention, and those had replaced 20-watt A-Lamps. These new high-wattage lamps created a band of brightness located eighty-five feet over the main concourse floor that darkened the features of the vaulted ceiling above. High illuminance obscured those features and it created a relative difference in luminance between the main concourse and its surrounding spaces, like the north balcony and south ramps. The effect “visually and spatially separated them.”\textsuperscript{158} The decision was to remove the inefficient and costly 200-


\textsuperscript{155} Githens, “World’s Biggest Color Photo.”

\textsuperscript{156} Gray, “Streetscapes: Kodak’s Colorama; The End of the Line for Grand Central's Big Picture.”

\textsuperscript{157} Viggo Rambusch (Honorary Chairman and Senior Project Manager at Rambusch) in discussion with the author. March 3, 2015.

\textsuperscript{158} “HPS and MH Lamps in One Fixture Revitalize Grand Central Station.”
watt A-lamps (18-lumen-per-watt) and replace them with 25-watt A-lamps.\textsuperscript{159} It seems the intent of this intervention was to restore the original general lighting, but it did not deliver the required levels of light in the main concourse (Figure 4.5).

Later, in 1995, lighting designer Richard Renfro was in charge of restoring and enhancing the lighting in the building while working in the firm of Fisher Marantz Renfro Stone. In an interview conducted for this research, he explained the main task of the terminal hadn’t changed since 1913, so it was important to consider the lighting methods of the original scheme in the landmark’s interior restoration.\textsuperscript{160} He clarified by saying he reduced contrast in the terminal, which is his most important contribution to the interiors. The idea matches the design intent behind the arrangement of frosted lamps to render diffuse light using general, direct, and indirect lighting methods combined. In his opinion, the “cornice necklace” provided some of the room’s most “dramatic effects,” and replaced incandescent with compact fluorescent lamps to reduce energy consumption.\textsuperscript{161} He observed the new bulbs were too long compared to those in the original scheme, so he removed the stems and raised the sockets so that the fluorescent lamps would look the same size as the originals.\textsuperscript{162} The team also decided to use 15-watt bulbs as opposed to 25watt after they realized the terminal would look brighter after the corresponding cleaning of the surfaces. First they changed the lamps in the cornice, and almost nine years later MTA Metro-North would be able to change the lamps with a more modern technology.

In April 22, 2008, MTA Metro-North changed all the remaining bare incandescent bulbs to environmentally sustainable fluorescent light bulbs.\textsuperscript{163} The official report claims the reason was compact fluorescent (CFL) lamps improved during the last years and that they finally matched the shape, color, and intensity of incandescent lamps.\textsuperscript{164}

\textsuperscript{159} Ibid.
\textsuperscript{160} Richard Renfro (Principal Lighting Designer at Renfro Group, former a principal at Fisher Marantz Renfro Stone Architectural Lighting) in discussion with the author. March 18, 2015.
\textsuperscript{162} Ibid.
\textsuperscript{164} Ibid.
maintenance team had anticipated the decision and started changing to CFLs in out of sight locations years before, but had hesitated to move forward in landmarked spaces due to the lack of appropriateness of modern lamps. The alteration process required permission from the New York State Historic Preservation Office (SHPO), just like any other change in designated buildings of the city. The office showed its support and said; “We applaud the efforts of the MTA to conserve energy and at the same time preserve historic aesthetics of the GCT light fixtures.”\textsuperscript{165} Railroad experts claimed they would save more than one hundred thousand dollars a year on utility bills and more than one hundred thousand kilowatt hours of electricity, with reference to operating costs from 2008.\textsuperscript{166} With this in mind, Metro North President Peter A. Cannito argued everyone could participate in the mission for a more sustainable future and encourage people to change bulbs at home or at the office. It was not the first time the lighting manufacturing industry used the terminal to display new technology. In fact, the first time was in 1913, when the terminal showcased Mazda Edison lamps as the most efficient lamp in the market.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4.6.png}
\caption{Cornice downlights, 2015. (Photograph by the author, 15-03-05, digital photography)}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4.7.png}
\caption{Additional Lighting Above the concourse (Photograph by the author, 15-03-05, digital photography)}
\end{figure}

With respect to the current state of the ambient lighting method, all \textit{direct diffuse downlights} (Figure 4.6) under the cornice should deliver a uniform \textit{diffuse} soft light over

\textsuperscript{165} Ibid. \\
\textsuperscript{166} Ibid.
the entire ground plane of the main concourse as stated before. However, on repeated
visits between January and March of 2015, the ambient lighting seems localized
instead, giving an inappropriate effect of task lighting on the perimeter of the space
(Error! Reference source not found.). This is unintentional. Metro North Railroad’s
Chief Architect, George Monasterio, explained during an interview the lighting
manufacturer provided new warm-tone (2700K) LEDs and that he expected them to
change the specification because they were rendering light very differently compared to
their predecessors.\(^\text{167}\) He pointed out a dark area in the middle of the main concourse.
Either the original white-painted cylindrical recesses operate as directed reflectors using
a lamp that is too small, or the lamps are simply incapable of diffusing light throughout
the space. High illuminance levels on the cornice are accurate and provide hard light on
ornaments, but luminance on the floor is evidence that this setup doesn’t provide the
necessary uniform light for occupants to commute and occupy the main concourse. The
luminance on the north and south columns corresponds with the historic appearance
pictured in photographs, but this feature is irrelevant because it doesn’t relate to the
purpose of ambient lighting and the tasks involved.

\(^{167}\) George Monasterio (Chief Architect at Metro North Railroad) in discussion with the author, February 18, 2015.
METHOD 2

The second lighting method involves direct lighting. No changes happened for many years, until Mr. Renfro’s team addressed the issue. During the interview, he commented they discovered the spherical chandeliers that provided *multidirectional diffuse* light from the south and north balconies were not bronze, but nickel and gold-plated.\(^{168}\) They took down the chandeliers and Historical Arts & Castings restored them to their original appearance before they were put back in place. An article from Lighting Design and Application from 1999 indicated the corresponding lighting specifications for those chandeliers:

Each chandelier has 16 ribs and contains 7 A-lamps per rib for a total of 112 long-life, 40-watt incandescent lamps. In addition, Renfro concealed 16 pairs of 60-watt PAR16 narrow flood lamps between each of the ribs in the chandeliers to provide a soft uplights around the ceiling surrounding the skylights and downlight (Figure 4.10).\(^{169}\)

Then, he indicated the inverted cone chandeliers that of *downlight diffuse light* had two types of lamps. High-pressure sodium (HPS) lamps were installed in the sunburst, or upmost top of the chandeliers in the waiting room.\(^{170}\)

Renfro also addressed the problem of the frosted bare lamps in the passages and he explained how their irregular spacing made those areas dark and gloomy. The team decided to spread the wattage and make a softer light using replicated suspended and surface mounted fixtures. This solved the problem of direct and reflected glare from the original design in passages, ramps, and corridors.

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\(^{168}\) Richard Renfro in discussion with the author. March 18, 2015.

\(^{169}\) Donovan, “Grand Central Terminal Restoration.”

The current direct method resembles the restoration Mr. Renfro supervised. However, the high-pressure sodium lamps over the chandeliers (Figure 4.11) of the waiting room don’t correspond with the rest of the methods. The lamps render an intense yellow glow on the ceiling above, contrasting with color temperatures of other lamps. This doesn’t correspond with either the historic documentation or former schemes.

The new downlights of the spherical chandeliers of the north and south light courts that Renfro installed are no longer active (Figure 4.13). The light rings created by these downlights have disappeared, but the reason behind the elimination of this added light is unclear (Figure 4.12). This condition re-establishes the function of these directed diffuse sources, maintaining its historic purpose.
METHOD 3

The third method involves indirect lighting, or cove lighting. However, when MTA appointed The Rambusch Company work on the lighting, the team recognized the use of indirect lighting and added a fourth method called accent lighting. They had to design and fabricate new luminaires for the project for the new lighting scheme. Their approach did not specify any changes in the direct lighting method, but rather relied on indirect lighting to provide localized diffuse light – as opposed to general diffuse light of the original design – throughout the main concourse. Once the team recognized the vaulted ceiling was dark, they decided to make use of light’s reflective properties to provide higher illuminance and increase luminance. The idea considered wall-grazing the colored ceiling, meaning concentrated luminaires would direct light upward as close to the ceiling walls as possible to show its texture. However at that time, “the ceiling surface had been covered by four-by-eight-foot panels of one-quarter-inch tempered glass.”

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171 “HPS and MH Lamps in One Fixture Revitalize Grand Central Station.”
Masonite during a previous remodeling, and the lighting made the seams visible between panels distractingly evident.”\textsuperscript{172}

Knowing their initial idea was not possible, the team decided to wall-wash only the upper decorative plaster end walls, located to the west and east of the main concourse, above the tall and long windows. The \textit{local indirect cove} lighting method (Figure 4.15) used a combination of 400-watt high-pressure sodium (HPS) and a 400 metal-halide (MH) lamp in each fixture (Figure 4.14).\textsuperscript{173} They discarded the initial idea of using tungsten halogen lamps because they had low efficacy and would not represent savings for the terminal. When considering other alternatives,

Tests showed that the high-pressure sodium (HPS) lamp used alone was too yellow or golden, while the metal-halide (MH) lamp was too cool in color. But when the spectral energy distributions of the two sources were mixed, a color very close to that of the tungsten-halogen lamps was achieved.\textsuperscript{174} They claimed the ideal color would render the ochre or brown color of the surfaces with the most accuracy. Consequently, both \textit{color temperature} and \textit{color rendition index} determined the final decision. The new fixtures would include both lamps located one beside the other to render the most uniform color distribution. This type of light was not part of the original design of 1913.

Today, this method is replaced with architectural lighting to highlight the lunette windows, simulating the former effect but not the original one (Figure 4.7). The lighter tone is important for the effect of the sky and the feeling of limitless expanse. It also has a decorative value. Referring to the combination of golden forms over a blue background, a critic reminds us, “… It shouldn’t be forgotten that the sweep of those two gilded ribbons produces an optical illusion of greater height and makes the blue look as high as the sky itself.”\textsuperscript{175} For this and other reasons mentioned before, lighting should

\begin{footnotes}
\item[172] Ibid.
\item[173] Ibid.
\item[174] Ibid.
\end{footnotes}
not generate the same effect during the night as during the day. Artificial lighting should expand the space above with the indicated configuration.

METHOD 4

Task lighting throughout the terminal has not changed. This demonstrates how this type of lighting is inherently embedded in efficiency principles and has no overpowering reasons to change. However, Mr. Renfro and Beyer Blinder Belle restored the historic fixtures and updated the lighting to make it work with newer technologies.

METHOD 5

Finally, in 1976 the team of Rambusch Company decided to include a fifth method of lighting. Accent lighting introduced the notion of architectural display and
persuaded users of the terminal to appreciate the revitalized interior architecture. “Column fixtures” (Figure 4.15) provided *uplight-directed* light to shine on columns and ceiling ornament of the north and south bays. “Clerestory fixtures” (Figure 4.16) located at the base of each clerestory window provided uplight directed light to shine on the plaster-reliefs over the window. This attempted to simulate the effect of daylight, which was a unique effect that contributed to the character of the upper portion of the main concourse before tall buildings blocked most of the light. It also corresponded with the indirect method of the original intent because it displayed the ornament above the cornice with hard light, increasing contrast, and emphasizing the sculptural quality of the lunette window configuration. However, it disregarded the effect of the painted ceiling above due to technical considerations and separated the surface from the decorative elements surrounding it.

Today, this type of lighting does still contribute to the luminance of the space. They don’t use the same fixtures of the same technology. New reflectors shine directed light randomly across the main concourse ceiling, and a yellow glow provides a warm tone on the arched ends of the main concourse (Figure 4.17). However, these reflectors shine light on the upper arched windows inconsistently and randomly across the ceiling (Figure 4.18).
THE SCHEME TODAY

The current lighting scheme still corresponds with the functional paradigm of coherence and clarity by visually distinguishing spaces. Consequently, it represents chief principles of the role of artificial lighting in the early twentieth century. However, it does not establish the aesthetic character and style of the building in the same way as architectural form does. Even though the current scheme provides the functional requirements of the terminal, it does not contribute to the outdoor scheme of the main concourse. After a thorough restoration process that updated systems and technologies, the current lighting method over the cornice misses its intended function. The current light over the cornice detracts from the character of the main concourse because it has no clear purpose and it breaks the symmetry of the interior that was recently reinforced with the new east staircase below. While an alteration is not urgent, it is important to recognize the exclusive role of indirect lighting in the space.
CHAPTER 5 - SUGGESTIONS ON POSSIBLE IMPROVEMENTS

The original lighting of Grand Central Terminal represents chief principles of the role of artificial lighting in the early twentieth century. It is as important as architectural form in the main concourse because it helps establish the aesthetic character and style of the building with four distinct methods of lighting. Its planning corresponds with the functional paradigm of coherence and clarity by visually distinguishing spaces, where light follows and defines the logical sequence of movement and activity of the transportation terminal. For these reasons, the original lighting is an essential feature and constitutes a fundamental component of the station’s interiors.

In recent years, MTA Metro-North carried out major restoration work in Grand Central Terminal, even those spaces that were not included in the Landmark Designation Reports from the LPC. The preservation firm in charge of the project, Beyer Blinder Belle, leads a team of specialists to monitor weathering and deterioration, among a number of different tasks. They make sure that the building is environmentally sustainable, that it adheres to code and regulations, and that it continues to function as an efficient railroad terminal. The comprehensive lighting restoration was a major part of the Master Plan of 1996, as the Existing Conditions Survey explains:

The rehabilitation of Grand Central Terminal should preserve the image and essence of the original electric lighting system while also introducing appropriate noncompetitive supplemental lighting as required to create inviting spaces with variegated and reasonable brightness relationships.... Because of the significant role of daylight in Grand Central Terminal, the building enjoys two distinct atmospheres, one during the day and the other at night.176

General recommendations included the option to modify historical fixtures by adding concealed light sources, to add new fixture replicas, or to conceal supplemental lighting within the architecture. The document provides indications on color temperature

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during the day and night and establishes a correspondence between old and new interiors, “maintaining a sensitivity to the spirit of the architecture.”

This thesis also establishes the architectural and engineering features of the main concourse constitute an outdoor theme and represent nature with the play of colors, materials, and the effects of light. A future project could consider these ideas and expand the narrative that already exists. All elements that are deeply embedded in the building that exists today could operate collectively as they did in the initial design of 1913. As a consequence of this research, the LPC also has the opportunity to include these issues of historical significance in the designation report.

The repurposing of the indirect lighting method would enhance the decorative features of the ceiling, but the restoration of the original sky mural would reconstitute the original atmosphere of the main concourse. Adding on the historic notions of atmosphere mentioned before, a theoretic background will explain the contemporary use of this word applied in this context. In a recent publication, Christian Borch discusses the way in which architectural atmospheres affect us, change our moods, and influence our behaviors. Referring to German philosophers Gernot Böhme and Andreas Brenner, he defines ‘atmospheric politics’ as an attempt to manage behavior through interventions in the physical and/or socio-psychic environment, identifying it as a subtle form of power. In other words, architecture could govern and manage behaviors, desires, and experiences without people being consciously aware of it. A social analysis related to design intent unveils, for example, the politics of a public plaza or the persuasive force of gothic cathedrals. These ideas are inherent to architecture and might seem obvious, but their meaning transforms with time because perceptions change as people and societies change. Consequently, the objective of historic preservation is to reinterpret important lessons from the past and make them relevant for the present and the future.

The feeling of limitless expanse in the main concourse is part of the original narrative and it evokes emotion because it generates a memory. This memory is an image; the result of a careful manipulation of color, quality, and quantity of light. It involves illuminance, but most importantly luminance as it reveals the path and characteristics of light on surfaces. Most importantly, it corresponds with the effects of natural light. Lighting specialist and author of *Lighting for Interior Design* explains,

Light in the natural world is all about the layering of light from multiple directions: strong directional light mingling with softer diffuse light, white light with subtle tints picked up from the sky and reflecting surfaces. This mixture changes constantly, providing a new pattern of light and shade every time we look…. Even though pattern, texture and shadow provide a massive amount of visual richness in the natural world, they tend to be deliberately excluded from most artificially lit interiors.179

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179 Innes, *Lighting for Interior Design*. 
However, the original lighting of the main concourse, conceived more than one hundred years ago, contains these ideas.

The atmosphere of the main concourse today generates a memory that affects our experience of the interior of the building. As contemporary Schlichting said recently, the space “provides a secular cathedral to the spirit of commerce and the exuberance of travel.” Nonetheless, the impression and impact of the original interior was much greater, as seen throughout this document. Natural and artificial light powerfully enhanced the experience of visitors and travellers alike. The task of restoring its original aspect and replicating its intended effect will now depend on those professionals who continue to work on preserving the treasure we have today.

Finally, the IES could expand on recommendations for lighting interior spaces that belong to historic structures. A chapter on historic lighting and the history of illuminating engineering would benefit architects and lighting designers when discussing the historic significance of buildings. The US General Services Administration (GSA) could add a section on recognizing those features – as suggested throughout this document – under the “Character Defining Spaces in Historic Structures” of the Lighting Section. The report could read: “Spaces that contribute to the character of a historic structure ... should be lighted in a manner that enhances their historic and architectural character,” adding “without detracting from their intended purpose within the architectural scheme.” The likely significance of lighting in other historic structures should not be overlooked.

REFERENCES


“M. Helleu's Ceiling for the Grand Central Station (Matters of Art).” *New York Tribune.* February 16, 1913.


APPENDICES

APPENDIX A: COMPARATIVE ANALYSIS

METHODOLOGY

The following methodology could reveal clues on the original color of the surface of the original Sky Mural.

1. Collect, organize, and compare documented information including but not limited to: archival records, manuscripts, blueprints, architectural drafting, drawings, publications, photographs, Photochrom images, postcards, periodicals, journals, newspaper articles, trade catalogues…

2. Establish a theoretic framework as background for investigation

3. Understand design intent within the general architectural design, analyzing volumetric configuration, spatial sequence with respect to use, natural daylighting, artificial illumination, material choice, finishes…

4. Evaluate significance using architectural, technological, historic, social, and artistic precedents

5. Provide a parallel comparison between initial and current interior schemes to recognize successful design characteristics in both cases

6. Gather viable preservation solutions, if any, with respect to the importance of the meaning of the original building and its current condition

ART PALETTES

This analysis is a study of color composition using relevant art pieces. Online images do not necessarily represent the exact tone of each artwork, but will serve their purpose considering basic color theory principles. No image filters or alterations affected the images found. The use of real artwork and Munsell color charts would be the most ideal scenario for sampling and identification, but the conditions of this analysis is to establish general relationships between a combination of color tones and their unified effect.
Adobe graphic editing software will provide enough information to construct preliminary visual comparisons.

Specifically, Adobe Color CC allows the automatic or manual extraction of five color points within an image. This first analysis pretends to establish the suitability of automated scripted color sampling, eliminating any human bias in the selection of colors.
Extraction of Preliminary Palette: Analyzed Using Automated Color Identification

MUTED preset reveals a predominance of soft tones and only a few dark tones. The palette is a combination of earth (beige, ochre, brown, green, gray) colors and sky (blue, purple, white) colors. Currently, Grand Central has most of those earth colors already after the long process of restoration in charge of BBB. Sky colors are still missing.

PRINTING AND DRAWING

Advertising in the form of collectible postcards, newspaper notices, brochures, and tourist pamphlets constitute a valuable resource for color analysis. Different versions in the tone of the ceiling prove the difficulty of replicating the original color: not even official
publications of 1913 were exact. This is a general problem with historic paints, especially older ones that had no standardized recipe. After using automated analysis, this section takes five blue tones from the artist’s work and compares them with four images from reliable sources. The exercise identified a similarity between parallel sets of color compositions as shown in the graphic below. Using the same strategy of color identification in art, this case calls for the same analysis considering the subject matter is a visual artist’s tempera mural. Aside from this concluding graphic representation, a set of color palette outcomes will suggest the final proposal included in this investigation.
Figure 0.1 Figure 0.2 Color Identification of Grand Central Advertisements and Paintings vs. Paul Helleu
Figure 0.3 Pigment Analysis And Color Correspondence With Tones
PHOTOGRAPHIC MATCHING

The following visual exercise is the conclusion of the theory of the former research analysis. It does not indicate the real color, but establishes an alternative image to the current dark ceiling. It attempts to illustrate the closest match to the historic condition of 1913 (See process 1-6 below). The 1913 photograph is a view of the main concourse before opening. The image shows the effect of indirect lighting over the cornice on the left side of the large ceiling, while the right side is left without light. The photographic record provided information for future reference and suggests the actual intent of indirect lighting on the ceiling.

As color varies under different amounts and types of light, the surface color of the mural in the photograph taken at night appears darker than the one taken during the day (step 6 vs. Ornament Detail). The location of the real color would be next to the cornice just above the concealed lamps (see near cornice on step 6). As recent projects illuminated parts of the lunette upper windows, some areas of this ceiling are seen under the effect of direct lighting from up-lights, showing how the appropriate type of illumination should replicate the sun’s effect on the sky.

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1. Scale to match original

2. Add sepia colorizing
   - Adjust contrast levels and exposure

3. Select surface
   - Make brighter
   - Adjust contrast (RGB levels)

(Author’s Personal Collection)  (Avery Architectural and Fine Arts Library, Columbia University)
4 remove sepia

5 adjust cerulean blue using color palettes

6 adjust saturation for softer and lighter tone

(Author’s Personal Collection)

(Avery Architectural and Fine Arts Library, Columbia University)
same process used for visualization

(Reed & Stem Archive at WASA Studio)

(Author’s Personal Collection)