INCORPORATING MECHANICAL, ELECTRICAL AND PLUMBING SYSTEMS INTO HISTORIC PRESERVATION PROJECTS – THREE CASE STUDIES

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ABSTRACT

Architectural engineers face many challenges in the design and implementation of mechanical, electrical, lighting, plumbing, and fire protection systems in buildings. Space and aesthetic coordination must be managed between the architects, engineers, contractors, and building owners. Further design issues are involved when renovating or preserving historic properties. Historic buildings often contain additional design limitations and character defining features that must be preserved. A building's character defining features often represent past history, culture, and architecture.

To better understand the design coordination and other issues faced in historic renovation, three case studies located in Kansas City, Missouri, are presented to investigate the application of mechanical, electrical, and plumbing (MEP) system design into historic buildings. The three case studies include: the Stowers Institute for Medical Research, as a mechanical design; the Union Station, as an electrical and lighting design; and the Webster House, as a plumbing and fire protection design. The renovation projects' architects, engineers, and contractors were personally interviewed to obtain the most accurate information and account of the design and construction process. Additional information was gathered, and a tour of each building allowed for the pictorial documentation of each site.

Preserving the historic character of buildings during renovations has many advantages and disadvantages for both the owners and the designers. The additional design parameters in historic renovation projects foster creative thinking and problem solving during the design and construction process. In order to implement a successful design, the architects, engineers, and contractors must work together and understand the

value of a building’s historic character during the design stage when adapting to a new usage.

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1.0 Introduction

1.1 Importance of mechanical, electrical, and plumbing systems design / implementation in historic preservation

Renovation and preservation of historic buildings can often present significant challenges for the designers of mechanical, electrical, and plumbing (MEP) systems. Designers must not only integrate these systems with each other and the structural system, but the character-defining historic features will also impose design difficulties when their features conflict with MEP systems. Designated historic buildings and other historically significant buildings will have additional design conditions, possibly restrictions, affecting the site and structure to preserve the character and historic evidence of the buildings. In many instances, a historic renovation project will require a new heating, ventilation, cooling, electrical, lighting, and/or plumbing system, but the design of these utilities is often restricted by the architectural and historic character-defining features that should not be destroyed or moved. When this is the case, creative problem solving must take place to provide efficient MEP systems for the historic building while not destroying the historic character.

Design for historic preservation is therefore usually more complex than design for new construction. Coordination among engineers, architects, historians, contractors, and owners must take place to not only determine what the character defining features are, but also how the MEP systems will be designed and installed without compromising the historic character of the building. In many instances, choices must be made regarding compliance with both the Americans with Disabilities Act (ADA) and current building code safety issues. Alternative code and regulatory requirements have been established for historic buildings, thus giving building officials options when meeting new construction standards of design would compromise the historic character or original design of the building. Therefore, some areas of the renovated building may not meet current ADA or building safety codes, although life safety is never completely compromised. Often, building safety and ADA compliance is improved from the original design.

Several case studies exist to illustrate some of the problems and complications encountered when renovating historic buildings which include updated MEP systems. Three buildings in Kansas City will be analyzed in particular: Stowers Institute for Medical Research, Union Station, and Webster House. Many of the design concerns and problems related to installing new MEP systems in historic buildings are specific to historic buildings and their individual architectural character. Studying these buildings and their design issues will enable designers to better understand some of the complications that can arise in the renovation of historic structures.

1.2 Preserving historic buildings

While many older buildings are simply torn down, others are saved because of their historic, cultural, or architectural value. Some of these historic buildings are designated by state or federal government entities. Historic designation typically provides some protection to the historic property in an effort to preserve the structure and its physical and historic integrity. When historic buildings are saved and renovated, occupancy or intended usage is often changed from the original which can require alteration of the building with demolitions, additions, and remodeling. When renovating, remodeling, or preserving a building, the MEP systems are often redesigned either to accommodate the new building use or because the original systems have become so damaged or inefficient that replacement is the best action.

Many cities throughout the United States contain historic buildings, such as old courthouses or government buildings that have been saved over the years and renovated to accommodate current usage. It is during these remodels and renovations that decisions are made regarding the preserving or demolishing of many of the buildings' character-defining features. While some buildings are ultimately demolished, others are preserved to save their historic character. The National Park Service's National Register of Historic Places is an inventory of all registered buildings and sites. All historically significant buildings are not listed in the National Register. Any historic building could be historically significant and represent a cultural history that should be saved. Many owners today have to make decisions regarding the future of their older and sometimes deteriorating buildings. Sometimes it is much more cost efficient to demolish the old buildings and replace them with new modern and efficient structures. On the other hand, when a building is demolished, its architectural, historic, and cultural history is lost forever.

1.3 Introduction of three case studies and the scope that will be presented

To gain an understanding of the problems associated with the incorporation of the MEP systems into historic renovation projects, three case studies are presented. Specifically, these studies provide insight into some of the design issues and problems faced from preliminary planning to the actual construction of these projects. One case study focuses on the mechanical heating, ventilation, and air conditioning (HVAC) issues, the second case study examines the electrical and lighting issues, and the third case study explores the plumbing and fire protection issues.

The three case studies chosen, all in the Kansas City area, include: The Stowers Institute for Medical Research, a HVAC study; the Union Station, an electrical study; and the Webster House, a plumbing and fire protection study. Each of these buildings was chosen to highlight one of the MEP systems where unique problems and coordination issues were part of the design and construction process. To fully understand the issues underlying these historic preservation projects, the building architects, engineers, and contractors were personally interviewed to discover the problems faced in the design and construction process. The scope of the Union Station project was limited to the north waiting room and grand hall where most of the design issues conflicted with the historic character. Both the Webster House and the Stowers Institute for Medical Research were examined in their entirety.

2.0 Goals of historic preservation

2.1 Introduction to historic preservation

When preserving a historic building it is very important to identify which character-defining features will be retained during the renovation. A state historic preservation office can identify these historically important features by their cultural, architectural, or historic value. Effort should be made to preserve the unique historic features in their present or original state. In many instances, cleaning or refurbishing can return a feature to its original state. In other situations, features can be completely rebuilt to match adjacent material and design characteristics. If a new feature is added to the building, it should be documented in the renovation plans by the architects and engineers. The new feature should also be visually apparent that it is not part of the original design. The new feature addition should therefore be visually different in its architecture while still maintaining aesthetic similarity to the historic features. When a historic characteristic is being repaired or restored to its original condition, similar materials and construction techniques should be used to match the appearance of the original design.

2.2 Secretary of Interior Standards for Rehabilitation

The United States Secretary of the Interior's *Standards for Rehabilitation* (Secretary, n.d.) have been developed to guide in the preservation of a property's significance through the protection of historic materials and features. The Standard's definition of rehabilitation is "the process of returning a property to a state of utility, through repair or alteration, which makes possible an efficient contemporary use while preserving those portions and features of the property which are significant to its historic, architectural, and cultural values" (Secretary, n.d.). Each of the ten Secretary of the Interior's *Standards for Rehabilitation* are explained in the following section with the impact they will have on design decisions.

1. "A property shall be used for its historic purpose or be placed in a new use that requires minimal change to the defining characteristics of the building and its site and environment."

This first Standard is intended to protect the character-defining features of a built structure and its surrounding environment. It is intended that a change of occupancy for a building will not require the "gutting" of the historically-significant design characteristics. A similar occupancy use of a property will normally allow for an easier adaptation of the space to a new use without major modifications. Keeping the same building occupancy will help in the design of the MEP systems by reutilizing the existing ductwork and mechanical equipment, whereas increasing the building occupancy will require additional building loads and therefore an increase in the sizes of ducts and mechanical equipment. Allowing the building to maintain its original purpose and occupancy will therefore not only help to preserve the interior spaces by not redesigning the interior layout, but it will also allow the MEP systems to be designed with minimal impact on the character-defining features.

2. "The historic character of a property shall be retained and preserved. The removal of historic materials or alteration of features and spaces that characterize a property shall be avoided."

Application of this Standard results in maintenance of the character-defining features of a building by saving these characteristics when renovating the space. Effort should be made to preserve these features throughout the building's current and future usage and occupancy. When incorporating the MEP systems into a historic preservation or renovation project, the systems should be designed so that these important features are preserved. In many cases, the MEP systems will require a unique design to accommodate the architectural features which characterize the historic building.

3. "Each property shall be recognized as a physical record of its time, place, and use. Changes that create a false sense of historical development, such as adding conjectural features or architectural elements from other buildings, shall not be undertaken."

Design elements or additions can be supplemented to the structure. However, these additions cannot appear historic or even be historic components from other buildings which might confuse the reality of what was historically part of the building; doing so would be a misrepresentation of its historic character. Although redesigning the MEP systems might change the original design, it is often necessary to provide a higher level of comfort for the occupants than what the original systems provided. In some instances, original MEP design features can be saved, but in many situations, new MEP materials and designs can produce better human comfort and efficiency, thus saving money on operation expenses.

4. “Most properties change over time; those changes that have acquired historic significance in their own right shall be retained and preserved.”

Prior modifications to the building should be analyzed to determine if they are historically significant before deciding if they should be either retained or removed. Just because they are not part of the original structure does not mean that these changes should not be preserved. This Standard states that if these changes have become historically significant, then they need to be retained. Sometimes design aspects of the MEP system acquire historic significance and should be retained and preserved. Many times, old MEP systems will be saved for historic value while new MEP systems will be installed in the same space to provide improved comfort or efficiency. Therefore, some original MEP features can be saved even though they are not functional.

5. “Distinctive features, finishes, and construction techniques or examples of craftsmanship that characterize a property shall be preserved.”

During repairs and renovations, character-defining features and construction techniques need to be identified and preserved. It is possible that some MEP components would be deemed distinctive features under this standard and therefore would need to be preserved.

6. “Deteriorated historic features shall be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature shall match the old in design, color, texture, and other visual qualities and, where

possible, materials. Replacement of missing features shall be substantiated by documentary, physical, or pictorial evidence."

When important historic features begin to deteriorate, an attempt to preserve the original materials must be made rather than substituting a new material to match the original. However, in some instances, the deterioration may be so great that repair is not an option and replacement of the feature is necessary. When replacing a historic feature, every effort must be made to research the original characteristics to ensure similarity in construction and visual appearance. Documentation of replacement components and repairs to existing features is encouraged to aid in future preservation efforts by depicting and recording the original versus the replaced feature. Therefore, future studies will easily indicate which features are original to the building and which have been replaced.

7. "Chemical or physical treatments, such as sandblasting, that cause damage to historic materials shall not be used. The surface cleaning of structures, if appropriate, shall be undertaken using the gentlest means possible."

When cleaning a material surface, the method least harmful to the surface should be undertaken first. Additional methods of cleaning can be used to find the effective means that is the gentlest on the surface. When testing a cleaning agent or method for its effectiveness, an area out of sight should be tested before cleaning a prominently visible area.

8. "Significant archeological resources affected by a project shall be protected and preserved. If such resources must be disturbed, mitigation measures shall be undertaken."

It is best to limit the ground disturbance caused by a construction project if possible. When it is necessary to excavate a site for construction, archeological investigation should be conducted to determine if there are buried resources that should be documented prior to undertaking the work. When excavation work proceeds, care should be taken to observe and stop excavation if historic artifacts or human remains are discovered. When possible, ground disturbance should be avoided. For example, new trenches should be avoided unless deemed absolutely necessary. This Standard protects archeological resources that may be present under a project site. If something of archeological significance is discovered during construction, then these findings must be documented, protected, and preserved without damaging these archeological resources.

9. “New additions, exterior alterations, or related new construction shall not destroy historic materials that characterize the property. The new work shall be differentiated from the old and shall be compatible with the massing, size, scale, and architectural features to protect the historic integrity of the property and its environment.”

When making an addition or alteration, the new construction should be added to the existing building in such as way that does not destroy existing features. Additions should be constructed in a manner so that they can be visibly distinguished from the original character of the building. When adding onto an existing material, the connection should not damage the original surface or finish. In many instances where new MEP systems are installed in a building, these new systems will be very different and will contrast with the existing characteristics of the property. These new systems might be aesthetically dissimilar from the original design, but it is important to be able to differentiate between original and new features. However, many times occupant comfort and the ability to fully utilize the building's MEP systems will take precedence over visual appearance of the space. Older MEP systems are commonly upgraded to provide better efficiency and economy.

10. "New additions and adjacent or related new construction shall be undertaken in such a manner that if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired."

Every addition or adjacent new construction needs to be thought of as non-permanent. In this manner, the new construction needs to be assembled so that it can be removed in the future if necessary while not harming the surfaces or finish of the historic property. In many cases, a barrier will be installed between the surface of the historic feature and the new construction to protect the original surface.

2.3 Design challenges of mechanical, electrical, and plumbing systems

A common theme that became apparent in the preservation work studied was a lack of space to install new or upgraded MEP systems. Based on the standards that were reviewed in the previous section, all of these systems should not conflict with the historic features of the building. Each MEP system has unique design challenges that must be faced when renovating and preserving historic buildings.

The mechanical system is often the most difficult of the MEP systems to design because of the large size of equipment. Modern mechanical equipment such as air handling units, chillers, boilers, and the like requires a large amount of space.

Furthermore, routing ductwork can be an issue when not enough space is available in plenums or when original architectural features inhibit the desired routing locations. In some instances, historic buildings might not have had a central mechanical system. In these cases, routing access and required space will probably be an issue because the original design did not have the similar constraints of modern mechanical equipment. Another common HVAC issue for historic structures is the change in humidity levels that results from the installation of a new system; this can cause damage or deterioration to historic structural or finish materials.

The electrical system is often the least difficult MEP system to incorporate into an existing building because of the small size of equipment. The routing of conduit is also simplified because of the small penetration sizes through walls and routing in existing limited plenums. Design problems can arise when a renovated building would require more electrical loading or power to supply additional electrical features. If supplementary electrical power is needed, then new electrical systems and equipment such as transformers, switchgear, panel boards, and the like might need to be designed and installed in the building. Routing additional conduit and making room for additional electrical equipment can be a design challenge in working around architectural features and spaces.

Plumbing and fire protections systems have unique design challenges. For example, many older buildings might not have fire suppression systems or fire-rated walls required by current building codes. It can be difficult to bring a building up to current fire safety codes while still maintaining the historic characteristics of the building. This is because if a new fire suppression system is to be installed, it will usually require new piping and penetrations in the structure. When redesigning a building's interior spaces, the plumbing piping consisting of hot water, hot water recirculation, cold water, sanitary water, and vent piping will all need to be coordinated with the other design disciplines and the architectural features of the structure in order to not penetrate through any character-defining areas of the building. Plumbing equipment such as pumps, hot water heaters, backflow preventers, and the like also need allocated space in the building. Besides locating the basic plumbing equipment, storm water drainage can pose one of the most difficult design issues. If storm water piping will be routed within the building, this can possibly mean very large piping and penetrations. It could be very difficult to integrate and coordinate the large storm water pipes with existing MEP routing, equipment, and the historic character of the building.

3.0 Mechanical system case study – Stowers Institute for Medical Research

3.1 History of building

The original Menorah Hospital was built in the 1930s at 1000 East 50th Street in Kansas City, Missouri. The preliminary design drawings were produced in the late 1920s, but the stock market crash in 1929 caused a drastic change in many of the planned design features. Much of the detail and advanced designs were value engineered out of the original plans (Newman, 2002). The first Menorah Hospital building was constructed as a T-shape structure with an adjacent elevator tower rectangular structure. Next, a second building was built on the other side of the elevator tower. In the 1960s and later, several additions were joined to the original design. During the 1970s, a very large patient wing addition was constructed adjacent to the existing buildings. This patient wing would later be demolished during the Stowers Institute construction (Schaadt, 2008).

The vacant Menorah Hospital building had become very dilapidated and run down by the early 1990s (Architects, n.d.). The old hospital was deteriorated to a point where much of the building would have to be completely destroyed and rebuilt. Because of this factor and the desire to build a completely new state-of-the-art facility that incorporated only the best technology and design techniques, most of the hospital would be torn down. In fact, only the concrete framing of the Menorah Hospital would be saved (Rozgus, 2002). This included the basic structural design along with the basic elevator shafts and equipment (Schaadt, 2008). Every other non-structural aspect of the interior and exterior would be gutted and redesigned. The new vision for the Stowers Institute for

Medical Research would include four old Menorah Hospital building frames and one newly constructed building on the site (Rozgus, 2002). A medical office building was to be housed in the new building. A six hundred car parking garage would also be located on the site. To make the Stowers Institute campus aesthetically pleasing, a variety of landscaping would surround the buildings (Schaadt, 2008). One of the main architectural challenges was to design a coherent research campus with the intended goals of the new facility while at the same time bringing the new and old buildings into a united identity (Rozgus, 2002). Therefore, the old Menorah Hospital buildings were not preserved; only the structural frame of some of the buildings was reused in order to renovate the structure into a new usage.

The former Menorah Hospital site was bought by the Stowers Institute in 1995. Several top research facilities throughout the United States were studied as precedents to provide optimum research capabilities in the future Stowers Institute. Beginning in November of 1997, three years of construction took place before the first phase of the renovated facility was opened. The Stowers Institute for Medical Research was officially opened in November of 2000 (Stowers, 2005). Two additional phases were completed over a two year period after the initial phase was opened (Geary, 2008). The building occupies 600,000 square feet and is located on a ten acres site (Stowers, 2005). About 250,000 square feet of the old Menorah Hospital was renovated, and over 300,000 square feet of new buildings were constructed (Schaadt, 2008). The Stowers Institute for Medical Research is shown in Figure 1.

Figure 1. Stowers Institute for Medical Research

The total construction and equipment cost of the facility was $300 million. The institute contains some of the world's most state-of-the-art laboratories that incorporate the most advanced design techniques and technologies. The quality of technology in the institute allows scientists to work both quickly and efficiently in order to preserve human health and prevent disease. The facility houses the best possible equipment to suit the needs of the scientists and researchers. As a result of the high quality design, the Stowers Institute hopes to attract scientists from other institutions such as Harvard and the Howard Hughes Medical Institute in order to continue their research at the Stowers Institute (Stowers, 2005). "When candidates see the offices, they are more than ready to leave their dank, overcrowded basement offices behind. The design has played an integral role in recruiting potential candidates" (Newman, 2002). The laboratories are characterized by open planning with an abundance of natural sunlight. Through the success of recruiting efforts, the Stowers Institute has employed five times more employees than it originally planned (Newman, 2002). Current Stowers researchers have come from more than twenty countries in order to purse their studies at the Stowers Institute (Stowers, 2005). Research & Development Magazine awarded the Stowers Institute for Medical Research with the title of High Honors – 2002 Laboratory of the Year "on this building for its research labs, vivarium, and overall 'humanness'" (Architects, n.d.).

Today, the Stowers Institute for Medical Research is one of the most innovative biomedical research facilities in the world. Some of the research conducted by world-renown scientists involves studying genes and proteins to discover processes in living cells in order to find causes, treatment, and prevention of diseases. The owners of the Stowers Institute are Jim and Virginia Stowers. Both Jim and Virginia Stowers are cancer survivors of prostate and breast cancer, respectively. Mr. and Mrs. Stowers have dedicated much of their time and money in the support of research for gene-based diseases. Today, the institute has over thirty independent research programs with more than four hundred sixty people working in the building on a daily basis. Of these daily workers, more than three hundred sixty-five staff members are part of the scientific team (Stowers, 2005). About three hundred of these individuals are laboratory scientists (Geary, 2008). Many of the occupants include scientists, research associates, technicians, supporting staff, and administration workers (Stowers, 2005).

Currently, the Stowers Institute for Medical Research campus is completely landlocked without any space to expand its facilities in its current location. The institute is quickly approaching capacity and will need to grow to another campus in order to accommodate the influx of scientists and researchers. One hundred acres was just purchased about fifteen minutes away from the Stowers Institute for Medical Research for a new campus and more laboratories (Barber, 2008).

3.2 Importance of keeping the building and preserving

When the architects and engineers were designing the new Stowers Institute for Medical Research, the recommendation was to demolish all of the original Menorah Hospital buildings and start the Stowers project with all new construction. However, Mr. and Mrs. Stowers, who were the owners and visionaries behind the project, did not allow everything to be torn down. Mr. and Mrs. Stowers actually met for the first time in the old Menorah Hospital so this building had a significant value to them so they wanted the structure to be saved from demolition. Therefore, the original 1930s design was salvaged while the later additions were taken down. Mike Schaadt, who was the Principle Architect for PGAV on the job, commented that it would have been much easier to tear down everything and start new from a design standpoint. However, the owners dictated that they wanted to keep the old Menorah Hospital building because of its sentimental value to their relationship. Reutilizing the old hospital structure would prove to be a complicated design challenge, and provide an interesting utility master plan (Schaadt, 2008).

Furthermore, the condition of the hospital building was very poor, and there was not much historic interest in keeping anything from this previous structure or design. The new usage of the Stowers Institute would incorporate only the best designs and materials, so the decision was made not to save anything but the basic concrete framework of the old buildings (Schaadt, 2008). The exterior of the Stowers Institute for Medical Research is shown in Figure 2.

Figure 2. Exterior of the Stowers Institute

A benefit to saving some of the old building structures was the high floor square footage to site area ratio of the original structure. Based on current zoning ordinances, a completely new design on the same site would have had more restrictions and setbacks, limiting the square footage that could be constructed. If all of the old Menorah structure was demolished, then zoning would have mandated a lower floor area to site area ratio. Therefore, incorporating some of the old hospital buildings allowed for more usable site area and therefore more net floor area than all new construction (Schaadt, 2008).

3.3 Architectural / cultural / historic character-defining features

Since all of the Menorah Hospital was torn down except for the basic concrete structural system, there are no present character-defining features with the exception of the building layout on the site. In an effort to create a state of the art facility, the interior of the old hospital was completely gutted and redesigned. In this instance, the character-defining features and historic character of the hospital were deemed less important when envisioning a newly constructed medical research facility.

3.4 Renovation and construction facts

The construction of the Stowers Institute for Medical Research was led by the general contractors JE Dunn Construction Company. Peckham Guyton Albers and Viets, Inc. (PGAV) was the principal architect on the job (Stowers, 2005). PGAV were also the lead master planners and architectural developers for the research facility (Schaadt, 2008). The specific laboratory spaces and other areas complementing the research were designed by MBT Architecture. Based in San Francisco, MBT Architecture specializes in research facilities (Stowers, 2005). Walter P. Moore Associates were the structural engineers on the project, and Gayner Engineers were the mechanical, electrical and plumbing engineers (Rozgus, 2002). The construction of the Stowers Institute was done with a "fast-track approach." This quick design process allowed occupancy in the building within three years of ground-breaking (JE Dunn, 2008). With the rapid construction method, about $300 million of construction was completed in a six month period. The demolition of some buildings was done before the re-designing of those spaces. In many instances, design and construction would take place at the same time

(Schaadt, 2008). In some cases, the building construction was even ahead of the design (Geary, 2008). Utilizing such a quick method of construction created some coordination issues between the contractors and design engineers. However, the owners were very prompt at making decisions which facilitated the teamwork between the architects, engineers, and contractors (Schaadt, 2008).

Spatial design considerations for the Stowers Institute were primarily based on scientific collaborations between the researchers. Instead of isolating each laboratory, the general design promotes teamwork and the sharing of ideas for the overall goal of promoting human health. Many unique architectural design characteristics further this cause. For example, in the middle of the laboratory building lays an open sky-lighted stairwell to facilitate informal discussions among the researchers without having to take an elevator between floors. All laboratory spaces are connected by interior doors to make it easy for researchers to move between labs for discussions and brainstorming. The tendency to stay in the lab and focus on their own work is strong, but scientific breakthroughs often come from collaboration between scientists that do now work in the same laboratories. The library also contains a gathering area with comfortable seating in front of a fireplace where scientists can collaborate when they meet each other away from their laboratories. Many other areas in the Stowers Institute promote collaboration and discussions such as indoor gardens and other strategically placed seating areas throughout the facility. A key architectural design characteristic of the Stowers Institute is openness of interior spaces. Very expensive and high-end materials were also used to decorate the interior of the complex (Stowers, 2005). Some sustainable materials were used as well in the interior design (Schaadt, 2008). However, many materials were even brought in from other countries (Barber, 2008). Some of these exotic materials include artistic glass and exotic woods such as anigre and makore (Stowers, 2005). Stone and woods used were purposely chosen lighter in color so that the appearance of the facility would not be institutional. "MBT (Architecture) developed a color and materials scheme that included tans, golds, limestone, and an abundance of lighting – both manmade and natural – to make the Institute's interiors as light and uplifting as possible" (Newman, 2002).

A central interior design theme was the inclusion of typical residential materials to increase occupant comfort and performance. Richard Rietz, a design consultant and 2002 Lab of the Year judge stated, "The working environment created to attract top scientific staff to Stowers is first-class, from the private investigator offices to the specialty labs to the health club to the seminar room to the barrier vivarium. Nothing has been left out, no detail has been missed, and each piece is first-rate" (Rozgus, 2002). Dave Barber of JE Dunn Construction commented that a "Cadillac" building was both designed and constructed (Barber, 2008). From a construction standpoint, very little was cut out of the architectural and engineering design (Schaadt, 2008).

The completed campus of the Stowers Institute consists of a six-story research building complex with three additional basement levels, a four-story administrative building, and a parking garage. The six-story research building is part of the old Menorah Hospital structure, shown in Figure 3, while the four-story administrative building, shown in Figure 4, and parking garage are new construction (Stowers, 2005).

Figure 3. Six-story research building complex

Figure 4. Four-story administrative building

The administrative building contains offices, a health club, and a floor of guest suites for researchers temporarily visiting the Stowers Institute (Stowers, 2005). The Stowers Institute houses twenty-two independent laboratories and three state-of-the-art technology centers (Stowers, n.d.). Each floor of the research complex includes eight laboratories and private offices. Each laboratory includes six to eight work benches for research. Each lab is supplied with fume hoods, ergonomic lighting, natural gas, compressed air, vacuums, water, electrical power, and data outlets (Stowers, 2005). Each laboratory is equipped with an advanced waste management system which disposes of waste material through a double containment piping system. This waste piping system also incorporates leak detection monitoring of the inner pipe (JE Dunn, 2008). Two rows of laboratories on each floor surround a research support area. The research support areas include darkrooms, tissue culture labs, equipment rooms, and cold rooms for tissue preparation (Stowers, 2005). These lab support spaces also house temperature control rooms, double containment chemical storage rooms, noisy equipment rooms, and special procedure rooms. Many of these special uses require liquid nitrogen and CO_2 piped to points of use (Newman, 2002). The Stowers has also compiled a very large range of support facilities such as Advanced Instrumentation and Physics, Drosophila Stock Facility, Histology and Immunohistochemistry, Imaging, Laboratory Animal Services, Media Preparation, Microarray, Molecular Biology, Proteomics, Tissue Culture, and Reptile and Aquatics (Stowers, n.d.). Core laboratory facilities provide technologies such as bioinformatics, flow cytometry, knock-out and transgenic technologies, imaging, DNA sequencing, and genomics (Frequently, n.d.). The first floor of the research facility contains an auditorium, conference rooms, teleconference rooms, broadcasting rooms, and a cafeteria. To make the landscaping aesthetically pleasing, fountains and ponds surround the campus buildings as shown in Figure 5 (Stowers, 2005).

Figure 5. Site landscaping

One interesting research area of the facility is a vivarium which houses transgenic mice and other highly specialized research animals. This animal research area is the first in the United States to utilize the Automated Cage and Rack Washing system designed by Steris Amsco, a Swedish company. The importance of this $1.5 million system is that it robotically empties the mice cages, washes and dries the cages, places food and bedding back into the clean cages, and installs the cages for use all without being touched by human hands. In the very precise animal environment in which every variable must be controlled, this system helps to reduce outside human factors of exposure and contamination (Stowers, 2005). The vivarium also includes an automated system to provide drinking water to the caged animals without human interaction. The animal holding rooms also incorporate ventilated cage racks to limit air contamination (JE Dunn, 2008). Services to this vivarium area such as changing light bulbs are done from the above floor to decrease contamination factors. By keeping sealed light fixtures that are changed from the above floor, this ensures a cleaner environment for the animals. Flexible connections join the wall to ceiling seams; these seams are also cupped so that bacterial formation is circumvented in these areas (Rozgus, 2002).

Although only the basic structural system of the old Menorah Hospital was kept, the biggest architectural design challenge for the architects was giving "the diverse buildings constructed during varying time periods a seamless identity." This unified appearance had to cover the campus buildings from three distinct construction eras: the main Menorah Hospital built during the original US-depression period of the 1930s, the medial offices addition in the 1960s, and the new building construction required for the Stowers Institute. The final architectural solution was an exterior appearance of seamless horizontal glazing and vertical towers. This planning effort would have to prove to be both functional and aesthetically welcoming to the surrounding environment (Newman, 2002). The Stowers Institute campus is shown in Figure 6.

Figure 6. Stowers Institute campus buildings

A unifying design aspect to the exterior appearance is the windows. Windows appear horizontally throughout the entire length of the building. However, not every glass pane is a window; primary structural elements and utility shafts are covered with opaque glass with the same exterior appearance. Mike Shaadt of PGAV Architects stated, “The horizontal glazing technique allowed us to diminish the fact that each of the existing buildings was very different. It allowed us to achieve continuity and deal with functional issues. The low-e, green-tinted glass also has a high visible light transmission and lets in as much natural light as possible.” This technique unified the buildings without a disjointed appearance (Newman, 2002). The horizontal window design is depicted in Figure 7.

Figure 7. Exterior band of windows

The roof of the medical campus structure was a further architectural feature used to unify the campus and blend the various building structures as a coherent design. Mike Shaadt commented, “The roof is the most distinguishing feature of the facility. During conceptual design, Mr. Stowers expressed his desire to include water features and an expressed roof structure as integral design elements. He wanted to see the overhangs because he felt that facades that terminated at the parapet didn’t look finished.” The roof structure also was designed to cover the massive mechanical equipment that is housed on top of the building. Much of the exhausting equipment is located on this penthouse area of the building, and it takes up a significant amount of space because of the outside air requirements of the research facility. Much of this equipment includes exhaust fans, piping, and mechanical ductwork. The roofing is stainless steel which provides excellent corrosion resistance. This type of roof is ideal for the Stowers Institute because it is very aesthetically pleasing while requiring very minimal maintenance (Newman, 2002). The penthouse roof level covers the mechanical equipment as shown in Figure 8, and the exhausting penetrations through the roof are shown in Figure 9.

Figure 8. Penthouse roof level

Figure 9. Exhaust penetrations through the roof

Architects and engineers preliminarily had to study the old Menorah Hospital building design. Each space was evaluated to determine if it could be reused in the new research setting. Even though over 270,000 square feet of the old Menorah Hospital was demolished, all of the main Menorah Hospital building was saved (Newman, 2002). The old patient wing in the center of the campus was taken down; this center area of the site was where much of the original footprint was demolished (Schaadt, 2008). This old hospital building now houses the main laboratory rooms of the Stowers Institute. Because of the old Menorah Hospital's regular structural system, the former hospital patient rooms were transformed into research laboratories. Mike Schaadt, vice president of PGAV Architects, commented on the demolishing of part of the Menorah Hospital, "The irregular structural geometry was just not conducive to reuse in a modular laboratory concept. From a campus planning perspective we wanted to strengthen the relationships between the existing buildings and create one unified campus setting which is what demolishing part of Menorah helped us achieve" (Newman, 2002).

When new construction was added adjacent to an old Menorah Hospital building, the floor-to-floor height had to be the same in both the new and old buildings. This was important so that no ramps would have to be added between the differing structures (Barber, 2008). However, additions to the original buildings would have mechanical complications because of the low floor-to-floor heights. From a design perspective, designing all of the new construction with a larger floor-to-floor height would have made the mechanical system design much easier. Only the new non-connecting buildings would be able to have a larger designed floor-to-floor height. The new buildings' floor-to-floor height was designed at fifteen feet. However, the floor-to-floor height in the renovated, original buildings was only about twelve feet (Schaadt, 2008).

In the old Menorah Hospital building, there was a central, double-loaded corridor running through the middle of the wings, with equally sized patient rooms on each side of the corridor. In the new design of these wings, the corridor was moved off-center so that bigger lab spaces would be on one side and smaller offices would be on the other side of the corridor (Schaadt, 2008).

The Stowers Institute for Medical Research now stands as a "state-of-the-art research center that has set new standards in healthcare design." Tully Shelley III, president of MBT Architecture, highlighted the research facility, "The research spaces are incredibly well-planned and thought through to the last detail. The spaces are beautiful, durable, functional, flexible, and adaptable. They honor those doing science" (Newman, 2002).

3.5 Specific mechanical system facts and design

Different design techniques had to be incorporated between the new and old buildings because the older structure had a much lower floor-to-floor height (Rozgus, 2002). Low floor-to-floor heights were problematic because of the space needed for the utility equipment (Barber, 2008) and required different designs for mechanical and other utility distribution (Rozgus, 2002). The small plenum heights (space between ceiling and floor structure or roof structure above) made it very difficult to run large mechanical ducts through the facility. The ceiling heights in the old Menorah Hospital buildings are now about 8'-6" leaving a 3'-6" plenum space (Schaadt, 2008). This research facility required much more space dedicated to the utility systems than other buildings because of the high percentage of outside air and exhausted air needed. The research facility also required laboratory hoods, extra ductwork, extra gases for the lab areas, and the like (Barber, 2008). In general, at the beginning of the project, the mechanical system was a primary design consideration in regards to space planning (Schaadt, 2008). Major design aspects of the Stowers Institute mechanical system consisted of redundancy and piping to each laboratory (Barber, 2008).

The mechanical design for the renovation of the old Menorah Hospital utilized new "super shafts" which distribute air, exhaust air, and provide piped utilities to labs spaces (Newman, 2002). The super shafts had to be located about every fifty feet and were about eight feet by twenty five feet in size. These vertical shafts penetrate directly through the existing structure. With this design, there was now a method for easily distributing vertical mechanical ductwork through the building (Schaadt, 2008). These super shafts were required because of the low floor-to-floor heights that would be in the new laboratories outfitted from the old hospital structure. The floor-to-floor heights ranged from eleven to twelve feet. In order to not disrupt research in progress, the service maintenance points were located within the super shafts. This allows the maintenance of utility spaces without having to go through existing ceilings or walls (Newman, 2002).

Air is supplied to most areas of the campus along the perimeter walls, next to the windows. The research and laboratory areas have both a general and fume hood exhaust (Schaadt, 2008). The fume hood exhaust is designed with a higher air flow rate to ensure no contaminants are able to escape these areas. Coordination between all of the utility and structural design was the main challenge. For example, each lab required vacuum air, natural gas, hot water, cold water, deionized water, and the like (Schaadt, 2008).

The newly built administrative building of the Stowers Institute was a mechanical systems challenge in itself because of the many varied occupancies and uses of this building. This building incorporates administrative offices, residential suites for visiting scientists, meeting rooms, break rooms, a full kitchen, and a health club (Newman, 2002).

One design parameter of the mechanical system included the allowance of direct outside views from the lab spaces. Even the basement facilities would include outside views without the mechanical system blocking the direct views (Rozgus, 2002).

Since almost all of the supplied air is exhausted from the Stowers Institute, a very large amount of energy is used in the mechanical system. These energy costs are huge because very little energy can be recovered and recycled back into the mechanical system (Barber, 2008). Basically, the Stowers Institute requires almost one hundred percent outside air, and very little of the supplied air is returned back into the mechanical system because of contamination issues (Schaadt, 2008). Some of the only return air spaces include: the administrative hallways, cafeteria eating area, and some offices (Geary, 2008). The research areas require one hundred percent outside air which is all exhausted out of the space. This is an important design feature so there is no unclean contaminated air in these areas of the building (Schaadt, 2008). Therefore, it is imperative that all labs and even lab corridors have supplied air with no return (Geary, 2008). In an effort to offset the large energy usage, many portions of the buildings are using point-of-use mechanical systems so that the mechanical units are not operating at one hundred percent all of the time. Non-contaminated air from non-laboratory spaces can also be returned back into the supply air system to save energy. During the design and construction, balancing the mechanical system was a very time-intensive process. Since many of the rooms inside the facility required absolute control on the room environment, the room mechanical balancing had to be exact. Any variation from the design conditions could disrupt and invalidate the research testing. Every space is therefore controlled by a variable air volume (VAV) system (Barber, 2008).

Outside air is introduced to the Stowers campus along the building exterior ground level. Several steel grates are located along the perimeter of the buildings as shown in Figure 10 (Schaadt, 2008).

Figure 10. Outside air intakes along the building perimeter.

These intake air locations bring the outside air to the lowest basement level in order to be supplied upward in the building. The exhausted air is also moved upward vertically from each level to the roof. The roof consists of a penthouse floor for the exhausting equipment (Schaadt, 2008). Cooling towers are also located on the roof, but they are architecturally screened for aesthetic purposes. The only noticeable mechanical features on the roof are the exhaust plenums (Geary, 2008).

Even though energy efficiency was limited due to the high exhaust requirements of the laboratory spaces, some mechanical energy saving methods were achieved (Barber, 2008). However, more mechanical energy saving technologies could have been incorporated to save both energy and money. Mike Schaadt from PGAV Architects commented that utilizing heat wheel technology would have made the building more energy efficient. An energy recovery ventilator would have taken heat out of the exhaust air stream and put this heat back into the supply air stream (Schaadt, 2008).

As a further item that could have been improved, Dave Barber from JE Dunn Construction stated that some advanced lighting techniques could have been incorporated into the design which would have provided for a more energy efficient system. Many lighting schemes were based on fixture appearance rather than the light fixture efficiency. Although day-lighting was incorporated into the design, other lighting improvements could have been considered. However, in an effort to make the space seem luxurious and accommodating, several lighting fixtures were chosen which compromised energy efficiency (Barber, 2008). Mike Schaadt agreed that the lighting technology could have been improved also. Schaadt would have liked to have seen even more day-lighting utilized, but natural night was not the most important design theme in the plans (Schaadt, 2008).

Dave Barber also commented that using a 3D modeling program such as Building Information Modeling (BIM) would have decreased the coordination issues in the field during construction. Since space was limited, there were many integration issues concerning the installation of the utility systems. Modeling the utilities in three dimensions would have aided in fitting all of the required utilities in the space provided without running into coordination conflicts when being installed in the field (Barber, 2008).

The mechanical equipment for the Stowers Institute was very expensive: each VAV box is valued at about $500, while each Phoenix Valve off of the laboratory exhaust hoods is about $2500 a piece. In the exhausting system for the laboratories, one hundred cubic feet per minute of air must be exhausted. This high rate of exhaust ensures that contaminants are pulled from the space and are not able to return back into the room (Barber, 2008).

Because the laboratories and their associated research cannot be disturbed by outside factors, vibration control was very important for much of the utility equipment. For this reason, the majority of the utility equipment is not located in the old Menorah Hospital building. Instead, the equipment is placed in the newly constructed buildings of the complex where floating and isolation slabs have been designed (Barber, 2008).

Built-in redundancy was designed into the mechanical chilled water and steam system. It is imperative in some areas of the building that these systems stay functional so that the indoor temperature conditions within the space are not changed. Allowing the interior spaces to fluctuate in temperature would have a drastic effect on the control variables of the laboratory research. Along with redundant mechanical systems, there are also three power generators for the campus which provide backup power in the event of an electrical outage (Barber, 2008). These emergency generators only power the critical spaces. The critical spaces can go for four days with this emergency power (Geary, 2008).

Most of the mechanical equipment is located in the lowest basement level of the research facility building (Barber, 2008). The heating and cooling central plant is located here which serves both the new and originally constructed buildings (Schaadt, 2008). Four boilers are located in the lowest basement level for heating; reheat coils are then located in the VAV units closer to the conditioned space (Geary, 2008). A boiler is shown in Figure 11.

Figure 11. Boiler

Two of these four main boilers are dual fuel, meaning they are supplied by natural gas but they also can run on fuel oil. There are also two separate steam boilers which are used for sterilization procedures. These steam boilers run at higher pressures in order to provide the sterilization process (Geary, 2008). A steam boiler is shown in Figure 12.

Figure 12. Steam boiler

The Stowers Institute also has four chillers in a separate designated chiller room (Geary, 2008). A chiller is shown in Figure 13.

Figure 13. Chiller

The air handling units are located in the basement mechanical area and are positioned depending on what spaces they are conditioning. The air handling units therefore move the air vertically through the super shafts to the desired level. The campus has very high mechanical loads and therefore required capacity because most of the air is not recirculated back into the supply stream. The electrical source is brought in from Kansas City Power and Light (KCPL) through two feeds into substations, connecting to electrical switchgear in the basement of the facility (Geary, 2008).

As mentioned, the third basement level (B3) houses the majority of the mechanical equipment, but the second basement level (B2) is also a mechanical floor. The animal facility is located in a separate area of level B3. The animals are located on this controlled environment level so that maintenance can take place in the B2 level without disturbing the animals' environment. For example, all light fixtures in the animal facility are completely sealed to the ceiling and must be changed out from the B2 level above. An aquatic water system has also been installed to service the animal facility. This aquatic system provides water treated through reverse osmosis for several animal species' rooms such as the frog room (Geary, 2008). The aquatic system is shown in Figure 14.

Figure 14. Aquatic system

A specialty laser used in research is also housed in the B2 level which requires three chillers to function. The laser splits cells and particles by using light reflection and projecting a shot of air in order to disrupt the cell by "shooting" it out of the light stream (Geary, 2008). This laser is shown in Figure 15.

Figure 15. Specialty laser used in research

Air is changed over twelve times per hour in the lab spaces and fifteen times per hour in the animal facility spaces. All of the mechanical controls are monitored by Johnson Controls equipment. An in-house maintenance staff of eight people is in charge of the facility plant engineering. Overall, the Stowers Institute for Medical Research was mechanically designed for one-and-a-half times necessary capacity for redundancy. The building is mechanically operated all hours of the day, seven days a week because of the animals living in the environment (Geary, 2008).

3.6 Problems with preservation versus mechanical system

In the renovation of the Menorah Hospital into the Stowers Institute, access for the mechanical equipment and routing was a primary challenge (Barber, 2008). The original Menorah Hospital structure provided small floor-to-floor heights, especially for the large ductwork required for the HVAC building loads. Super shafts were used to penetrate vertically through each floor to distribute air to each level and bring exhaust air to the roof to exit the building. Given the small plenum heights, routing the mechanical ductwork provided a challenge in coordinating with the other disciplines. Piping, electrical, lighting, and structural issues had to be coordinated with the ductwork to prevent routing conflicts.

The high aesthetic quality of the Stowers Institute also proved to be a challenge in designing the mechanical system. In most areas, linear slot diffusers were utilized instead of basic square diffusers and grills in order to provide a better visual appearance. The mechanical system located on the roof such as the exhausting equipment and the chillers had to be architecturally covered to keep the attractive appearance of the building. Such efforts in making the building as aesthetically pleasing as possible increased the design coordination between the architects and engineers. These visual effects also enlarge the building construction cost.

3.7 Final product

Since the Stowers Institute for Medical Research opened to scientists in November of 2000, more than 225 papers have been published by Stowers scientists in leading scientific journals such as *Science and Nature*. The Stowers has received funding from many key organizations developed to promoting health and research such as the National Institute of Health, the Howard Hughes Medical Institute, the American Cancer Society, the March of Dimes, the Leukemia and Lymphoma Society, and the like. The mission statement of the Stowers Institute for Medical Research states, “To make a significant contribution to humanity through medical research by expanding our understanding of the secrets of life and by improving life’s quality through innovative approaches to the causes, treatment, and prevention of diseases” (Stowers, n.d.). As an organization dedicated to studying how genes cause many diseases in order to develop new therapies, drugs, and diagnostic techniques, the Stowers Institute for Medical Research has been mechanically designed to optimize laboratory research.

4.0 Electrical / lighting system case study – Kansas City Union Station

4.1 History of building

The Union Station's design was first conceived in 1903 after the second major Kansas City flood demolished the previous rail station in the city's West Bottoms district. In the planning of Union Station as a new train station serving Kansas City, rail executives decided that the new station would be located in a more central location and on higher ground than the West Bottoms to prevent future flooding disasters. Chicago architect Jarvis Hunt was selected to develop plans for the new station and surrounding landscape. In Hunt's design, he wanted to incorporate "well-designed buildings and street plans with green spaces in the urban streetscape." Construction finally began on Union Station in 1911. The design was architecturally styled after the beaux-arts era which was popular in the United States and France during the late 1800s and early 1900s. When finished, this building would stand as the nation's third-largest train station. In design and construction, the building was envisioned to last 200 years (Union, n.d.).

The Kansas City Union Station, located at 30 West Pershing Road in Kansas City, Missouri, was originally opened on October 30, 1914. The first train to operate through the Station was the Missouri-Kansas-Texas flyer which arrived into the station just after midnight on the morning of November 1, 1914. The original construction cost was about six million dollars. It was partially funded by a $50 million investment from The Kansas City Terminal Railroad (KCTR) formed by the union of twelve railroad companies. The 850,000 square foot structure contained about 900 rooms. The building contained restaurants, a cigar store, the city's largest barber shop, a post office, drug store, and offices. Even a small jail and an emergency hospital were located in the Station. Every effort was made in the design to accommodate every need of the average traveler. Two very popular eateries included the Harvey House coffee shop and The Westport room. The largest Railway Express Building in the nation was also housed in the complex to ship freight and mail (Union, n.d.).

The original architectural design of Union Station consisted of three sub-levels. These levels were created to accommodate traffic flows of the various people using the Station including: departing travelers, baggage transportation, and other local citizens who were just there to utilize the facility's services. "Arriving passengers were channeled down concourses on either side of the north waiting room toward the grand lobby, allowing separate space for those arriving and departing." A power plant located west of the main building provided steam and electrical power for the building (Union, n.d.).

Social class segregation was very evident in the Union Station's original design of sub-levels. Different social classes were separated from each other while waiting to board the trains. The first class travelers were located on the first or main level. The second and third class passengers had to wait below the first floor, while the United States immigrants who were traveling had to stay in the back of this basement area toward the wall (Fountain, 2008).

The original Union Station incorporated sophisticated technology for its time period. For example seventy elevators were installed that were operated by an oil pressure system. This was the first project in the entire country to incorporate oil pressure elevator technology. The museum currently located inside the renovated Station has information pertaining to this new technology. The elevators served both the mail system and the baggage freight for the trains. The mail operated in a two-level tunnel system where the mail would be sent one level below grade to be transferred over the adjacent post office building. The elevators were also primarily used to move the baggage and freight from the lower level to the main level. The underground level was important because the baggage could be sorted without conflicting with passenger foot-traffic. After the baggage was sorted, the elevator would lift these items up to the main level to be placed on the train. In this manner, passengers would arrive and depart on the main level, and their luggage would be sorted below in the basement area (Fountain, 2008).

The north waiting room of the Union Station had a capacity of 10,000 travelers at any one time. It is estimated that tens of thousands of passengers traveled through the Union Station every year during its operating years. During World War I, 79,368 trains were passing through Union Station each year. This included 271 daily trains through the Kansas City terminal. It is also believed that during World War II, about one million commuters including travelers and military service personnel passed through the station (Union, n.d.).

From the 1950s through the 1970s, passenger rail traffic started to decline as the airline industry began to grow. By 1968, many of the restaurants and retails stores had closed due to decreased traffic. Finally in 1972, the Kansas City Union Station was placed on the National Register of Historic Places, thus receiving federal designation as a protected structure. By 1973, only six trains per day were passing through the Station, and passenger traffic fell to only 32,842 travelers per year. The last Amtrak train passed through Union Station in 1985, and the last restaurant, The Lobster Pot, closed in 1989 (Union, n.d.).

During the 1980s, Union Station was slowly closed down. The first main section to close was the north waiting room. Then other sections started to close down as maintenance issues became too time-consuming and costly. The building would sit vacant for the next several years, becoming more and more neglected. Many efforts to demolish the building were presented, but the Union Station remained standing empty and deteriorating. Finally in 1996, a bi-state initiative was passed to preserve and renovate the Union Station to its original appearance and create a science museum. The one-eight of a cent bi-state sales tax raised $118 million of the $250 million renovation and construction cost. Federal funding and private donations contributed the remainder of the necessary money. In the history of the United States, this was the first bi-state tax. The restoration of the Union Station was completed in 1999. On November 10, 1999, Union Station was once again opened to the public (Union, n.d.). An exterior photograph of the Union Station is shown in Figure 16.

Figure 16. Exterior photograph of the Union Station

In December of 2002, the Amtrak railway began serving the Union Station again. Finally in 2005, a permanent exhibit showcasing the history of the railroads and the Union Station opened for viewing. The rehabilitated structure now stands as a fully-restored building which preserves the cultural uniqueness of the Kansas City Union Station (Union, n.d.). The grand hall of the Union Station is shown in Figure 17.

Figure 17. The grand hall of the Union Station

Today the Union Station in Kansas City serves the area with many entertainment and cultural activities including: a vintage rail car exhibit called the KC Rail Experience, an interactive science center called Science City, a theater, several restaurants, shops, a planetarium, exhibit spaces, and areas for meetings or events. Furthermore, the Union Station still serves the Kansas City area with rail transportation through Amtrak service lines (Union, n.d.). The adjacent railroad lines are shown in Figure 18.

Figure 18. Union Station railroad lines

Newly preserved, the Union Station provides educational and cultural information about one of the regions most important buildings through museums and attractions. The Union Station showcases part of the unique Kansas City history and now promotes "innovation, research and discovery in science in technology through the development of collections, exhibitions, and other educational programs, for all citizens of and visitors to the Greater Kansas City metropolitan area" (Union, n.d.).

4.2 The importance of preserving Union Station

The Union Station stands as one of Kansas City's most important historic and architectural landmarks. One of the main goals in preserving the Union Station was to "collect, preserve, and interpret materials and artifacts that represent the broad scope of history within the diverse Kansas City metropolitan area, and to safeguard those collections for future generations." The vision for the renovated Union Station was in part to educate Kansas City citizens of the regional history and to also provide a venue for the exhibition of scientific understanding. The Union Station would therefore "assist in experiencing old and new technologies affecting our lives and inspiring others to become innovators in developing technologies for the future." The renovated Station now serves as a venue for traveling exhibits and events. Visitors to the newly renovated Union Station now "understand the importance of historic preservation in contemporary society." Union Station is not only a magnificent building, but it also serves the Kansas City area with many memories (Union, n.d.).

The Union Station was the site of one of the most interesting stories in the history of Kansas City: the June 17, 1933, Union Station Massacre. Frank Nash, a convicted murderer and gangster, was being escorted through Union Station by a group of FBI agents and local police officers when a shootout erupted. Two or three gunman began firing at the police as they escorted Nash outside the Station toward their police cars. In the exchange of gunfire, Frank Nash was shot to death just outside of the Station. Four police officers were also killed in the shootout. For many subsequent years, marks on the front exterior of the Union Station building were believed to be bullet-holes from the shootout. These marks can be found just outside the east entrance of the Station. However, Kansas City, Missouri, police officers have since proved that the marks could not have come from bullets. Nevertheless, the story and the myth of the bullet holes in the Union Station exterior still live on today. In reality, the term "Union Station Massacre" helped as a method to build the modern United States Federal Bureau of

Investigation (FBI) because of the public outrage over the viscous shooting in such a populated area (Union, n.d.).

4.3 Architectural / cultural / historic character-defining features

The character-defining architectural features were put into three priority categories to be saved: high, medium, and low priorities (Fountain, 2008). Along with historians, Mary Oerhlein, AIA, with Oerhlein & Associates Architects was also brought into the project as a specialist in preservation architecture (Downey, 2008).

Two of the main character-defining areas of the Union Station were determined by the historians and Mary Oerhlein to be the north waiting room and the adjacent grand hall (Union, n.d.). The north waiting room is depicted in Figure 19, and the grand hall is shown in Figure 20.

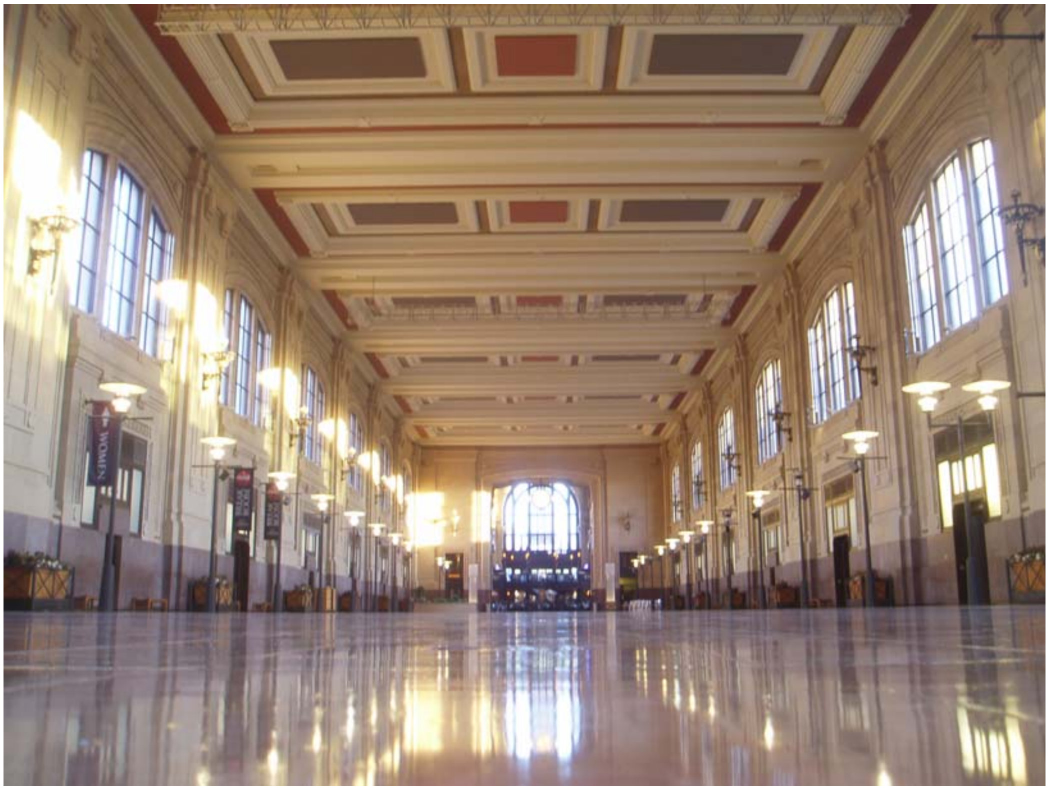

Figure 19. North waiting room

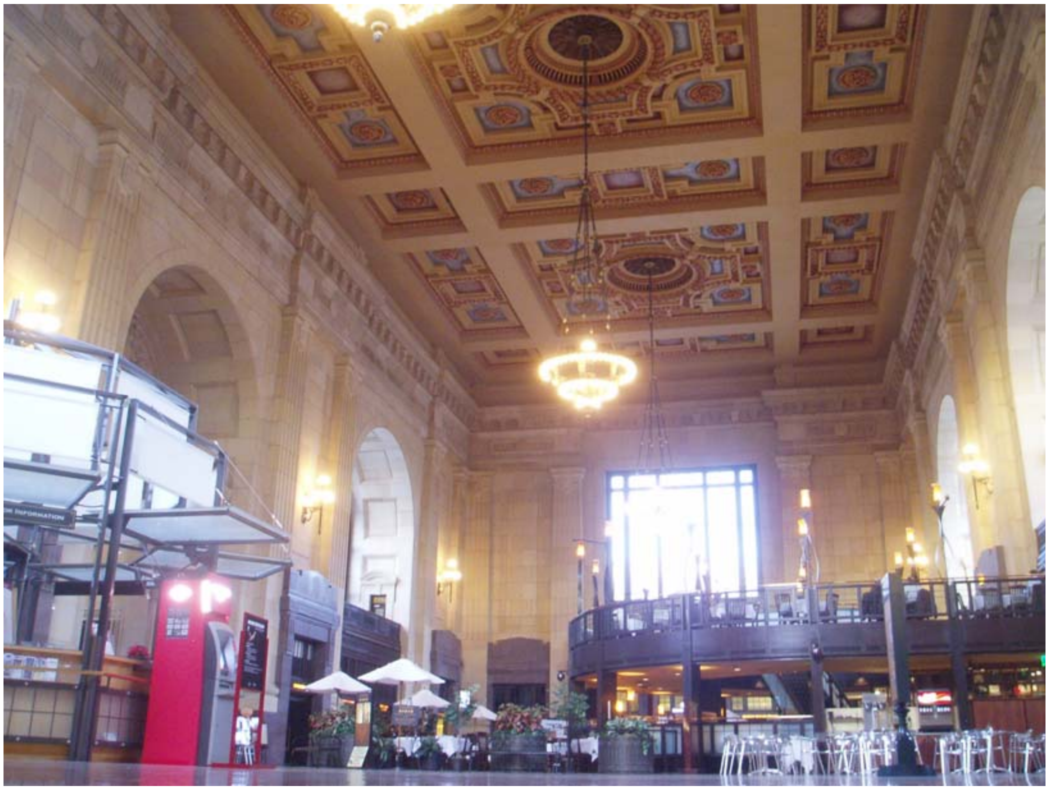

Figure 20. Grand hall

The preservation goal then was that all of the architectural characteristics of these two main rooms would be kept and restored to original condition. When preserving and selectively restoring the interior of these spaces, some areas were in good condition and could be restored to their original state, while other areas or portions were deteriorated or missing and had to be completely recreated to restore an original appearance. The smaller rooms flanking the north waiting room were also restored to their original condition (Fountain, 2008). Some of the character-defining aspects of these rooms include the marble flooring, the 95-foot ceiling in the grand hall, three 3,500-pound chandeliers in the hall, and the six-foot diameter clock (Union, n.d.). While the floor-to-ceiling height is about 110 feet in the grand hall, the chandeliers hang down about thirty feet from the ceiling (Downey, 2008).

The famous Union Station clock is one of the most recognizable features of the building. The signature clock is located in the archway connecting the north waiting room and the grand hall (Union, n.d.). The Union Station clock is shown in Figure 21.

Figure 21. Union Station clock

"Meet me under the clock" was always a familiar expression in Kansas City. This was the easiest way to meet with a group of people in the Union Station because of its vast open space and frequently crowded halls (Union, n.d.). Many local Kansas City citizens have personal stories and memories regarding the Union Station clock (Fountain, 2008). Throughout history, a number of couples became engaged and have even married under the clock. The massive clock is positioned in the archway between the north waiting room and the adjacent grand hall. The clock measures six and a half feet in diameter and three feet thick. The weight of the clock is about 2,000 pounds, and light illuminates the clock facing. Throughout the years, it also became popular to ring in the New Year under the clock at Union Station, symbolizing the passage of time. This New Years Eve event became a tradition at the Station after the initial opening of the building, and this event continues today. Crowds estimated at around 15,000 people would pack into Union Station's grand hall and north waiting room each year for the event. Many Kansas City locals will always consider the clock the heart of Union Station (Union, n.d.).

The vast open spaces of the north waiting room and grand hall can be architecturally characterized by rose-brown marble interior walls, painted plaster ceilings, and "terra cotta floors in geometric designs" (Union, n.d.). The interior architecture of the grand hall ceiling is shown in Figure 22.

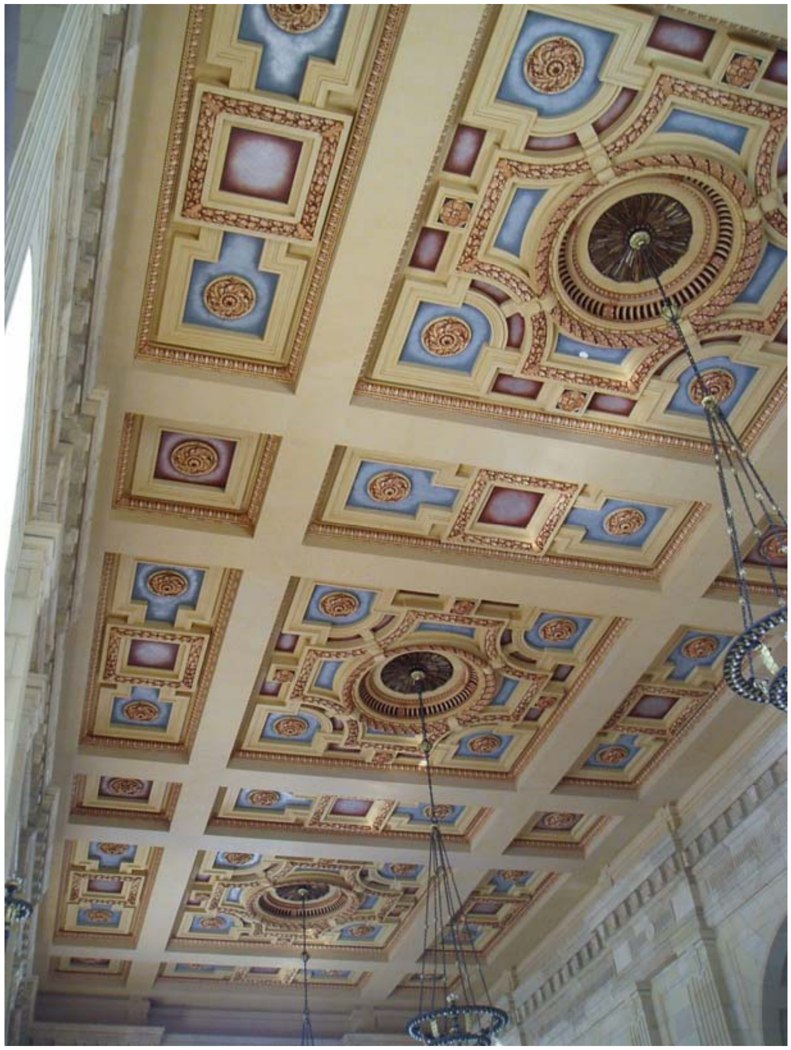

Figure 22. Grand hall ceiling

Michael Fountain of HNTB Architects commented on a few architectural and cultural items that were not preserved in the Union Station renovation. In the bathrooms, for example, there were original marble partitions between the stalls, but because of their deteriorated condition, they were not saved. Urine stains in particular had damaged the partitions to a point where they would not have been able to be refurbished. Many of the original plumbing fixtures were also historically unique in their character, but the decision was made to replace all of the old fixtures with new equipment to completely modernize the bathrooms. Refurbishing many of the old fixtures which needed servicing would have proved very costly. Where damage and deteriorated fixtures would need to be replaced, it also would have been very difficult to match these old fixtures. Because of these budget concerns and maintenance efforts, the decision was made to completely modernize the bathrooms with new materials and fixtures (Fountain, 2008). The new Union Station bathrooms are shown in Figures 23 and 24.

Figure 23. Bathroom stall

Figure 24. Bathroom counter

The old underground mail sorting system and associated tunnels running underground to the old adjacent post office were taken away and have been converted to new usage areas. Although one lift off of the current parking lot is still visible, this is the only reminisce of the old mail system. Much of the old mechanical equipment such as chillers and boilers were also very interesting in their unique historic qualities, but they were in a non-usable state. Therefore, all of the mechanical equipment was completely replaced (Fountain, 2008). A few pieces of the old mechanical equipment, however, are on display in the Union Station's exhibit area. A historic chiller and associated valves are shown in Figure 25.

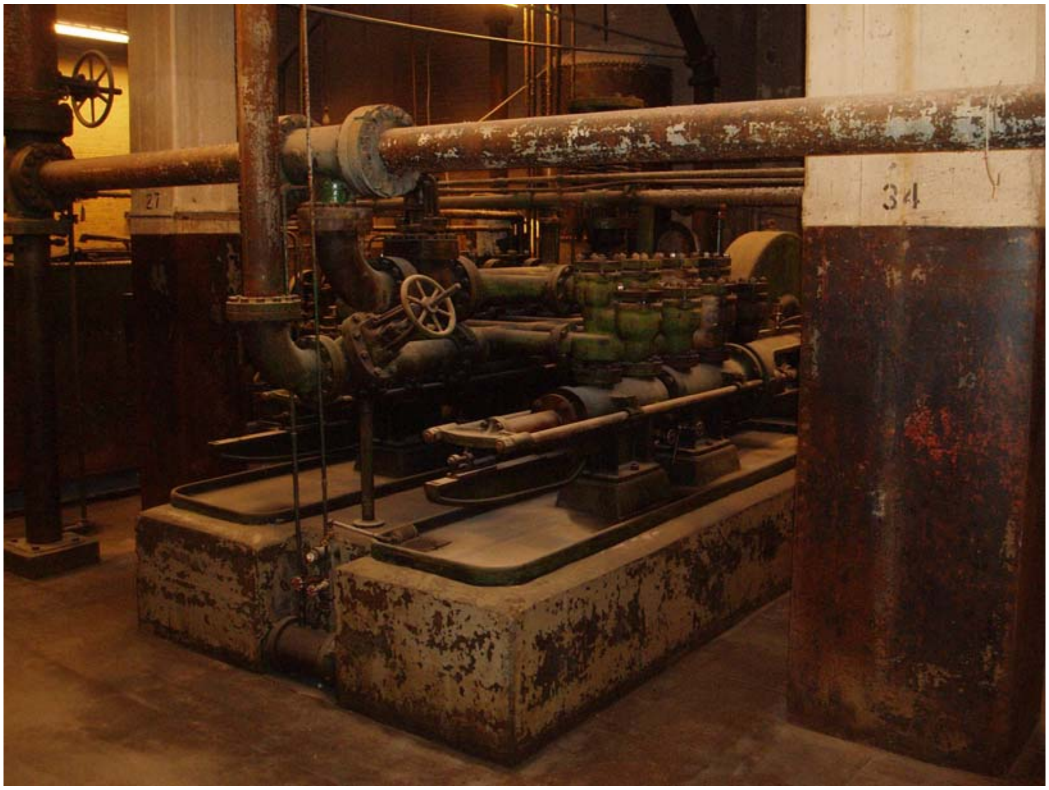

Figure 25. Historic Union Station chiller and valves

In the basement freight distribution room, which served as the main baggage area, there was wood floor the same size as the entire north waiting room and grand hall. When the building was left vacant, water damage from the leaking roof warped and destroyed this wood flooring. This historic characteristic of the original design was therefore not restored because of its poor condition. To remedy the problem, concrete topping was poured over all of the wood flooring to finish out the basement floor (Fountain, 2008). The Union Station freight distribution room floor is shown in Figure 26.

Figure 26. Union Station's basement floor

With the building lying east-west, many of the underground tunnels were under the adjacent streets to deliver baggage to the trains and transport mail over to the adjacent post office across the street. This underground tunnel system facilitated the transporting of both luggage and mail under the streets. The freight level of Union Station was therefore under these tunnels. The elevators would transport the luggage from the sorting area to the tunnels. The tunnels ran both east-west and north-south. The north-south branch tunnels were perpendicular to the train tracks while the east-west tunnels were parallel. These tunnels were also not saved in the rehabilitation process mainly because of budgeting issues. The tunnels have either been demolished or simply sealed off (Fountain, 2008).

4.4 Renovation and construction facts

Since the Union Station had been vacant of occupants, workers could set up onsite offices without having to worry about disturbing tenants during the two year renovation of the building (Downey, 2008). Two years of design and planning the Union Station restoration began in 1994 (McCosh, 2008). The first phase of renovation began in 1997 with the cleaning of the building's interior and exterior. Throughout the cleaning process, ten million pounds of waste and damaged materials were removed from the structure (Union, n.d.). The interior walls were in desperate need of washing to remove the black soot that accumulated from years of exhausting the coal-fired steam train engines through the Station roof (Fountain, 2008). The original mechanical system did not provide air conditioning, but windows could be opened to allow air flow through the building. Opening the windows cooled the building through natural ventilation (McCosh, 2008). The preservation effort was centered on restoring the building to its original state of the 1914-era; therefore, every material and color was matched to the original construction (Union, n.d.). The grand hall ceiling in particular was a tedious task of preservation and restoration to its original condition because of the intricate moldings and color designs (Fountain, 2008).

The overall scope of the project consisted of 720,000 square feet of reused building space (JE Dunn, 2008). Electrical and mechanical systems were a very large portion of the design, construction, and budget of the project (McCosh, 2008). There were two phases to the design and construction of the Station. The first phase of design and its associated construction consisted of restoring the interior and exterior of the grand hall and north waiting room to its historically accurate original condition (JE Dunn, 2008). This first phase of the grand hall and north waiting room opened to the public in November of 1999 (Downey, 2008). Science city, Kansas City's first science and technology museum, along with other museums and attractions were completed in the second phase of design and construction (JE Dunn, 2008). Construction continued on the Union Station during this phase until it was finished in April of 2000 (Downey, 2008).

Because of the various areas and occupancies of the Union Station, the architectural and engineering work load was divided between several consultants, engineers, architects, and designers. HNTB Architecture was the local architects on the project, doing most of the construction administration. Michael Fountain led the Kansas City HNTB group during the project. A total of five different architectural firms worked on the project and each had their own scope of responsibility. These scopes were broken down into the museum spaces, the exterior, the interior historic renovation, and newly renovated areas. One of the architecture firms, BNIM Architecture, was heavily involved in the project's museums and other renovated spaces for new uses. BNIM therefore worked as a special exhibit designer and was employed for some of the specialty areas (Fountain, 2008).

The original structure did not contain any insulation on or in the exterior walls. When renovating the space, some insulation was installed in the attic spaces and also along the edges of the small windows and their surrounding walls. However, the large original windows were still non-insulated which allowed more outside air to penetrate the walls (Fountain, 2008). Compared to the old mechanical system of steam and radiators, the new mechanical system consists of a multiple air handling unit system that is very efficient for the Union Station. The new all-electric system consists of using chilled water to cool the building and electric heating (McCosh, 2008). A chiller is shown in Figure 27.

Figure 27. Union Station chiller

When designing the new mechanical HVAC system for the north waiting room and the grand hall, only the air at occupancy level was deemed necessary for conditioning. It was determined that if only the air near the floor was conditioned, stratification would occur in the space above (Fountain, 2008). The stratification above the occupancy level in the grand hall and the north waiting room is not a design concern because there is no public access in this space. Stratification is better in this location than trying to heat and cool this above-occupancy level. Otherwise, unnecessary levels of heating and cooling would take place especially because of the large single-paned glass windows. It is now much easier to just let this air get hot because it doesn't affect the occupants (McCosh, 2008).

In the mechanical design, return air was therefore taken at the floor level. Radiator cabinet locations from the original design were utilized for the new mechanical system; the previously constructed holes in the floor from the radiator cabinets served as return air intakes (Fountain, 2008). Return air grills are shown in Figure 28.

Figure 28. Return air grills

The overall routing of the mechanical ductwork proved to be a major design challenge during renovation (Fountain, 2008). The mechanical outside air intake was located on top of the flat portion of the roof. It was placed in this location because no penetrations were allowed to be made in the outer walls for historic reasons. Not allowing penetrations in the exterior walls was a huge design challenge for the mechanical engineers (McCosh, 2008).

In the new mechanical design, air is supplied in the grand hall and the north waiting room either at the occupancy level or as high as twelve feet above the floor, and return air is taken in at the floor level. The balconies which are about twelve feet above the floor are also used for areas of supplying air by putting diffusers below the landings of the balcony walkways, and air is also returned at the kiosk areas throughout the main hallway. Above the doors in the north waiting room are positioned the original grills of the previous mechanical system that are now used for supply air locations (McCosh, 2008). These supply air grills are shown in Figure 29.

Figure 29. Supply air grills

On either side of the center grills are speakers for the fire and evacuation annunciation system. These grills are original so the space behind them has now been reused with new mechanical and electrical equipment (McCosh, 2008). The side grills containing speakers for the fire and evacuation annunciation system are shown in Figure 30.

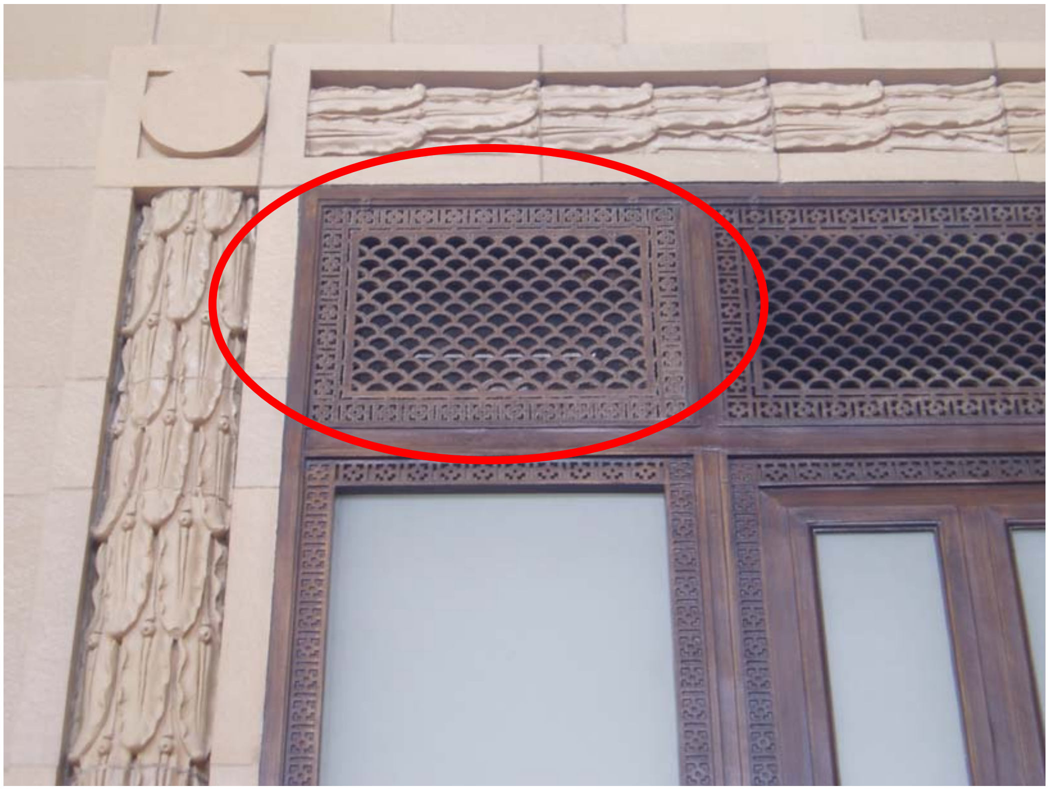

Figure 30. Location of speakers for the fire and evacuation annunciation system

In the original design of the Union Station, plenum spaces (space between the ceiling and the structure above to run piping, ductwork, and electrical conduits) were not provided. Therefore, when installing fire sprinklers in some of the smaller spaces, no horizontal branches could be installed because of the lack of plenums. The fire sprinkler branches had to be run vertically in the walls with through-wall sprinkler heads. The fire sprinkler heads also had to be individually located on the plans for the contractor in addition to the pipe routing locations. These plan specifications were necessary because of the intricate detailing of the building interior. Each sprinkler head had to be placed in an area where it would minimally disturb the interior architectural features. In the large-volume spaces such as the north waiting room and the grand hall, no fire sprinklers or other method of fire suppression were designed for these areas. These large halls therefore have no fire protection systems installed (Fountain, 2008).

To ensure that the newly renovated Union Station matched the original colors, Oehrlein & Associates were hired to determine what those original colors were. Oehrlein & Associates had experience working on other historic landmarks such as the Washington Monument and the Lincoln Theater. In their study of the Union Station, they analyzed walls, floors, ceilings, and even roofing tiles. Every material from metal to plaster was investigated. In their examination, they scraped away layers of filth and paints from surfaces in an effort to match colors as closely as possible (Union, n.d.).

Designers and contractors also had to deal with major structural damage issues in the rehabilitation of the Union Station. A leaking roof caused most of the structural damage as the roof became deteriorated and neglected while the Station was vacant for a number of years. The perimeter of the roof was especially damaged by weathering and created many of the leaking issues. The water caused rotting of many of the wood structural beams in the building because they had alternately wet and dry periods for many years which caused bacteria to grow and rot the wood (Fountain, 2008). This was problematic because all the wood beams were encased in concrete, and it was not always obvious which beams were becoming structurally deficient. During the renovation and construction, workers would continuously find more wood beams that were rotting away inside the concrete. These failing beams caused the most structural issues and created numerous requests for information and change orders (Downey, 2008). Some steel floor beams under the wood basement floor even swelled so much from the water exposure and oxidation that they pushed the floors up from a normal, level position (Fountain, 2008).

Because of the extreme damage and deterioration, the Union Station roofing had to be completely replaced (Union, n.d.). . The original roof system consisted of GRRC tiles and a roofing membrane (Fountain, 2008). The newly installed roof tiles were matched to the original size, shape, and color. Even though the lightweight concrete mixture was lighter than the original, each single roofing tile still weighed about two hundred pounds (Union, n.d.).

After the roof was repaired, the Union Station ceiling could then be restored. Hayles & Howe were contracted to re-build and preserve the ceiling which had been severely deteriorated by weathering and the water damage from the leaking roof. Hayles & Howe had previously worked on other train stations and high-profile projects including New York's Grand Central Station and England's Windsor Castle. Twenty-two Hayles & Howe employees specializing in ornamental plastering and restoring original moldings and ceilings worked on the Station ceiling (Union, n.d.). Some of the plaster craftsman even came from England where they had experience working on many of the historic churches (McCosh, 2008). The final ceiling appearance is shown in Figure 31.

Figure 31. Union Station ceiling

Because the water damage had terribly destroyed much of the original ceiling, over half of the original ceiling was completely torn down and rebuilt. In the restoration process, every detail was matched to the original appearance (Union, n.d.). Molds of the original ceiling plaster work were made on site, while the larger pieces were constructed and assembled in Baltimore with the use of more sturdy and lightweight materials (JE Dunn, 2008).

Basically all of the architectural ornamental details were either preserved to their original condition or recreated as exact replicas of the original appearances. Some of the recreated pieces incorporated a variety of creative and modern materials along with various application techniques to match the adjacent finishes. The ceiling restoration specialists worked on full-height scaffolding to reach the ceiling. The resulting ceiling is a perfect blend of new and original construction. Because of the restoration efforts, the lines in the ceiling are actually straighter now than they were originally (Fountain, 2008).

The marble flooring on the main floor of the grand hall and north waiting room was another key characteristic to be restored and preserved. However, some areas of the floor had been damaged and had to be patched to match the original finish. Nevertheless, rows of small ruts that have been left untouched can still be seen today on the marble flooring where travelers would sit on the wooden benches and swing their feet. The swing and dragging of the many feet over the years while sitting on the benches created these ruts and marks on the floor. A match to the original stone was used to fill in the stairs down to the tracks (Fountain, 2008). The Union Station's restored marble flooring including the visible rows of ruts is shown in Figure 32.

Figure 32. Union Station's marble flooring in the north waiting room

In general, most of the first level of Union Station was able to be fully preserved and restored to original condition. One challenge for designers, however, was the existing stairs because of Americans with Disabilities Act (ADA) requirements to make the building safe and accessible to those with disabilities. There is also a code-required two hour fire separation of the stairs from other areas for fire protection. This implies that the wall would contain a fire to within the space for two hours before the fire would be able to pass through the wall. Nevertheless, the design teams were given leeway on many of the issues by building code officials because of the historic character of the building. Compliance with many of these issues would have required demolition of features that are historically significant to the building. Therefore, in the effort to preserve the building to its original condition, there was not a lot that could be done in order to meet some of the ADA and fire codes. It is important to note, however, that even though the preserved building does not meet every current code, it is still much safer than the originally designed structure because of the many improvements to life safety and welfare that were made through the rehabilitation project. For example, the grand hall and the north waiting room are not equipped with a fire suppression system, but other areas of the Union Station have new fire sprinkler lines. Some of the old stairways do not meet ADA code for the rise and run of the steps, but other renovated areas were redesigned with ADA compliant stairs (Fountain, 2008).

The clock located in the archway between the north waiting room and the grand hall had to be refurbished (Union, n.d.). The old mechanical parts inside the clock were very weathered and damaged so the decision was made to completely gut the clock mechanisms and install a new system. The cost to repair the old parts was not feasible with the given budget (Fountain, 2008). The mechanical pieces of the clock were therefore replaced with a computerized system which has ensured better efficiency. The new computerized clock mechanisms now allow the clock to be automatically adjusted for daylight savings time. Furthermore, the hands of the old clock would routinely scrape against each other during operation, which was adjusted during the clock's preservation efforts. Therefore, even though the original clock facing and housing can be seen today, the mechanisms inside the clock which are not visible have been replaced (Union, n.d.).

The north waiting room of the original train station has now been transformed into a festival plaza for various cultural and entertainment activities (Union, n.d.). The original single story ticketing office has now been changed into a restaurant area which has two stories. The same shape was kept but the function of the space was completely changed. The second story mezzanine was added for visual effect and more seating area for the restaurant patrons (Fountain, 2008). The old ticketing office area which now houses a restaurant is shown in Figure 33.

Figure 33. Old ticketing office which now houses a restaurant

As part of the new construction, a theater was designed on the basement level. This concept had an interesting design aspect because the theater would be located below the ground water level. Therefore a concrete bathtub conception was developed to build this theater below the water level. Spring isolators also had to be utilized to neutralize the vibrations from the trains. In the theater, these advanced design ideas had to be implemented to ensure maximum acoustical quality inside viewing rooms. In the planetarium, a used projector was purchased in an attempt to save some overall money on the project (Fountain, 2008).

OK Creek actually ran through the site, but now all that is left is a storm sewer beneath Union Station (Fountain, 2008). The OK Creek is now encased in a six foot diameter clay tile pipe. It also runs three feet beneath the road to the south of Union Station. During the renovation construction of the Station, a flood caused two feet of water in the basement. This water damaged much of the material that was being stored in this location (Downey, 2008).

Most visitors to the Union Station only stay on the main level, but there are actually very large basements underneath the primary floor. However, many of the basement areas have been blocked off throughout the years (Fountain, 2008). The basements had twenty foot ceilings, and this is where the baggage was arranged. Mail was also sorted in this basement area and then transferred by tunnel to the post office across the street from the Union Station. The central mechanical plant for the facility is now also located in the basement (Downey, 2008).

The Henry Wollman Bloch Fountain has also been constructed directly in front of the primary Union Station entrance. The fountain is characterized by its many geysers which shoot water 120 feet vertically in the air. This unique fountain was dedicated in 2001 to the founder of the H&R Block Foundation. Although the fountain was originally given as a gift to the city of Kansas City, it is now maintained by Union Station. It is interesting to note that the fountain pumps 10,000 gallons of water per minute. Water is pumped at approximately two tons or 500 gallons in a single gush. This is enough force to lift a full-size SUV in the air. The fountain system also contains 232 nozzles, and it is illuminated by 232 lights. Created by the same designers of the Bellagio Hotel in Las Vegas, Nevada, WET Design built the fountain to recycle all of its own water (Union, n.d.). The Henry Wollman Bloch Fountain location is shown in Figure 34.

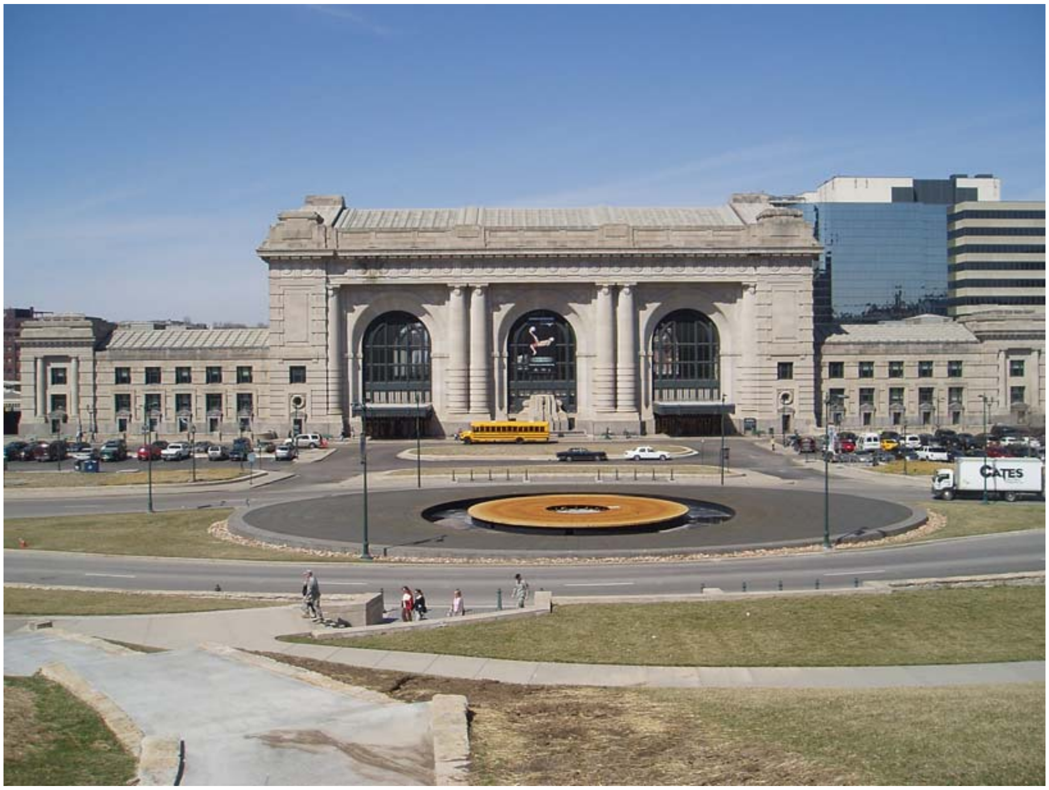

Figure 34. The Henry Wollman Bloch Fountain

4.5 Specific electrical / lighting system facts and design

Capital Electric was the electrical contractor for the Union Station project and Smith & Boucher was the engineer. Ed Downey, serving as the senior project manager of Capital Electric, commented, “The Union Station Project took about fifteen years off my life.” Major electrical renovations were required for the Station, and many coordination issues arose during construction of the project. Three shifts of electricians were working towards the project’s completion. In total, 126 electricians were employed. Seventy percent of these workers traveled to Kansas City just to help with the project (Downey, 2008).

Capital Electric estimated their services of the Union Station at about $8 million, but there were many items that were value engineered out of the original design. Many features were cut from the design in order to save money on the overall budget. The electrical construction estimate increased to about $13.1 million with inclusion of Science City (Downey, 2008).

Smith & Boucher, under the leadership of Kent McCosh, project manager, were in charge of all of the mechanical, electrical, and plumbing design. They were the Engineer of Record for the Union Station project. Cosentini Associates also worked with Smith & Boucher through the design development phase. Two design consultants were utilized by Smith & Boucher: one for the historic aspects and the other for the museum spaces. These consultants directed the design of the major public areas such as the grand hall and the north waiting room. Smith & Boucher then collaborated with the consultants and their designs and ideas in order to finalize the plans and finish circuiting the building (McCosh, 2008).

Capital Electric built a temporary office on the site adjacent to the Union Station building so that they could monitor the workers and associated issues. This helped the progress of the renovation construction because project managers were always available to talk about issues on site for quick problem solving and solutions (Downey, 2008).

Three lighting consultants were hired for the Union Station project. With budget constraints, there became a struggle with the lighting consultants to save money on these fixtures. Many of the originally selected lighting fixtures had to be value engineered to stay within budget. Overall, there was a conflict of interest between the lighting consultants and the engineers and contractors. The designers had to come to an agreement on aesthetically pleasing light fixtures that would be cost effective with the budget constraints. Maximum lighting efficiency was still desired but the budget could not allow for some of the lighting models that the consultants wanted to specify for the remodeled areas such as Science City and the museum spaces (Downey, 2008).

The interior chandeliers and sconces were in dire need of restoration. St. Louis Antique Lighting Company was hired to service and restore all of the original lighting fixtures. St. Louis Antique Lighting Co. is very well known for their restoration efforts including their restoration of lights and fixtures in seven different state capitals. Twelve of their employees stripped and restored the sconces and chandeliers (Union, n.d.). A typical sconce is shown in Figure 35, and a typical chandelier is shown in Figure 36.

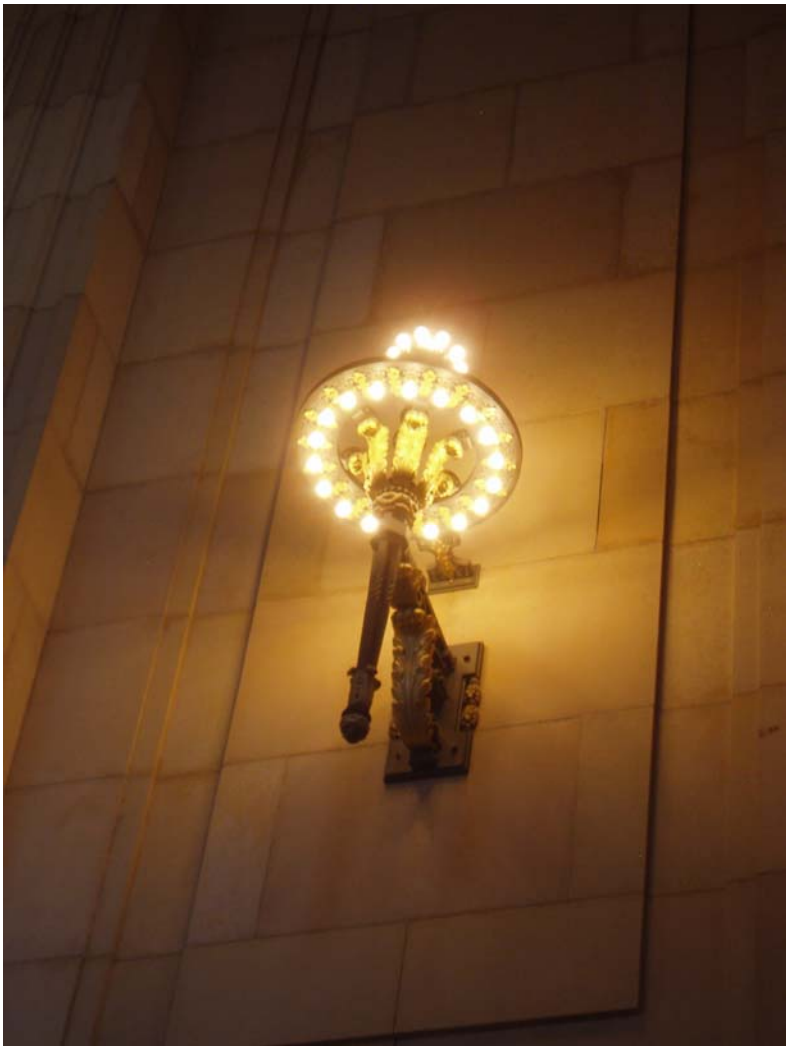

Figure 35. Typical sconce

Figure 36. Typical chandelier

St. Louis Antique Lighting Company charged $142,659 to refinish and refurbish the old lighting fixtures. Over time, these lighting fixtures had accumulated plenty of rust. Most of the sconces and all of the chandeliers are the original fixtures for the Station (Downey, 2008). Because of irreversible damage, a few of the sconces were recreated to match the originals (McCosh, 2008). Refinishing the chandeliers was no easy task as each chandelier is twelve feet in diameter and weighs 3,500 pounds. Each chandelier also requires 11,400 watts of electricity and over half of a mile in wiring for the fixture (Union, n.d.). Originally, a belt system lowered the chandeliers for cleaning and the changing of light bulbs (Fountain, 2008). A winch system was therefore located above each of the three chandeliers to raise and lower them (Downey, 2008). Only one motor was originally provided in the attic which had to be moved from one winch system to another. The chandeliers, therefore, could only be lowered one at a time (McCosh, 2008). However, a new pulley system powered by electric motors was installed as part of the renovation above each chandelier to raise and lower them without having to move the motor (Fountain, 2008). The refinishing of the chandeliers and sconces were one of the biggest visual improvements to the building’s interior (Downey, 2008). The chandeliers’ old belt system is shown in Figure 37, and the new electrical pulley system is shown in Figure 38.

Figure 37. The chandeliers' historic belt system

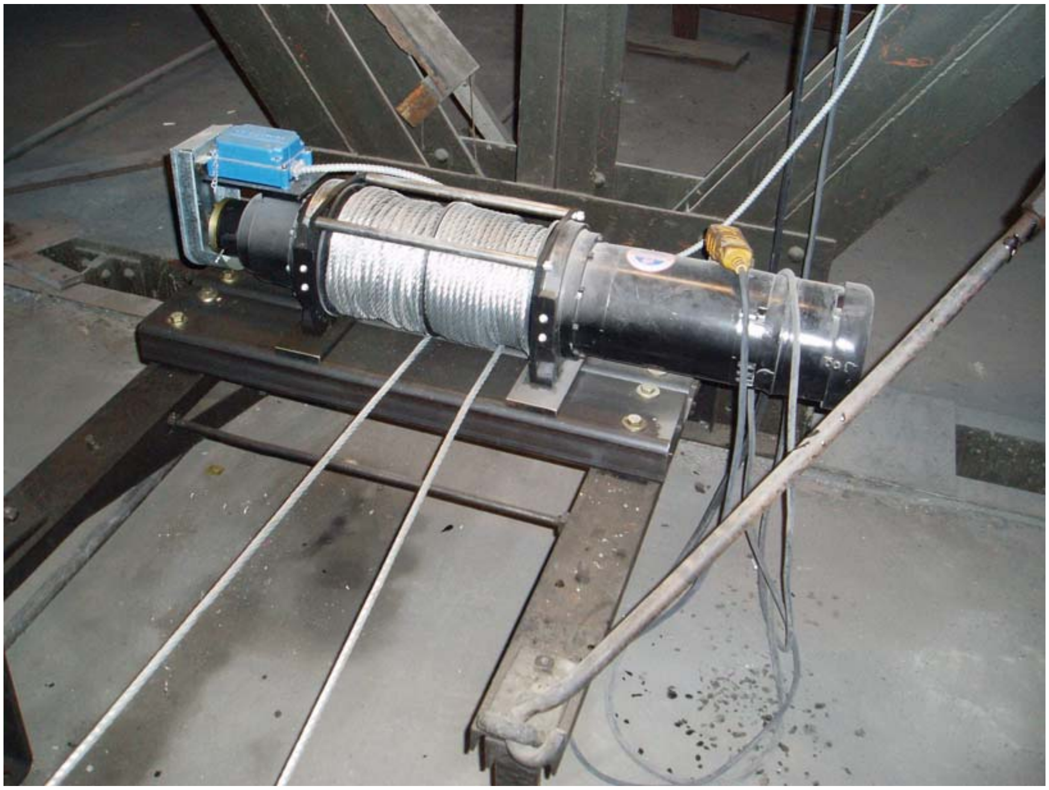

Figure 38. The chandeliers' new pulley system

It is interesting to note that as part of the renovation design of the Union Station, fiber optics were going to be installed for lighting of the chandeliers. A single fiber optic strand would connect to each light bulb. To power this fiber optic system, a light generator would have been located in the ceiling attic. Instead, numerous incandescent lights were chosen for the chandelier bulbs to save money (McCosh, 2008). The chandelier incandescent lights are shown in Figure 39.

Figure 39. The chandeliers' incandescent lights

In the north waiting room, two rows of post lights can be seen running lengthwise down the long space. These pole lighting fixtures are not part of the original Station lighting, but rather a new design addition. They were added to allow for extra luminance so that special events could take place in this area with more than just the wall sconces providing the light. They were patterned after street lights for the Science City concept. This street light pole concept is modern in design in order to distinguish them from the historic appearance of the original lighting fixtures (Fountain, 2008). These north waiting room post lights provide most of the required luminance so the chandeliers are turned off for the majority of the day (McCosh, 2008). The electrical wires were fed up through the floor from below to service these fixtures (Downey, 2008). The north waiting room pole lights are shown in Figure 40.

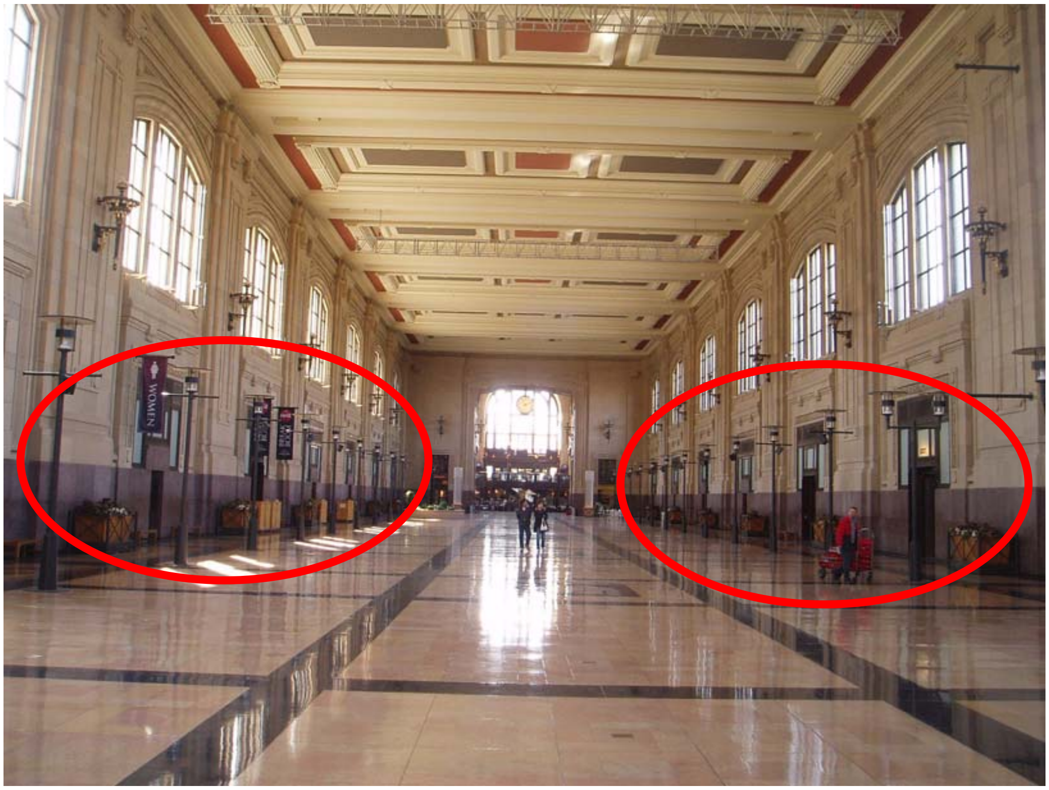

Figure 40. North waiting room pole lights

In historic areas where new lighting fixtures were to be installed, the new fixtures would either be an exact replica of the historic ones or they would be modern so that a distinctive difference would exist between new and historic fixtures. This would ensure that the public would not confuse the modern lights for an original fixture (McCosh, 2008).

The emergency exit lighting was architecturally engineered so that it would help assist occupants toward exits of the building while still displaying an aesthetic appearance (Fountain, 2008). Standard exit signs could not be used in the historic areas because they would not architecturally fit in with the rest of the space (McCosh, 2008). In several areas, translucent panels camouflage emergency exit signs (Fountain, 2008). Exit signs were placed above the doors where the old track numbers were located. Red lettering appears through the translucent panels with a light capable of illuminating the sign (Downey, 2008). The backlit lighting capability allows a red light to illuminate the exit letters while keeping with the original historic character. The red color will automatically lead occupants towards this exit, but it does not intrude on aesthetics. These typical exit doors in the north waiting room lead occupants to stairways where they can exit the building (McCosh, 2008). The north waiting room exit signs are shown in Figure 41.

Figure 41. North waiting room exit signs

Only one original smaller-sized window in the entire Union Station was kept from the historic design. All of the other smaller-sized windows were replaced with newer insulated windows. The window is located adjacent to the chocolate store at the end of the north waiting room on the main level of the Station. Because new construction of the Science City is located on the outer side of the window, lights have been installed around the windows so it appears as if natural light is shining through the glass all hours of the day. A glowing appeal is given off from the window (Downey, 2008). The original small window is shown in Figure 42.

Figure 42. The original small window is artificially illuminated

Most of the original light fixtures were able to be restored to their historic appearance. However, the old light fixtures were not very functional and were inefficient in their light output. When renovating the lighting system, more efficient lighting fixtures were used in many areas (Fountain, 2008). For example, the chandeliers now use long-life incandescent bulbs (Downey, 2008). In areas where the original light fixtures were not used, the new modern fixtures were selected in order to be differentiated from the original fixtures of the building (Fountain, 2008). Incandescent lighting is used for all of the historic areas including the grand hall and the north waiting room. The incandescent lights also provide for dimming capabilities (McCosh, 2008). A modern lighting fixture is shown in Figure 43.

Figure 43. A modern light fixture

Electrical rooms were to be located on each floor along the stairway adjacent to the main hall (Downey, 2008).

The engineers on the project had to work with the city to distribute primary power into the building so there would not have to be any outdoor transformers on the site. Outdoor units would just take away from the aesthetic value and historic character (McCosh, 2008). Eighteen single-phase transformers from the Kansas City Power and Light Company (KCPL) electrical service are now located in the Union Station basement (Barber, 2008). A typical transformer is shown in Figure 44.

Figure 44. A typical transformer

The incoming electrical service is supplied directly from a KCPL line of 15kV. 12,470 actual volts are brought into the building from the service line. Then, the electricity is fed to six transformer banks and to six 4,000 amp switchboards in the two-story tall basement (Downey, 2008). After passing through the transformer banks and the switchboards, a 277/480 volt line serves the building. Where a smaller power size is needed, the electric power line is stepped down further to allow the distribution of 120 volts (McCosh, 2008). The switchboards are shown in Figure 45.

Figure 45. Switchboards

There are three primary electrical switchboard service rooms located within the building (McCosh, 2008). The emergency power is distributed by a small gasoline generator in the basement of the Station (Downey, 2008). All of the emergency lighting is on emergency circuits. Strategic light fixtures were selected by the engineers to be put on emergency power for evacuation purposes. For example, the post lights in the north waiting room are all on emergency power. The sconces and chandeliers are not emergency lighting (McCosh, 2008). The back-up power gasoline generator is shown in Figure 46.

Figure 46. Emergency power back-up generator

Aluminum conductors were chosen over copper to save money. Much of the installation utilized MC (metal-clad) Cable from Alcan Cable Company. Alcan Type MC Cable is designed for above-ground application with three or four phase insulated phase-identified conductors and a bare equipment grounding conductor all contained within interlocked aluminum alloy armor. MC Cable was chosen so that many of the junction boxes could be eliminated. MC Cable allowed the workers to run conductors up to eight hundred feet in length without having a junction box. Therefore, specific runs of MC Cable were ordered so that junction boxes could be avoided. Much of the MC Cable can be seen in the basement of the Station (Downey, 2008).

Many of the original electrical junction boxes where able to be reused (Fountain, 2008). Some of the original junction boxes needed replacing because of water damage and were very difficult to replace because of their location. In certain areas, workers had to drill two to three feet into the concrete walls to get to the junction boxes. When drilling, the historic marble and stone was being damaged. Two different methods of drilling were employed. The first method involved the workers drilling through the stone, damaging them, and then patching the stones afterwards. The second method was to take the stones completely off before drilling and then putting them back on without causing any damage to the historic stone. Since some stones were already damaged and in need of patching and others proved to be difficult to take off without causing damage, the first method of drilling the stones while in place was utilized in these instances only when deemed necessary (McCosh, 2008).

All the electrical sockets in the Station are now UL listed (Downey, 2008). Since conduits are usually four inches or smaller in diameter in most building applications, the conduit runs are typically not shown on plans for the contractor. However, on the Union Station project, the engineers showed the conduit routing for the feeder conduits on the plans restricting the contractor to specify routing locations. This routing dictated by the electrical engineer is an uncommon design task that the contractor usually takes care of in the field. Locating the conduit pathways became a major issue of coordination because of the limitations of space and non-plenum areas. In some areas, the conduit from one wing would penetrate down through the floor, pass under the main hall, then penetrate up through the floor in another wing because the conduit could not cross above the floor of the main hallway. Therefore, connecting the conduit from one wing to another became a difficult design challenge. The conduit could also not be run across the front balconies near the front widows because of aesthetics (McCosh, 2008).

In many areas, damaged materials meant that the original architectural detailing had to be reconstructed. In these areas, electricians installed conduit in the walls and ceilings while the construction workers temporarily had either the walls or ceilings opened to repair the architectural features. Normally construction workers would try to reuse existing conduit, but this was not the case in the Union Station project because of the extensive water damage. Original conduit was simply abandoned and left in place. New boxes were installed in the floors where necessary. To replace the floor boxes, the stones surrounding it were removed and then put back in place carefully (McCosh, 2008).

Ed Downey commented on a few issues that he felt could still be improved within the Union Station. He stated that the lighting in Science City was very intricately designed and installed, but the lights are not used to their full potential. Between 1,500 and 2,000 circuits for dimming the lights in Science City were installed, but the dimming functions are rarely used. Colored cathode lighting was also installed in the basement ring surrounding the grand staircase to make this area glow, but this function is not utilized either. The installed strand dimming system allows each light to be individually dimmed because each light is served by an individual line. Hence, the capability for a complex lighting system is there for Union Station, but the advanced light controls are ignored. In a coordination error, track lighting was installed above the escalators adjacent to the grand staircase. The track lighting fixtures were quickly taken out, however, because the maintenance crew had such difficulty changing the bulbs. Therefore, the lighting tracks are still in place above the escalators, but all of the bulbs have been taken out (Downey, 2008). The tracks' absent lighting bulbs are shown in Figure 47.

Figure 47. Track lighting above the stairs

Advanced lighting design was also incorporated into the stage theater for performances and into the planetarium theater (Downey, 2008). Both of these areas required unique lighting designs (Downey, 2008). Incandescent lighting was provided in the museum and entertainment areas so that different lighting levels could be achieved. Colored gels were also utilized in the theatrical lighting for added effects (McCosh, 2008).

4.6 Problems with preservation versus electrical / lighting system

The electricians had a difficult job with the renovation project primarily because of the large scope and the tight construction schedule (Fountain, 2008). The electrical design for historic renovations is generally easier compared to the mechanical designs. The reason for this is that electrical equipment is normally much smaller and can be hidden much easier than the larger mechanical ductwork and equipment. Nevertheless, coordinating space and lighting selections were a huge issue in the design and planning of the electrical portion of the Union Station renovation (McCosh, 2008).

4.7 Final product

The completed Union Station renovation is truly an uplifting project in its historic character, design aspects, and construction. The preserved and renovated structure continues to draw tourists and awe locals. A Kansas City Star newspaper journalist named Jeffrey Spivak even wrote a book about the Union Station renovation project titled, Union Station – Kansas City (Fountain, 2008).

Upon completion of the renovation project, the Economic Redevelopment Council of Kansas City for revitalization presented the project with the Cornerstone 2000 Award. The Station was also awarded the 2000 Project of the Year for Historic Restoration and Preservation from the American Public Works Association (JE Dunn, 2008).

Although the renovation of Union Station is looked upon as a success, many designers disagree with many of the finished aspects and occupancy uses. Michael Fountain of HNTB Architecture stated that he would have preferred not to have included the Science City museum. He feels that the two designs and uses are a bad marriage for the historic character and architecture of the Union Station (Fountain, 2008).

Today, the Kansas City Union Station is the nation's second busiest freight-railroading center with as many as 180 trains passing through the Station each day. Also, after seventeen years of absence, Amtrak is back in Union Station, serving between 400 and 1,000 travelers daily through Kansas City. The new waiting room for the Amtrak service contains five of the old wood benches that were used in the original north waiting room. Amtrak has three trains with four daily departures (Union, n.d.).

5.0 Plumbing / fire protection system case study – Webster House

5.1 History of building

Originally built in 1885 as a schoolhouse, the Webster House has had many owners and building uses over the years. The school was designed by architect Manuel Diaz in the Romanesque Revival style (Webster, n.d.). This style of architecture was popular in Kansas City during the 1880s for commercial and civil buildings. Charles Mumma was awarded the construction contract as a part of Mumma & Wood general contractors (United, 1981). Both design and original construction techniques were very modern and innovative for the 19th century construction period. Some of the advanced design techniques included: improving the interior spatial arrangements, lighting efficiency with the usage of natural lighting, along with heating and ventilation (Webster, n.d.). The original construction was completed in only nine months (Hobbs, 2008). The schoolhouse was named after Daniel Webster, a statesman (United, 1981). Just three years after the completion of the schoolhouse, an addition by architect William Hackney on the western side of the building was constructed (Webster, n.d.). This addition consisted of two rooms on each of the first two floors along with an attic and basement. It was connected to the adjacent structure by a narrow hallway (United, 1981).

Commercialization of the area around the school led to its permanent closing as a schoolhouse in 1932 (Webster, n.d.). The Webster House was therefore part of the Kansas City public school system for forty-five years (United, 1981). After the closing, the building went through stages of vacancy and changing ownership (Webster, n.d.). Some of the several owners and occupants of the building included the Social Security

Administration, the Helping Hand Institute, the Kansas City Association for the Blind, the Midland Radio School, Bell & Howell, the Historic Kansas City Foundation, and the Ramos Group (United, 1981). It is interesting to note that one of the owners designed and built a swimming pool in the building basement which attached to an adjacent outdoor pool area. This swimming pool contained a manhole penetration in the exterior basement wall to allow passage between the interior and exterior part of the swimming pool. This addition to the original schoolhouse design has been taken away (Hobbs, 2008). Most recently, Shirley Helzburg purchased and became owner of the Webster House, leading a team to preserve the building (Webster, n.d.). The preservation design and construction of the old schoolhouse took three years to complete (Hobbs, 2008). In 2002, the Webster House officially opened as an antique store and restaurant (Webster, n.d.). The Webster House is shown in Figure 48.

Figure 48. The Webster House

Every room in the renovated schoolhouse has been transformed into a unique experience of antiques, gifts, dining, and interior design. The Webster House also offers special holiday events throughout the year and can be leased for parties or weddings. Today this historic building is listed on the National Register of Historic Places. Locals also believe the Webster House is the oldest standing public school in the Kansas City area (Webster, n.d.). The Webster House is located on the corner of 17th and Wyandotte Streets in Kansas City, Missouri, and is a prime example of Italianate and Romanesque style architecture (United, 1981).

5.2 Why important to keep building and preserve

The Webster House is an important historic building because of its architectural style and its educational history. Many of the historic buildings in the Kansas City area built in Italianate and Romanesque style have been demolished. Some of these buildings include: the Old City Hall, Old Jackson County Courthouse, and the original Board of Trade. Not only is the Webster House a prime example of Italianate and Romanesque architecture, but it has also been fairly well restored close to its original condition. This building is a key example of a distinct architectural style which as been almost completely destroyed in the Kansas City area (United, 1981). The exterior of the Webster House is shown in Figure 49.

Figure 49. Exterior of the Webster House

The Webster House is also a significant part of Kansas City's educational history because this building stands as the oldest remaining schoolhouse in the area. No other school in the Kansas City area has a documented construction date that is earlier than the Webster House. Furthermore, the advanced construction techniques and engineering design incorporated into the structure make it a unique schoolhouse. Special innovations incorporated into the original design include: interior arrangements, room layouts, lighting design, seating improvements, and advanced techniques in heating and ventilation (United, 1981).

5.3 Architectural / cultural / historic character-defining features

The original schoolhouse included a bell tower atop the structure (JE Dunn, 2008). However, just a year after the school opened, the bell tower was removed. At the time, another local school bell collapsed into its building during the high winds of a nearby tornado. For this reason, the bell tower at the Webster House was removed to prevent a similar result (Hobbs, 2008). The new bell tower included in the renovation was designed using old photographs that were taken immediately after the original construction was finished and the school opened. The newly built bell tower is an exact replica of what the original bell tower looked like in both appearance and scale (JE Dunn, 2008). The structure of the new bell tower was constructed in Kentucky from aluminum, not out of wood like the original (Hobbs, 2008). The bell tower is shown in Figure 50.

Figure 50. Bell tower

Also, a front porch which was on the original schoolhouse but was later removed was recreated from the historic photographs (Hobbs, 2008). The front porch is shown in Figure 51.

Figure 51. Front porch

Every effort was made to match the original design and appearance of moldings, wood trim, finishes, and masonry. In areas that needed restoration, mockups were used to imitate and match original designs so that new construction would exactly match the adjacent appearance of materials (JE Dunn, 2008). New windows, doors, and interior woodwork were installed and milled to the original design (Hobbs, 2008). The stained glass windows were a feature that was preserved, even though the window frames and surrounding wood were replaced. The stained glass window panes were repaired and cleaned and placed back in new frames (JE Dunn, 2008). Stained glass windows are shown in Figure 52.

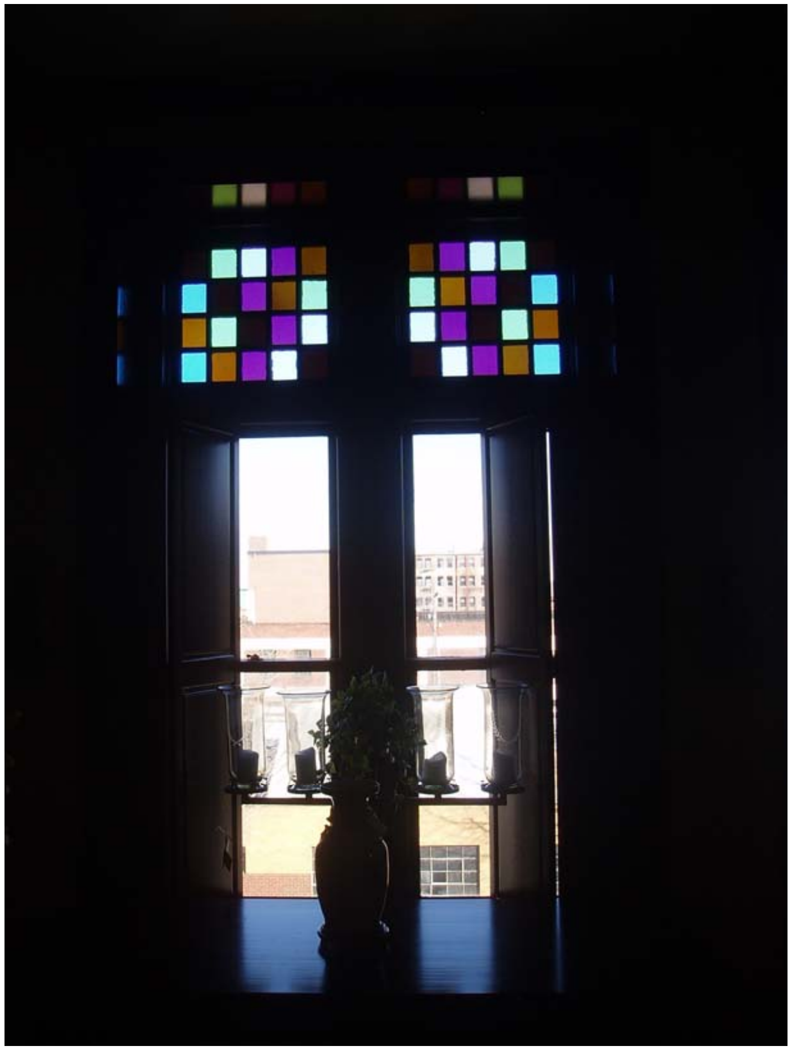

Figure 52. Stained glass windows

The original wood flooring was able to be preserved in most of the rooms. However, in some areas, this wood had to be replaced because of deterioration and damage (Hobbs, 2008). In this manner, the appearance of the original 1885 Webster House has been preserved in much of the building's interior and exterior features (JE Dunn, 2008).

Since the original design and construction of the Webster House had been well maintained and preserved, every effort was made to keep all of the walls unless absolutely necessary. In the present design of the spatial arrangement of the Webster

House, the majority of the original walls and ceilings are still there. Most of the walls even have their original blackboards still attached (Oxler, 2008).

Many original design characteristics of this typical Romanesque building were important to preserve as to retain the same building style. For example, the floor plan of the school is longitudinally symmetrical; the current usage of the building still utilizes this symmetrical floor plan. Further Romanesque characteristics of this structure include gabled wall dormers on the east and west and conical roofs with stair towers on the northern and southern sides of the building. The red brick exterior wall surface is another typical Romanesque feature. The exterior also depicts string course molding running horizontally between the different stories of the building, stone bands above the windows, patterned brick facing, and gabled wall dormers (United, 1981). An exterior side view of the Webster House is shown in Figure 53.

Figure 53. Side view of the Webster House exterior

5.4 Renovation and construction facts

The scope of the renovation of the Webster House involved 27,682 square feet of floor space of the historic building. Major construction included new electrical, domestic water, and sanitary water systems. All renovation and new design work was developed according to the standards of local and federal historic preservation authorities. A major architectural challenge was restoring the exterior to the original appearance and condition. Seven layers of paint were stripped off the exterior walls, craftsmen patched mortar cracks and holes, and much of the brickwork had to be repaired. The exterior limestone and sandstone bands and sills were weathered and deteriorated so badly that they were completely replaced (JE Dunn, 2008). After the preservation of the exterior walls, the exterior now appears almost exactly as the original schoolhouse was when first completed in 1885 (Hobbs, 2008).

The basic spatial layout and design of the original schoolhouse was kept, transforming the rooms into new uses. In the place of classrooms, the new Webster House now contains antique furniture sale rooms, banquet rooms, dining halls, and two kitchens for dining and catering (JE Dunn, 2008). Upon entering the Webster House, the historic floor plan of the schoolhouse is still very apparent today with several large rooms connected by a central corridor. Both the first and second floors originally contained four large classrooms that have been renovated into antique furniture sale room spaces. In an effort to preserve the original walls and condition, all new interior walls were installed with a few inches of buffer space from the original walls. Every aspect of the original walls has therefore been kept and preserved in their deteriorating condition (Hobbs, 2008). An interior room is shown in Figure 54.

Figure 54. An interior room

One room was designed to expose the original brick walls. In another room on the second level, a transparent window has been installed to reveal the condition of the original interior wall. Looking through this transparent window, a chalkboard from the 1885 schoolhouse is still intact on the wall with writing depicting an attendance schedule. Many other chalkboards are contained hidden between the buffer of the newly installed interior walls and the original walls of the 1885 structure (Hobbs, 2008). A transparent glass in the second floor wall reveals an underneath blackboard shown in Figure 55.

Figure 55. Blackboard underneath newly constructed walls

To serve the current usage of the building, two elevators were installed: one for public access and the second for service and maintenance. To complement the dining and catering features of the Webster House, two kitchens were also designed in the interior of the building. The first kitchen is located in the basement to serve catering needs. The second kitchen is located on the second floor, adjacent to the dining halls. An adjoining room on this second floor contains a small bar area to serve guests (Hobbs, 2008). The pubic access elevator is shown in Figure 56.

Figure 56. Public access elevator

In redesigning the mechanical, electrical, and plumbing systems, the new uses of the building as an antique store and restaurant posed many design problems for the team of engineers and constructors. Because many of the antiques sold within the Webster House are 18th and 19th century furniture and décor pieces such as Georgian walnut, mahogany, and carved oak furniture, the humidity level throughout the entire building must stay within a two or three percent range. This is very important in order to prevent the expensive wood furniture from cracking and becoming damaged (Hobbs, 2008).

The preservation and construction team was led by the contractors of JE DUNN Construction, architects of Helix Architecture and Design, and engineers of US Engineering Company. The Webster House, with this high-quality preservation and construction team, received the Preservation Award from the Jackson County Historical Society on November 1, 2002 (JE Dunn, 2008). The efforts to preserve the Webster House can be seen today in the restored condition of the building which suits the current tenants. An interior view of the Webster House is shown in Figure 57.

Figure 57. An interior view

5.5 Specific plumbing / fire protection system facts and design

The main plumbing and fire protection design involved the piping for the bathrooms, two kitchens, fire sprinklers, and storm water system (Hobbs, 2008). Since the usage of the building was completely changed from the previous occupancy, all of the plumbing systems inside building had to be redesigned. Even the restrooms were relocated to adapt to the new usage of the building (Oxler, 2008). To facilitate access between floors, vertical chases were constructed with new walls which enclose mechanical ducts, electrical wiring, and plumbing pipes. In these chases run many of the pipes which serve the kitchens. The two kitchens are vertically stacked, but one is located in the basement, and the other is located on the second floor. Therefore, the vertical chases on the first floor provide access for pipe routing between these spaces (Hobbs, 2008). The vertical chases on the first floor are located behind the foreground walls as indicated in Figure 58.

Figure 58. Vertical chases on first floor

The addition of two commercial kitchens to the Webster House was one of the most problematic design issues in the plumbing system. In designing for the water demand, the existing water service did not have the capacity to supply the building with the addition of two commercial kitchens. Therefore, a new service line was brought in from the water main under the adjacent street to supply the Webster House. Furthermore, each kitchen required a grease waste piping system. The location of the thousand gallon grease interceptor was an issue since this piece of equipment is inherently very large. Because of interior space restrictions and coordination issues, it was determined that the best location for the grease interceptor was outside of the building on the lawn. This piece of equipment would be placed away from the entrances and the main view of the building from the street to hide its appearance. The grease line had to be routed from the basement out to the interceptor on the exterior lawn (Oxler, 2008). The grease interceptor location is shown in Figure 59 enclosed by brick walls.

Figure 59. The grease interceptor is located outside of the building and behind brick walls

The wood floors were an issue in the bar area where floor drains required by the building code would need to be located. The selected floor drains would need to aesthetically match the color of the wood floor finish. This area would have to be properly sealed and painted to match the adjacent finish. The bar area does not get much usage by the current occupancy, but the area by these floor drains need to be periodically touched up and repainted to keep the desired finish and appearance (Oxler, 2008).

The original coat closets which were located off of each classroom now function as mechanical, electrical, and janitorial rooms. While some of these old coat closets now have janitorial supplies such as mops, brooms, and various miscellaneous maintenance items, other closets now contain electrical breakers and plumbing shut off valves. The locations of these service areas are ideal because they are easily accessible to maintenance staff, but they are also hidden from the eye of customers who only transit between the main rooms and the corridors (Hobbs, 2008). The closets are shown in Figure 60.

Figure 60. Utility closet

The Webster House contains four levels including a basement, two stories of retail/dining space, and an attic. Both the basement and attic levels contain most of the larger mechanical, electrical, and plumbing equipment. The basement level also provides for storage and a receiving area for antiques (Hobbs, 2008). The basement only has a floor to bottom of joist clearance of about eight feet, so this level works well for its intended service, maintenance, and storage purposes. With such a low ceiling clearance, this space would be hard to accommodate public accessibility without compromising comfort (Oxler, 2008). Four separate mechanical rooms are located in the basement along the exterior walls of the structure. The placement of these mechanical rooms is coordinated with the spatial design of the areas they serve. One of the mechanical and electrical rooms is situated underneath the staircase because this area would have otherwise been unusable space (Hobbs, 2008). One of the basement mechanical rooms is shown in Figure 61.

Figure 61. Basement mechanical room

The attic is also space that cannot be used by the public because of the structural system that takes up most of the space. Therefore, the attic mainly contains mechanical system equipment and ductwork (Hobbs, 2008). The attic is shown in Figure 62.

Figure 62. The Webster House attic

The basement and attic levels proved to be very useful in their open plan layout to provide the Webster House with both storage and space for the mechanical, electrical, and plumbing equipment (Hobbs, 2008). In total, the Webster House contains sixteen air handling units which are located in either the basement or the attic to condition their respective areas of the building (Oxler, 2008). It is interesting to note that many spaces such as the restrooms, closets, and maintenance areas now have motion sensors on the lights to turn them on and off automatically (Hobbs, 2008). A typical motion sensor is shown in Figure 63.

Figure 63. A motion sensor

A remote fire access panel is located just inside the first floor front door. The main fire panels are placed in one of the basement mechanical rooms, as shown in Figure 64 (Hobbs, 2008).

Figure 64. Main fire panels

Recessed sprinkler heads can be seen throughout the building in the public areas. These recessed heads were architecturally designed to be less obtrusive to the visual appearance of the space, as can be seen in Figure 65 (Hobbs, 2008).

Figure 65. Interior room ceiling and recessed sprinkler heads

Pull stations and fire extinguishers are also distributed throughout the building. Smoke detectors were architecturally chosen to blend in with the ceiling and not be obtrusive in the space. To facilitate evacuation and exiting of the building, audio and visual fire evacuation devices are located in the building also, as shown in Figure 66 (Hobbs, 2008).

Figure 66. Fire notification device

With the high value of the antiques in the Webster House, it was imperative to have a fire suppression system that would quickly activate and limit the damage to the building and its contents (Hobbs, 2008). The design of the fire protection system was primarily dictated by the local building code. In this regard, the design of the fire suppression system was standard and was not greatly impacted by the historic nature of the building. The main concern was coordinating other systems with the fire suppression piping to avoid conflicts. However, with dropped ceilings and a buffer between walls, the layout of the system was not too complicated (Oxler, 2008).

Shirley Helzburg wanted high ceilings in both the first and second floors. Even though a new ceiling would be dropped, hiding the original ceiling, space would still be required for plumbing, electrical, and mechanical systems. The original ceiling support consisted of a two-way wood joist structural system. This provided space to run the fire suppression sprinkler lines without much trouble or spatial conflict (Oxler, 2008).

The storm drainage plumbing was one of the easiest systems to design and coordinate on the Webster House. The original design consisted of exterior scuppers and downspouts which ran the water along the exterior walls of the building. When renovating the building, this system was replaced with new piping, but the same design was kept. This exterior storm drainage system is important because storm drainage piping is usually very large and can cause coordination issues if located in the interior of a building. Because of this exterior design, no piping larger than four inches is located inside the building. The current storm water design consists of solid copper scuppers and downspouts. Today, the storm drainage system appears tarnished so that it blends in to the exterior of the building (Oxler, 2008). The storm water drainage system can be seen in Figure 67.

Figure 67. Exterior of the building

There is an interesting story relating to the installation of the new storm water system. Once the new copper scuppers and downspouts were installed on the exterior of the building, they were stolen within a week. To deter future vandalism, a new set of storm water pipes were installed, but this time with the addition of exterior security cameras for surveillance. Needless to say, the increased security has prevented any further major vandalism on the Webster House (Oxler, 2008).

After the plumbing system was redesigned for the current usage of the Webster House, an evaluation of the existing piping system was made to determine if any of the old piping could be reused. After inspection, some of the underground piping was reused but not much of the other piping. Many of the lines were capped off so it was hard to track down which lines were still usable. An occasional branch line was also used within the building, but for the most part, most of the new plumbing system consists of newly installed piping. The Webster House uses a cast iron waste drainage piping system (Oxler, 2008).

The basement level has two entries, one on the north side and one on the south side. A newly designed floor drain has now been installed by each of these entrances. Both of these floor drain lines lead directly beneath the street and tie into a nearby manhole (Oxler, 2008).

5.6 Problems with preservation versus plumbing / fire protection system

The 16" thick solid exterior brick walls were a design challenge for the mechanical, electrical, and plumbing engineers because this hindered penetrations between the exterior and interior of the structure (Hobbs, 2008). Within the building, space is usually one of the biggest problems in designing the system. Space needs to be made available to run piping for domestic water, sanitary water, storm water, and fire suppression systems. In the Webster House, a large grease interceptor was also one piece of plumbing equipment that needed to be located on the site (Oxler, 2008).

Overall, the plumbing system had adequate space for the design and location of piping because of the dropped ceilings and the furring out of the interior walls. In this regard, the building and its historic character was very accommodating to the plumbing design. The original walls and ceilings were kept while adequate space was given for the mechanical, electrical, and plumbing systems. The exterior storm drainage system design was kept; the original piping was just replaced with new copper piping (Oxler, 2008).

Because the public has access to the first and second floors of the Webster House, it was very important to make the visual plumbing system as aesthetically pleasing as possible. Shirley Helzburg, the owner of the building, directed the decisions for all of the fixtures and trim in the design. In valuing the historic appearance of the building, the decision was made to incorporate recessed sprinkler heads into the dropped ceiling. Even though the bathrooms are of modern design, the finishes and the plumbing fixtures themselves are made of very high quality materials. The bathrooms do not have the same historic character because of their modern design, but they still present a very elegant and luxurious appearance which complements the architectural and interior design of the building (Oxler, 2008). The public bathrooms in the Webster House are accessible and ADA compliant, as illustrated by the bathroom lavatory in Figure 68 (Hobbs, 2008).

Figure 68. Bathroom lavatory

6.0 Conclusion

All three case studies presented showed a different level of preservation, and each building had unique design challenges incorporating the mechanical, electrical, and plumbing systems. In some instances, the Secretary of Interior Standards for Rehabilitation were followed, while in other situations they were not. Preservation projects differ from new construction as many inherent design issues were faced in working with the historic buildings. Nevertheless, understanding the integration of the MEP systems into historic preservation projects protects a building's character-defining historic, cultural, and architectural features.

The Stowers Institute for Medical Research was renovated from the previous Menorah Hospital building. This case study showed minimal preservation efforts because it only kept part of the concrete structural frame of the hospital. Many character-defining features of the previous building were lost in the demolition and new construction of the Stowers Institute. This decision was ultimately made by the owners of the new building, Jim and Susan Stowers. They wanted to keep part of the structural frame of the old Menorah Hospital because of its sentimental value to their relationship since they originally met in the Menorah Hospital. However, every historic feature of the hospital was removed and replaced with a new modern design. In this case study, the Secretary of Interior Standards for Rehabilitation were ignored in order to build a new state-of-the-art facility. Nevertheless, reusing the old structural frame and uniting the old and new buildings proved to be an architectural and engineering design challenge.

The Webster House, on the other hand, did follow the Secretary of Interior Standards for Rehabilitation. The exterior of the building was cleaned and repaired in order to return its condition to the originally constructed appearance. Almost the entire original interior was also saved. However, much of the original walls and ceiling are hidden behind new construction. The new walls and ceilings have been installed with a buffer of space offsetting from the original design. Therefore, the old walls and ceilings were not restored back to their original condition, but they are being preserved without further damage behind the new construction. In this manner, the new construction can be removed in the future without damaging the historic materials.

The grand hall, north waiting room, and many of the other spaces of the Kansas City Union Station were completely restored to their original condition. The Secretary of Interior Standards for Rehabilitation were followed during this design project. The preserved Union Station now stands as a cultural, historic, and architectural timepiece in Kansas City. Both the exterior and interior were returned to their original appearance. New additions including Science City were of a more modern architectural design so they would not be confused with the historic features.

It can therefore be seen in these three case studies that the Secretary of Interior Standards for Rehabilitation were followed to a varying degree. Since the Kansas City Union Station and the Webster House are historically registered with the National Register of Historic Places in the United States Department of the Interior, there were design limitations and boundaries already set in place to protect the historic character of these buildings. Since the Stowers Institute was not historically registered and the owners wanted to completely redesign the old hospital building, the character-defining features were lost in the new construction.

Each of the three case studies had individual design problems when integrating the new MEP systems into the buildings, but there were a few common themes to the design challenges. Inherent design concerns are coordination, integration, collaboration, and preserving character-defining features. Space and access were also primary issues in the design and construction. Not only was space limited, but additional design dilemmas arose when trying to accommodate the historical character and features. These historic features and characteristics impacted the location of MEP equipment and routing. The routing of system equipment had to avoid penetrating or otherwise damaging the historic materials and features. Systems also had to be designed to keep with the historic appearance and aesthetic value of the building.

An understanding of the Secretary of Interior Standards for Rehabilitation along with the historic character and defining features of the building will allow for a successful design and integration of MEP systems in a historic preservation project. The Standards for Rehabilitation are guidelines for design, but in order to implement these standards, the building's character-defining features must be understood. A building can contain historic significance through its architecture, culture, or history. A successful MEP designer must first understand these issues and collaborate with the architects and owners to protect the important features. Teamwork between the owners, architects, engineers, contractors, historians, and consultants is key to success. Each design team has different interests and objectives during the construction project. If the teams do not collaborate and strive for creative ideas to save the defining features while incorporating MEP systems, then the final product will be compromised. Before designing for the MEP systems, the engineers should therefore meet with the owners, architects, historians, and consultants to identify the defining features and their associated design parameters that will impact the MEP systems. In the case studies presented, creative problem solving techniques were used in order to incorporate the MEP systems into the preservation projects. In some of these instances, previous penetrations were reused for the new systems. In other situations, creative materials, routing, and designs were used in order to integrate the new MEP systems into the building.

To preserve the building's character-defining historic, cultural, and architectural features, the MEP engineers must first recognize the goals of preservation and the importance of collaborating with the other design teams. Following the Secretary of Interior Standards for Rehabilitation and working together with the owners, architects, and other key decision makers will allow the MEP engineers to create a successful and unique design.

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