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DIGITAL MUSEUM TECHNOLOGY FOR WORCESTER'S INDUSTRIAL HISTORY

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DIGITAL MUSEUM TECHNOLOGY FOR WORCESTER'S INDUSTRIAL HISTORY

An Interactive Qualifying Project Report submitted to the Faculty of WORCESTER POLYTECHNIC INSTITUTE in partial fulfillment of the requirements for the Degree of Bachelor of Science

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The Worcester Historical Museum

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ABSTRACT

Working alongside the Worcester Historical Museum (WHM), our group collected historical and technological information to aid the reconstruction of the Fuller Industrial History Gallery. Experts, scholarly literature, and digital platforms were surveyed to ascertain modern digital methods of museum display. This report also presents potential new artifacts for the Gallery with information regarding the evolution of the wire and metal trades industries especially Morgan Construction in the early 20th century and Kinefac in the late 20th and early 21st centuries. This IQP provides recommendations on smart technologies and industrial artifacts for inclusion in the renovated Gallery.

EXECUTIVE SUMMARY

The Worcester Historical Museum is looking to renovate its Fuller Industrial History Gallery in order to modernize and more fully engage their diverse audiences. Currently the exhibit is overcrowded with artifacts that do not seem to smoothly showcase the industrial evolution of the city. When entering the exhibit, 18th century industrial artifacts are shown, cluttered into one side of the exhibit. Then the other part of the exhibit somehow transitions to a NASA flight suit alongside plastic toys and products, without any clear explanation or chronology. Apart from the limited space and overpopulated displays, the exhibit attempts to educate with bulky television screens with audio coming from adjoining wired phones. This IQP aims to clarify the history of the city, in a strictly wire and metal trades context, as well as to portray such information with more current and less weighty technologies.

Specifically, an overview of peer-reviewed literature assessing currently implemented modes of smart technology in museums and other educational institutions was conducted. For each adopted technology, the effects on museumgoers/students upon exposure to each technological treatment was assessed via hardcopy and online questionnaires, electronic quizzes, or having students complete presentations of artifacts they observed. Within classrooms, smart technology such as iPads can come preloaded with applications that enable electronic discourse among students by allowing them to alter and share digital images and text as they see fit. Museums can adopt such technology with software they design to keep pace with the prevailing modernization of learning. Moreover, smart tablets and other hardware can serve as a means for students to bring what they learn at the museum into the classroom so as to integrate museum learning into their curriculums, and potentially carry over classroom learning into WHM.

Beyond school learning, for the general populace, the usage of technology with quizzing functionalities like multiple choice questions facilitates "deep learning" of museum information, whereby museumgoers not only memorize but must comprehend the information they are faced with to answer a digital prompt. This assessment feature thereby encourages visitors to engage more with exhibits than they would otherwise without the electronic quiz. However, too much emphasis placed on entertaining museumgoers to encourage engagement may hinder learning by distracting one's mind from the core lessons of the presented artifact.

For the museum's archival organization, electronic storage presents a means of centralizing information. Additionally, the construction of a smartphone/tablet applications to access museum artifacts or increase user accessibility within the museum via sensors detecting the presence of visitors and automating exhibits based on their locations may further enhance visitor experience.

This IQP also approached professionals in different fields in order to develop a multi-faceted opinion for the exhibit's updates. By interviewing museum, historical, and technological experts, ideas on how to shape and manage the specific metal industry sections of the exhibit were cultivated. Many technological advancements have been adapted by other city museums in order to function correctly within their exhibits, such as tablets and aids for those who might be impaired. These technologies were also lauded for their small size because they would not clutter the exhibit like the current displays do within the Gallery.

Finally, the IQP provided information on the largest wire-producing companies in Worcester during the past few centuries, such as the Washburn & Moen District Works, the Morgan Construction Company, and the Kinefac Corporation, to trace the industrial development of the metal trades industry within the city. Starting with background into the creation of the wire making facility, Washburn and Moen District Works, the interview with independent scholar, Allison Chisholm, dives into the concept of endless novelty in Worcester. Section 3.4.4, describes how Charles H. Morgan, a pioneer in mill manufacturing, was able to flourish as a superintendent of the industrial juggernaut Washburn and Moen District Works. After years of working with his mentor, Ichabod Washburn, Morgan went on to found his own company, the Morgan Construction Company, which would eventually rival Washburn and Moen in size.

Chapter 4 goes into detail about how tapping into the broader steel production industry, Morgan was able to expand his company and provide the necessary equipment that would be used in hundreds of Worcester, American, and global companies. This cycle of incubation continued, some of the Morgan Construction workers would go on to a more modern company like Sleeper Hartley and later Kinefac, spreading ingenuity from one steel company to another. Chapter 5 explains the history behind Kinefac, and expands on their production, which does not specialize in producing steel mills, but utilizes the steel to create shaft-like components.

Thus, the evolution of the largest industries that helped Worcester flourish is traced through the mentorship that each company had to its workers in order to expand the high quality of work and inventiveness throughout different metal industries. This story-like development is then further explained in the context of a museum, where this overarching theme of endless novelty can be portrayed as the way of thinking that all of the founders and presidents of these companies had in order to create such long lasting manufacturing companies. Artifacts, documents, movies, pictures and other memorabilia from the WPI archives are then described in the final sections of Chapter 4 to be utilized as part of the exhibit.

Therefore, in order for a museum to become more modern, it must digitize historical evidence and relics to complete a connection between the past and current times that will be more relatable to the museumgoers. It must also adopt smart technology with quizzing functionalities to measure visitor learning.

CHAPTER 1: INTRODUCTION

1.1 Problem Statement

Worcester Historical Museum is now undergoing renovations to update its Fuller Industrial History Gallery to attract more visitors and increase their engagement with the collection. The last major renovations occurred in the early 1990s when technology present in the exhibits was considered progressive at the time. They now appear dated compared alongside more efficient, compact, and digital alternatives on the market today. Perusing the galleries, one is encouraged often to interact with handheld phones and engage with text on interpretative panels, laminated flip books, and a historical timeline. However, simply listening to an audio recording or reading analog text neglects the potential interactivity of a digital interface that has become increasingly the norm for similar museums. Digital displays can increase content presented and deepen visitor's engagement and interaction with the exhibit.

During the renovations, WHM also hopes to bring greater coherence to the gallery's thematic presentation. The city's history presents a problem on this point, however. Since Worcester's industry was most characterized by its diversified nature, the gallery has many disparate elements, giving the space a cluttered and crowded feel. While the Woonsocket Museum of Work and Culture can focus on the textile mills of the area and Lowell National Historical Park can narrate the expansion of the cloth trades on the Merrimac River, Worcester's industrial history is not so tidy. From wire to ice skate, firearms to valentines, and envelope folding machines to looms, the city's industrial story cannot be reduced to a few thematic units (Washburn, 1917).

Image 1.1. American Steel and Wire Product Display created by A. F. Weissinger for the company's one hundred twenty-fifth anniversary. This captivating panel in WHM's Fuller Gallery neatly captures some of the diversity of production that characterized just one company in Worcester larger steel and wire sector.

One approach to address this diversity is to embrace it and create zones on particular industrial sectors like wire and metal trades, tool and machine makers, or abrasives. Drawing upon the approach of historian Philip Scranton, the central governing theme can be one of "endless novelty" and each sector can illustrate how the diversity of firms and specialties exemplified the concept (Scranton, 2000). With each broader category like wire goods, the gallery can emphasize the general significance of the sector through anchor firms, such as Washburn and Moen or American Steel and Wire, and then illustrate the endless novelty with multiple examples of secondary companies in the sector, like Kinefac in producing specialty machines for processing metals today (Washburn, 1917). The current installation does not take this approach. Rather the stories of particular sectors and even firms are told across several areas in the room in alignment with a rough chronology right now governing the placement of artifacts and interpretative apparatus.

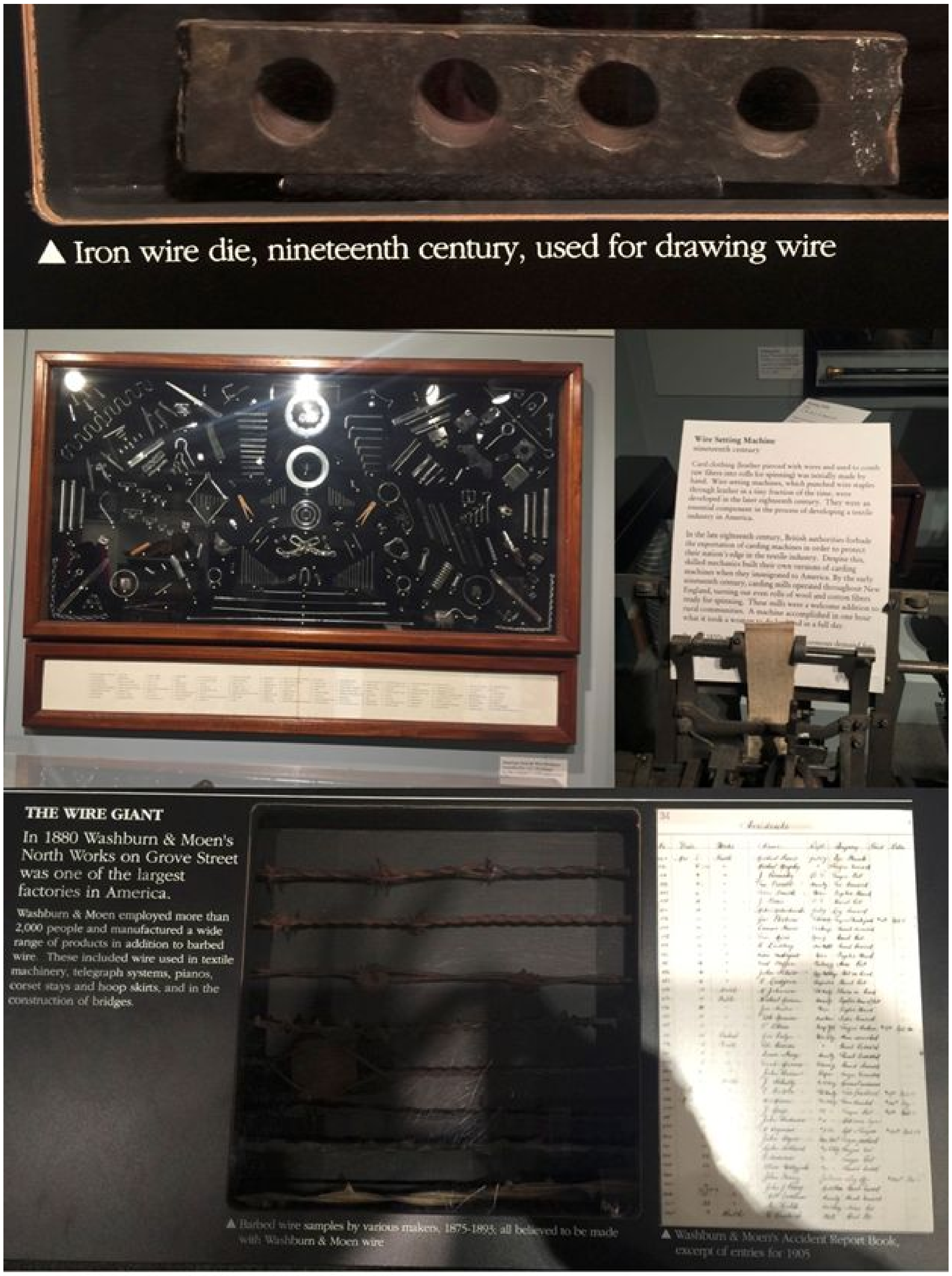

Image 1.2. Dispersed interpretive panel and artifacts relating to Washburn and Moen (late American Steel and Wire) are dispersed across Gallery so the visitor does not experience them as a coherent, thematic whole.

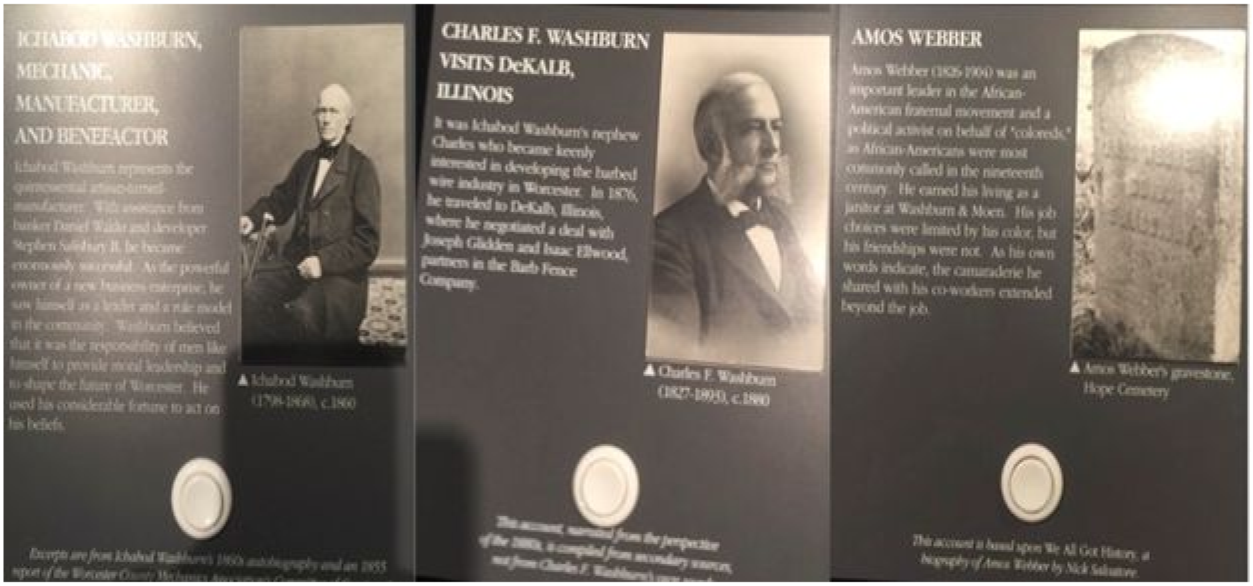

Image 1.3. Audio panels with handheld phones that use the voices of Ichabod Washburn and others associated with wire manufacturing.

Image 1.4. From the timeline along the ceiling. Milestones in Washburn and Moen's history are noted.

All artifacts, images, and text that adorn the Gallery room are presented by obsolete means. Supported on a ponderous hip rail, flipbooks and corded telephones preface each exhibit, beckoning visitors with a physical approach to learning, appealing mainly to the physical senses of hearing and touching historical information. Younger visitors, brought up in this age of wireless technology, may be unfamiliar or even question using a wired telephone to hear information, where a video or touch screen can suffice for teaching. Such formatting would seamlessly combine sight, hearing, and touch into one interface rather than delineating each into different pieces.

Current exhibits also lack the universal accessibility granted by digital technology. Wall text cannot be resized for the near-sighted. Text is monochromatic, which lacks the eye-catching ability to highlight text with animation and vivid coloration that digital software can readily do. Finally, an app synthesizing information with interactive/game-like features can improve interactivity, compared to reading flip books or using phones with pre-recorded tapes; visitors will have access to all information in the gallery at their fingertips. Integrating smart technology to the museum opens up exhibits to special-needs visitors as well, by way of apps tailored to presenting information to individuals with different learning styles.

The second component of renovations concerns what historical information is itself displayed. As mentioned, the Fuller Gallery lacks thematic cohesion: artifacts from the 1800s are placed adjacent to more modern exhibits. Specifically, the history of Worcester industrialists like Ichabod Washburn and Philip Moen sits close to post-industrial manufacturing artifacts. This juxtaposition has no visible flow beyond simple chronology. Therefore, the Gallery needs to be revamped with a singular part of history, which WHM has elected to be the history of wire and how it threads through Worcester's early history to today, telling the story, rather than a bulleted list, of Worcester industry.

WHM staff have so far met with designers and established a new floor plan and layout for the Gallery. While the physical designs are set in motion, the digitizing of present and new historical information is still incomplete and lacks a clear methodology of layout. Implementation of a digital timeline to maintain chronology while simultaneously facilitating the addition of new pieces of wire history will be considered. Furthermore, the usage of apps suited for special-needs visitors will be evaluated.

1.2 Project Goal

Find effective and accessible approaches to digitally and interactively display engaging artifacts of wire history that thread through Worcester's larger industrial past to increase museum traffic.

1.3 Project Objectives

- Survey and inventory the history of the Worcester wire industry to create an entertaining and insightful exhibit.
- Make recommendations on methods that may increase access to digitally-stored historical information.

1.4 Project Deliverables

- Develop plans for integrative and interactive exhibit, recommending ideas for accessibility
- Provide historical information of companies involved in the wire and metal trades industries in Worcester up to the present.
- Final Report and Presentation

1.5 Project Methodologies

To address each objective, literary sources and interviews will be evaluated with the most pertinent components synthesized into a final report. Specifically, the efficacy of implementing a digital interface to catalogue different pieces of Worcester wire history will be analyzed in two areas: one, how effective current digital installations are in increasing museum traffic and two, which historical information is most relevant to what WHM seeks to display in the Fuller Gallery.

For technological development of the Gallery, each expert and literary sources accessed will be analyzed for any commonalities, overarching trends, and examples of smart technology implementation. Based on these discerned characteristics, this report will summarize recommendations for the museum for which technologies may increase visitor engagement/interest and number and what aspects of smart technology adoption to avoid.

The other part of this report seeks to catalogue the transformation of the wire and metal trades industries in Worcester. This is to be accomplished through exploring the origins and development of the Morgan Construction Company from the earlier Washburn and Moen compound and then the evolution of other companies into the modern Kinefac Corporation by surveying historical photos, books, newspaper pieces, company websites, and experts. Ultimately a diachronic story of the development of wire production in the city will be presented to provide a case study of the larger industrial history of Worcester.

CHAPTER 2: LITERATURE AND ENVIRONMENTAL REVIEW

2.1 Introduction

Integrating digital displays in museums, while common today, has drawn mixed critiques. Studies into the most compelling means of presenting information, balancing information retention in visitors, all while minding a budget, all acknowledge a tenuous balancing act museums must face in developing new exhibits. Specifically, how and why a museum elects to digitally summarize their exhibits can be answered by multiple studies critically confirming and contesting which methodologies superiorly addresses each of the aforementioned issues.

2.2 Digital Interpretation, Engagement and Learning Outcomes

A mindful approach to integrating education with technology necessitates a survey of the efficacies and caveats in such an endeavor. Indeed, whether a school, museum, or any other institution of education, to facilitate a cost-benefit analysis of investing resources into going digital, one must heed studies exploring the efficacy of smart technology at heightening visitor learning and engagement.

In support of the utility of using smart tablets and other mobile technology in facilitating learning, a study by Isa Jahnke and Swapna Kumar in 2014 studied how effective and in what capacities 15 school classrooms around Denmark implemented iPads in teaching (Jahnke, 2014). The researchers conducted an observational case study whereby they had "observers" sit for 45 to 90 minutes in each class and interviewed each teacher after to understand how teachers sought to integrate iPads into their teaching (Jahnke, 2014). Moreover, to gauge the efficacy iPads had in the classroom, researchers were given a list to complete, comprising of space for observations underneath categories including: teaching objectives attained, learning activities, feedback (i.e. how students show their retention of new information), social dynamics, and to what extent iPads are used (Jahnke, 2014). The study presented five case studies of classes ranging from grades K-9.

Jahnke and Kumar found overall that teachers used iPads more as a means for their students to create products/projects and encourage critical discourse rather than as a resource tool solely to learn. More specifically, when observing a Danish and Arts eighth grade classroom, students were broken into groups of three and tasked with discussing Danish paintings and cataloging their discussions with iPad for submission (Jahnke, 2014). Observers saw much talking and collaboration among students with the iPads forming the conduits for discussions (Jahnke, 2014). With such a team dynamic, especially when in a museum exhibit crowded with other patrons, smart tablets can evidently create an environment that encourages not only discourse with other museum-goers but stimulate critical thinking of exhibits the likes of which are not seen with more traditional museum text.

Indeed, as explained in a 2003 review by Michael Macedonia of the Georgia Tech Research Institute, the combining of digital technology with how museums portray their exhibits and engage visitors is a necessity of survival (Macedonia, 2003). Citing Moore's Law of computing power doubling about every 18 months, Macedonia argues how easily museums, libraries and other educational institutions can lose visitors who stay home to play more modern, flashy video games like the Sims (Macedonia, 2003). He further details how then-current digital installations, like the virtual digging of an ancient Chinese tomb at the Seattle Art Museum, where museum goers could have their movements read by computer sensors to dig away dirt from virtual artifacts, displays a prototypical example of where increased visitor interaction is made possible via technology (Macedonia, 2003).

Nevertheless, in a 2013 study titled “Management of New Media Technology Application in Exhibitions of Science and Technology Museums,” researchers demark an upper limit in educating people through increased integration of digital technology. In this study, the authors remarked on how effective digital exhibits are at disseminating information and increasing visitor interaction (Zhang, 2013). A caveat they observed was, besides overhead costs accrued from maintenance and repair, an exhibit using too much technology to display artifacts may lead to sensory overload for museumgoers (Zhang, 2013). A mindful use of what technology is used is needed, as was evident by interviewing 30 visitors to the China Science and Technology Museum. In their interview, each participant was asked whether he or she approved of a particular exhibit at the museum that purposefully uses low light to heighten contrast of the digital displays to ease viewing (Zhang, 2013). Out of the people interviewed, 21 found the environment “distracting” and they felt uninclined to view all the artifacts. Moreover, the researchers outline an algorithm of what and how much technology should be used, cautioning that too much emphasis placed on “entertaining” visitors will inhibit learning (Zhang, 2013).

In contrast, a case study by Jocelyn Wishart and Pat Triggs of the University of Bristol provides a view into the enhancement of student learning with information and communications technology (ICT) (Wishart, 2010) Titled “MuseumScouts: Exploring how schools, museums, and interactive technologies can work together to support learning,” the authors detail a two-year-long, collaborative effort with research institutions (museums, galleries, libraries, nature reserves, etc), across 5 European countries (Portugal, Germany, England, Austria, and Lithuania) and schools native to each region (Wishart, 2010). Involving educators and their students across 22 projects and 27 schools, the European Union-funded project aimed to present students the combined resources of museums, ICT, and multimedia presentation software to develop presentations of artifacts they found in museums (Wishart, 2010). Students used ICT (i.e.computers and smartphones) to gather photos, background information, and facilitate "collaborative talk" between peers to create their presentations, all in the effort by the study's controllers to examine"deep learning." Citing others studies, the paper's introduction lays forth a foundation for integrating technology, remarking its ability to facilitate "deep learning" in the students that utilize it (Wishart, 2010). "Deep learning" in this study was defined as an engaged and active cognition: students participate in, ascertain meaning to, and teach the content they learn (Wishart, 2010), which, in this study, was information gleaned from museum visits. Benefits of this constructivist approach are increased retention time of material and novel understanding of various, sometimes disjointed, ideas. Moreover, physically manipulating and witnessing artifacts as opposed to reading a history text of it can further encourage this level of learning.

In the study, the authors gather observe and gather feedback data from 14 projects over 2008 over all five nations, involving 225 students and 25 teachers total. Projects, as stated, were collaborations between schools and nearby research institutions, like museums (Wishart, 2010). Teachers, to varying degrees, adopting this project into their class curriculums and allotted time and aid to students. Students, aged 10-19, then had to create presentations with quizzing functionalities through the program Evolution of artifacts they found to present their findings to their fellow students (Wishart, 2010). Through interviews with faculty, participant observations, and online surveys the study's methodology to learning received generally positive views: 88% of teachers surveyed remarked the increased responsibility/pride students took in their projects than what they would show "normally" and 100% agreed that students learned from the artifacts they witnessed and information they researched for their presentations. Moreover, the students, the test subjects, tagged various adjectives in the online surveys to denote their opinion of the study's stipulations, with "interesting" and "fun" being most often selected (Wishart, 2010).

Further extolling the benefits of implementing information technology on learning, a 2017 study by Jessie Pallud of the EM Strasbourg Business School explores the factors enabling learning and the impact of technology on museum visitor learning (Pallud, 2017). Titled "Impact of interactive technologies on stimulating learning experiences in a museum," Pallud prefaces the study with a literature review of the psychology of the various motivators that drive learning: authenticity of experience, emotional response (affect), and cognitive engagement, all in a technology-mediated learning (TML) context (Pallud, 2017). Pallud cites a lack of research studying the underlying psychology of TML in museums, a logical fallacy in her view, supporting this opinion with metrics such as the the Institute of Museum and Library Services' 52.7% of grants going to projects increasing "learning experiences" and only 33.1% to "collection stewardship" (Pallud, 2017). Indeed, Pallud further lists studies elucidating the increased interactivity and "audio/video features" granted by TML but posited increased immersion and the "production of real-world scenarios" as other critical necessities to enhance learning; the 3 aforementioned facets of deep learning Pallud lists must be met by any and all technology integrated into a museum (Pallud, 2017).

The study models its data falling into 8 hypotheses, each, either examining an aspect of learning or affect from using TML or the technical dimensions of TML (e.g., ease-of-use) on learning outcomes (Pallud, 2017). The venue of the study was the National Museum of History of Immigration (NHMI) in France, as Pallud believed the museum's mission to "providing an emotional experience" and use of technology in its exhibitions complemented the study's objectives. To assess visitor experience, 183 reverse-scored questionnaires were distributed randomly to visitors over 1.5 months regarding 2 ICTs at the museum: an interactive kiosk and digitally linked audio guides (Pallud, 2017). Each of their hypothesis composed the survey question items and results were compiled and assessed for statistical significance and path coefficients (to assess relationships between study variables, as denoted by individual hypothesis). All hypotheses were supported except for the relationship of authenticity of experience on self-learning outcomes (Pallud, 2017). Pallud reasons the lack of correlation between authenticity of museum experience and learning is due to a limitation of the scale she employed in her study, whereby she observes her surveys emphasized subjects measuring the "genuineness" of their museum experiences. This metric better relates with cognitive engagement, not with learning, positing better psychological rulers being the amount of "problem-based activities and opportunities of reflection" to measure authenticity-driven learning.

Thus, technology serves as a means of enhancing learning. Whether a smart tablet facilitating discussion in the classroom, to museum exhibits implementing sounds and visual cues, evidence shows education going digital positively correlate with psychological variables denoting deep learning, such as cognitive engagement, retention, and positive appraisal of information. The interactive component of digital technology, be it an online quiz, survey, or pushing a button, compels users, the students, the museumgoers, to not observe, but internalize information to answer the digital prompt, to think of presented information to answer the digital prompt. As technology pervades virtually all mediums of learning currently, an inquiry into current, successful applications can further inform the adoption of technology within WHM.

2.3 Best Digital Practices for Museums

Museums across the globe have adopted technology into their exhibits in varying amounts and different ways. Indeed, there exist many examples that highlight the successes of where furnishing exhibits can heighten visitor enjoyment and learning, while easing the presentation of information.

Exploring the facilitating capacity of digital technology to display information, a case study details the efforts by the Museum Victoria (MV) in Australia to digitize their audio and visual artifacts collections (Broomfield, 2009). MV is responsible for maintaining all "science and cultural collections" in the Victoria province (Broomfield, 2009). To streamline looking up images and cataloguing information, the MV ultimately developed a web-based interface called MV IMAGES in 2009 that allows for public inquiries into museum archives without the expenditure of staff to process requests and updating the previous system to allow public access from solely intra-departmental access within the confines of the museum (Broomfield, 2009).

A study by Vavoula et al. explored the impact a mobile app called Myartspace has on student learning in museums. The app comprises of three "stores" or places where visual data like images and text are stored: one curated by the museum visited, one for the student or teacher, and one for the class (Vavoula, 2009). Essentially, the app functions as a personal timeline/catalogue whereby users can take pictures by themselves or select from the museum store to create a slideshow of their findings, commenting what each student finds interesting or relevant in answering a research prompt (Vavoula, 2009) The app's overall goal is to facilitate "inquiry learning" where students freely learn by their own accord by way of exploration rather than sit confined to a desk and reading a textbook (Vavoula, 2009). This study details results of a final user trial where a history class of 23 students aged 13 to 14 visited the D-Day museum in Portsmouth, UK in 2006. Students were each given a phone preloaded with the software [7]. After the museum visit, students were given questionnaires inquiring into their experiences with the software: 57% said they would use the software again and 56% said they would suggest it to other students (Vavoula, 2009).

While the efficacy of employing a digital framework is extolled, the components of an adaptable and flexible interface is explored by Kovavisaruch et al. in their article titled "Museums Pool: A Mobile Application for Museum Network" (Kovavisaruch, 2015). In it, researchers detail using a mobile app that connects participating museums in Thailand into a central server to display information of each member, such as location and what types of exhibits are available at each, to users (Kovavisaruch, 2015). The app allows one to browse museums like a catalogue. Upon being near a museum premises, the app sends location data to a museum server (deviating from the central server from before) to obtain further detailed information regarding exhibits, shows, and artifacts within the museum nearby (Kovavisaruch, 2015). Three Thai museums participated: the Science Museum, the Information Museum, and Chaosamphraya National Museum, where all each contributed content to a central server. The app's creation was borne out of an effort to do away with tourists having to download an app for each museum they visit, which can needlessly fill the storage on their phones, in place for one, centralized app (Kovavisaruch, 2015). Moreover, the researchers cited their software occupies visibly less space on phones, at 8.7 MB on Android phones and 15.7 MB on iOS devices, compared to “5 other Thai museum mobile applications that range in size from 37 MB to 415MB ” (Kovavisaruch, 2015).

Observing the effects of IT and exemplars of its utilization a message of cautious adoption permeates the various studies cited. While smart technology does confers to its host institution a robust and flexible repository of virtual information, adaptable to the museum’s educational objectives, its implementation effects on user experience are mixed. While increasing mental cognition of artifacts and other presented information, too much technology can readily dampen and hinder learning; the careful balance between colorful appeal and informing must not be neglected. However, as mentioned above, by integrating it into the devices people use most often (e.g., apps on smartphones) a more seamless integration ensues that empowers visitors to learn at their pace and comfort.

2.4 Conclusion

An educational institution seeking to educate in modern times and maintain steady visitor/student attention and presence needs to inform through digital means. As Jahnke and Kumar displayed, smart tablets increase discourse of presented information. Indeed, students in their study discussed presented artifacts more than if they did not possess smart technology. Moreover, Moore’s Law serves as a statistical impetus for museums to go digital: computers increase processing power steadily, allowing for more engaging and lifelike video games and other entertainment that can pull potential museumgoers to stay home, viewing more traditional media (e.g., static museum text) as dated. However, designers must avoid focusing mostly on entertaining visitors, which can impede visitor viewing and retention of information. Technology emphasizing interactivity to learn and immerses visitors can, according to Pallud, improve "deep learning." Thus, a recommendation is to implement technology not only in-gallery but also in school learning modules and curriculums, as to construct an uninterrupted chain of deep learning opportunities that can increase retention of museum information.

Technological adoption can also benefit museum staff. By storing artifacts in a database for virtual viewing, an adaptive database is created whereby museum can do the nearly endless digital manipulations available to typical computer users. Whether describing artifacts more or hiding some to make room for newer additions, going digital allow for storage of more artifacts than the confines of a museum space can hold physical objects and deeper context descriptions for artifacts. This will also allow for a declutter of the current Gallery without excluding artifacts. Moreover, creating an app that centralizes artifacts from many museums can enrich museum-based learning by increasing accessibility and encourage increased and more active engagement with the Gallery's items. Smart technology also elicit a feedback system to measure and assess if learning outcomes are met by museumgoers. To increase visitor traffic, avenues of increasing accessibility by way of apps that consolidate artifacts and exploring digitizing museum collections entirely should be explored.

CHAPTER 3: ACCESSING EXPERTISE

3.1 Introduction

Many curators at Worcester Historical Museum (WHM) and historians across the city have detailed, firsthand knowledge of WHM's collection. Their collective experience working with the collection to create exhibits, respond to queries, and write books and journal articles give them an intimate firsthand knowledge of historical assets relating to Worcester's industrial history. This expertise is often not fully conveyed in their published work or their gallery installations. Further, as professionals who have struggled to convey Worcester's past to a broad and diverse audience, they possess special insights into what kinds of stories resonant with the Museum's many constituencies. Accessing their expertise allows this IQP to learn from previous scholars' efforts and to move more efficiently through the vast range of materials available on Worcester's wire industry available at WHM, WPI's Gordon Library's Archives and Special Collections Department, and the Baker Library's collection of American Steel and Wire (including Washburn and Moen) papers and photographs at Harvard Business School.

This chapter first describes the rationale for conducting interviews, identifies those interviewed, lists the questions asked of WHM employees, area historians, and museum professionals, and provides interpretative summaries of those interviews, and, finally, concludes with a collection of insights that informed the collection of subsequent artifacts and images for potential digital interpretation in the redesigned gallery.

3.2 Rationale

While scouring the literature can present studies and facts that aid in solving the research objectives, interviews, especially those conducted with sponsors, can provide deeper insight into the project goals. Any simple search through the internet or a book will enhance familiarity of the topics involved. However, solely gleaning information from published sources nets a two-fold loss: missing unstated criteria the sponsor may have and insightful opinions that can direct future research. A deeper context for the how the project should move, an assessment of current progress, is readily available by conversations with experts.

While interviews can coordinate research, the content of responses to our prompts deepens insight into how to tackle project objectives. As most interviewed people are museum employees, they possess first-hand knowledge of their different audiences (e.g., school groups, veterans, senior citizens, and visitors to the city, etc.) and are, therefore, aware of "who likes what." They can also tell us what resonants in the current industrial history and must stay as well as what pieces are mostly passed over. They know how to tailor exhibits to maximize visitor interest, as attracting more people is their main goal as a museum along with deepening engagement of those visitors. This opposed to haphazardly putting together a hodge-podge of artifacts in the hopes of garnering more visitor interest; a more informed exhibit design provides for a higher chance of attracting more people than mere shooting in the dark.

Moreover, employees may be familiar of the impact of intertwining digital and traditional forms of media into exhibits. Thus, their perspective illuminates how smart technology might be integrated. Only employees know the perspectives they wish to convey, the voice they wish to speak, and what pieces of Wire history complements and aid their vision of the exhibit.

Therefore, from all these aforementioned benefits and insights, interviews prove vital for this project's completion.

3.3 Interviewees and Interview Questions

This team identified a range of subjects some with expertise in Worcester history, others experienced in museum design, and some with curatorial experience. Special effort was made to interview subjects with extensive knowledge of wire drawing and wire related industries.

3.3.1 Interview Subjects

1. Vanessa Bumpus
2. Bill Wallace
3. Susan Heilman
4. Allison Chisholm

3.3.2 Interviewing WHM Employees and Worcester Historians

For those subjects familiar with Worcester's history (e.g., Alison Chisholm) or those who are employed by the WHM (e.g., Vanessa Bumpus, William Wallace), we composed the following questions to guide our interview. These questions served to initiate conversations and ensure that the most appropriate topics were covered, but we also allowed space for the interviews to veer off script into areas that the subjects considered most significant.

1. What is your favorite piece of Worcester wire history? Are there other artifacts that may relate to the exhibit and pertain to Worcester wire history and metal trade?
2. What do you naturally emphasize when presenting exhibits, particularly those that contain Wire history artifacts?

3. Which artifacts related to the wire and metal trade can be made more personable by way of presenting more historical background?
4. When you give tours, what do you find yourself emphasizing, and how would you measure the reactions of your visitors to elements of exhibits?
5. Is there is any consumer experience/ feedback data?
6. What do you think the benefit is of implementing digital tech and text? How do you see yourself implementing it?
7. Though a bit more abstract, what specific types of artifacts (e.g., digital photos) do you think are fit to be in the museum that are not currently on display?
8. Have you found anything particularly unique that offers a fascinating perspective or is thought provoking?
9. What do you have in mind what this project will look like in their gallery?
10. What is the target audience of the Fuller Gallery?
11. When children first walk into the Gallery, what exhibit usually lights up their eyes or draws their attention? How about with adults?
12. When you look at other museums, are there elements you see that you seek to implement at this museum?
13. Finally, what do you most want visitors to leave with after viewing Wire history exhibits?

3.3.3 Interviewing Professionals at Science and Technology Museums

One interview subject has no experience with Worcester's history or history exhibit design more generally, but was well versed in audience engagement at the Museum of Science, Boston. Therefore, this team crafted a second set of questions addressing broader subjects in museum design especially relating to science to technology.

1. Do you mind a bit about your background? What do you do for the Museum of Science?
2. What do you think the benefit is of implementing digital tech and text? How do you see yourself implementing it?
3. What current types of smart technology have you personally advocated for and seen succeed in drawing more visitors to your museum? Were there any failures or is this too hard to tell now?
4. Do you think there is a fine line between engaging visitors and annoying visitors with smart technology? If so, where do you draw the line?
5. What future technology do you see implementing in your museum to aid in attracting more people?

3.4 Interpretative Summaries of Interviews

3.4.1 Vanessa Bumpus, Exhibitions Coordinator, WHM, Worcester

Overall, Ms. Bumpus stressed the ubiquity of wire in modern society. From composing the circuitry of phones, to forming modern eyeglasses, wire "links our wireless society." Regarding the evolution of wire usage, she mentioned women's corsets, made of whalebone initially, becoming structured from metal wire later in the 19th century. Wire also just constitutes a portion of the industrial history of Worcester: tours of the Fuller Gallery will see wire's usage juxtaposed to other events, such as the Merrifield Fire and with ongoing infrastructure projects like the Blackstone Canal. Moreover, exhibits of biomedical milestones in Worcester, like the development of Umass Medical School and research at WPI would update the Gallery to cover Worcester's science history in addition to its industrial past.

To enrich visitor experience, she advocated for an intuitive, yet cautionary, integration of technology; a balanced use is mandated by the very nature of museums. Since technology is so accessible (e.g., 7 years ago having an iPad in the museum would be a novelty), now everyone has a computer in their pocket, virtually. She says museums don't have to provide so much information in their text, as people can fill in the dots themselves with their devices. That being said, the Museum has to present something. A teaser is required, so to speak. For example, the calliope (invented in Worcester) is an exhibit, but the Gallery currently has no auditory capacity to play it. If people could play it as an iPad application here, that would leave a larger impression than merely looking at a static picture, because one will now understand how its internal gears function. As another example, with Robert Goddard, a video of rocket launches would provide a more vivid representation than plain text and aid in visitor understanding.

3.4.2 William Wallace, Executive Director, WHM, Worcester

Mr. Wallace expressed similar sentiments to Vanessa with potential additions to the Fuller Gallery and with regards to how technology should intertwine with exhibits. Concerning historical artifacts, Bill provided a litany of potential artifacts and stories to aid to the exhibit, all in the effort to display the virtually ubiquitous impact Worcester wire has on modern society. Mentioned examples include: the diner knife stamped out pressed wire, the Golden Gate Bridge being composed of Worcester wire, etc. However, he also pointed to the indirect effects of larger wire production on Worcester's development, such as the fact Ichabod Washburn, a wire developer, handing company stock to the city of Worcester to develop Memorial Hospital.

Essentially, Bill stressed exhibits must strike a chord with the modern museum audiences by elucidating the connections products of today have with Worcester's industrial past. In that vein, he mentioned the pond at Institute Park being largely the size and appearance it is today because of utility rather than beauty: the pond functioned as a millpond to power the North Works factory but is enjoyed today as a recreational spot. With the digital game industry, WPI, MassDiGI and Becker are making strides in it becoming a potential enterprise for Worcester, in his opinion , but it is not down in the gallery in any shape or form.

Moreover, he advocated for the widespread usage of smart technology throughout the gallery. Citing the tactile video towers installed at the Museum of the City of New York, he described in detail how such technology accommodate the varied learning interests of modern audiences. For example, he mentioned the museum features maps of old and contemporary Chinatown as icons that can be swiped through horizontally on adjacent video screens, and if one seeks more information regarding an artifact, the user swipes vertically to view more details. Such technology also possesses the capacity for fast updates which static text on the walls in the Gallery sorely lack. This is in addition to displaying large artifacts in digital forms rather than in more traditional formats to permit many more artifacts inside the Gallery. An example for this is the addition of the Corliss Engine, an artifact that will not fit inside the limited confines of the Gallery, but a video of its operation or person standing beside it can.

3.4.3 Susan Heilman, Senior Educator, Museum of Science (MS), Boston

Dr. Heilman provided input from a more pedagogical perspective than purely that of a designer. Indeed, she consistently emphasized increasing visitor engagement and learning as the priority of museums. Describing her current position as an educator with various duties such as organizing guest lectures, presentations, and demos, she also provides input to the exhibit design department at MS. She explained how her museum is attaining exhibits of a "universal design" caliber, wherein exhibits are accessible to people of all walks of life: from children, to the blind, to the elderly. However, MS, and virtually every other museum for that matter, have not achieved such level of accessibility, due to the engineering and financial constraints imposed by such an endeavor; it remains a hot topic of museum research. That being said, her museum does favor tactile and visual exhibits in lieu of plain text to involve the other senses in learning exhibits, so as to enhance visitor engagement. Moreover, she stressed the need for museums to implement a rigorous evaluation process of exhibits. The MS has a sizeable design research department that publishes papers of the successes and failures of exhibits annually.

However, too much technology has its downsides. An example she cited was a recent acquisition of a supply of Samsung tablets for visitors. The goal was to use such devices to accentuate current exhibits by providing more information and fun activities revolving around artifacts. Not ascertaining any real utility for them after a period of time of brainstorming, MS was "cornered" into just using the tablets for activities like coding and controlling robots; activities that did not really elevate exhibit interaction. In contrast, the museum hopes to have visitors utilize their phones to interact with exhibits, a personal device where the user knows and feels comfortable using. As an aid to understanding exhibits, her hope is that a user's phone internal GPS can track a user walking through exhibits and permit him or her to explore an artifact that piques their interest. But it's rare and not fully understood yet, as well how precise such tracking can be. However, the museum does not want museumgoers to be "glued" to their phones and/or stay home. Another potential tracking system involves ceiling lighting. Using

LED lights that constantly flash, phone cameras, but not human eyes, can detect and discern certain patterns to signal where a visitor is in the museum. She concluded by stating a broad line lies between too much smart technology and none in enhancing visitor experience, as a fine line suggests that a museum can annoy people quickly, but technology is so ingrained that museumgoers will be gradual in their irritation.

3.4.4 Allison Chisholm, Independent Scholar, Worcester

Unlike the other professionals interviewed, Ms. Chisholm was mostly focused on the accuracy of the history of the wire industry in Worcester, more specifically the life of Charles Hill Morgan. As the leading expert, she focused primarily on three main avenues of Worcester wire industry. One highlight was the sheer size that the Washburn and Moen District Works was able to achieve through the near monopoly of the wire and steel industry. Another focal point was the advancement in production Charles Morgan offered in the form of improvements of previous machines, as well as new inventions. Finally, the last important avenue was on the impact that Charles Morgan had on Worcester, and even the United States as a whole.

Ms. Chisholm discussed that during the time that Charles Hill Morgan worked at the Washburn and Moen District Works, the company had grown to an outrageous size. Her most unique fact about the company was that it had grown so immensely that the variety of wire was simply outstanding. The types of wire she reported included, but were not limited to; bonnet, hairpin, hook and eye, reed, flat, piano pin, buckle, market, wearing, telegraph, and finished steel music wires. Since piano wire was previously only produced in England, Washburn and Moen became the only company in US to produce high grade piano wire. However as discussed before wire was not the only steel product that Washburn and Moen, or even the Morgan Company, were exclusively manufacturing. The Washburn and Moen District Works was making cotton mills as well. Their cotton mill made enough cotton products to cover 4 tons of wearing wire a day. They quickly became the largest consumer of cast steel, which they bought from other companies since it would have been a lot less efficient to cast the steel themselves. With the steel they bought, they would make their own steel rods for the wire drawing process. The company had made so much wire during their time that in an article from 1871 a man working for the Company was asked, "how much wire was made in 1871?" The man answered, "enough to reach around 3 times around the equator and make a telegraph line to the moon." Ms. Chisholm discussed that the Company covered several acres, made up of all of the mills the company was continuously running. And without all of the barbed wire that the Washburn and Moen District Works, the West would not have been settled.

Ms. Chisholm went into great detail about Charles Hill Morgan and his journey to founding the most successful wire manufacturing company in Worcester. Morgan had worked in carpet weaving as a child before joining one of the biggest wire companies, The Washburn and Moen District Works. Morgan himself was not school educated man, but nonetheless became a self-taught engineer through experience. During his time at Washburn and Moen he took trips to Sweden, where he would study the Swedish machines, as well as the workforce. From these trips he understood machines in ways no one else could. His claim to fame, however, was adapting the Bedson mill, which managed to make the processes of melting, shaping, and processing scrap metal into rods into one continuous system. In 1891, after his time at Washburn and Moen, Morgan went on to found his own company. Apart from the continuous rod mill, Morgan and his company continued to invent more practical tools and machines to further their dominance in the wire industry. Some of their inventions included the reel for coiling wire (1880), shears for cutting rods while in motion (1893), the morgoil bearing (1931), the no-twist mill (1963), and the Stelmor cooling system (1964). Through all of these inventions, the Morgan Company was able to stay relevant for more than a century.

Throughout the interview, Ms. Chisholm would remind the extent to which Charles Hill Morgan influenced the wire industry, which in turn went on to influence the rest of Worcester, and eventually the rest of the country. During his time at Washburn and Moen, the company had grown to the point where on the other side of the country, their steel wires and ropes were being used to build the Golden Gate Bridge. Morgan was so captivated by the Swedish machines and workforce that the company began recruiting workers from Sweden, creating direct ties to the Swedish immigration to Worcester. The industry Worcester was hosting at the time created a rapid increase of immigrants from other countries that around 25% of the population were foreign born. Ms. Chisholm stated that there is an argument that by importing Swedes, Worcester saw fewer numbers of Blacks migrating from the south. They had a much smaller population of blacks than other industrial cities. Thus creating a culture that Worcester was exclusively experiencing. During his time with Washburn and Moen, Morgan contributed to the foundation of the Worcester County Free Institute of Industrial Science, which later became Worcester Polytechnic Institute. He became the 12th trustee of the school, and since then a member of the Morgan family has been a part of the Board of Trustees. Even after Washburn and Moen was absorbed into American Steel, Worcester had not lost its influence in the wire industry. The Morgan Company flourished for another 5 generations in Worcester as the Morgan family ran the company until 2008, when Siemens bought out the Morgan Company. Later in 2015 Siemens partnered with Mitsubishi to create Primetals Technologies, which is one of WPI's current partnered companies at Gateway. Without Charles Hill Morgan, Worcester would not have become the flourishing powerhouse of the steel and wire industry in the 19 and 20th centuries, which later evolved into the biotechnological manufacturers that are now thriving throughout the city.

3.5 Conclusions

What started as limited uses in clothing such as corsets, to occupying virtually every facet of modern technology, wire continues to link the components of devices today. From composing the circuitry of smartphones, to serving as the frames of modern eyeglasses, wire serves as a structural basis for many modern technologies.

As WHM seeks to revamp its exhibits with wire artifacts, they can do so in different mediums. Whether videos utilizing sounds and sights to convey an artifact's significance, or tablet game applications to test recall of artifact information, smart technology in the Industrial gallery must work alongside presented artifacts; the space should not be dominated by technology.

Any intersection of technology with updates to historical exhibits has its caveats. Smart tablets like iPad applications need special tailoring to the learning objectives of the museum to function, or risk becoming more of a variable in application. Moreover, smart technology, which function as computers, to fully engage audience members from being distracted by other, irrelevant applications on them, must have sufficiently engaging applications made by the museum or lock devices to presenting only artifacts. Otherwise, technology may hinder the museum's objective to increase visitor traffic and learning.

The industrial artifacts concerning wire history and other pieces of modern developments should be, literally, wired together through technological means or physical linkages of some kind. Indeed, as Dr. Heilman described, the interactivity and accommodation of smart technology for a universal design inside a museum may positively increase visitor attention. However, more technical applications, like beacon technology, mandates adequate space to function, which may prove too large for the Fuller Gallery space.

To illustrate the widespread significance of wire, showcasing familiar, popular applications of it is required. The diner knife or Golden Gate Bridge, the former a common implement seen on many dining tables and the latter a popular US tourist spot, are only two examples.

However, to understand the progression to modern applications of Worcester wire necessitates a survey of wire development history and its impact on the urban development of Worcester. For example, Ichabod Washburn donated Washburn and Moen District Works stock to the city of Worcester to develop Memorial Hospital. Then with Morgan donating his namesake company stock funded the construction of the Worcester County Free Institute of Industrial Science, which later became Worcester Polytechnic Institute in 1865. Besides being a benefactor, Morgan's numerous wire patents and development (e.g., modifying the Bedson Mill and making the morgoil bearing) drove the diversification of wire products made in Worcester, developing Worcester's industrial image further.

CHAPTER 4: THE MORGAN CONSTRUCTION COMPANY

While wire manufacturing was monopolized by Washburn and Moen, there was still an unfilled void in the broader steel manufacturing business. Fortunately the economic rise that Worcester experienced from the wire production company attracted many other businesses. Ichabod Washburn allowed his employees to pursue what they thought would improve their company. Charles Hill Morgan, an employee under Washburn, was given even greater freedom in learning about the machines that produced the rods which would then be drawn into wire. This apprenticeship-like relationship is what continued the Golden Age for Worcester past the 19th century. Allowing employees to learn other trades that are involved in their work created a cycle of innovators that will either directly improve the company they were employed by, or go on to develop their ideas in other companies within Worcester.

4.1 Founder Charles Hill Morgan

4.1.1 Life

Charles Hill Morgan was born on January 8, 1831 in Rochester, New York. His father, Hiram Morgan, was a skilled mechanic who taught Charles at the young age of 12 years old. By the time Charles turned 15, he became an apprentice under his uncle at the Clinton Mill in Clinton, MA. Although he was around metal machines while he grew up, he also developed other skills. When he was 17 he learned machine drawing from the civil engineer of the mill, and by the age of 21 he was placed in charge of the dye house. His skill at machine drawing took him to the Lawrence Machine Company, where he would remain for 5 more years. His creativity and innovative mind lead to him starting his own paper bag company alongside his brother Francis during their short time living in Philadelphia. In 1860 his tenure at Washburn and Moen Wire

Works began. After some time he became a superintendent in the factory, until receiving a promotion to the general superintendent of the company. Although Charles H. Morgan was not educated in an university, his extended time as an apprentice and a worker in the steel manufacturing business taught him plenty about the machines, as well as their shortcomings. His time at the Washburn and Moen Wire Works came with many visits to European facilities. Mainly in England and Sweden, Morgan learned about their varied processes that would eventually inspire him to create his own patents. He died in January 10th, 1911 in Worcester, MA and left his company in the hands of Paul B. Morgan.

4.1.2 Key Patents

Charles Hill Morgan's time with the Washburn and Moen Wire Works marked the creation of his two of his most famous patented inventions, as well as a rumored invention that could have granted him credit for the invention of the modern elevator. His first invention, in 1878, was the continuous rod mill, which incorporated a mechanism which would transfer the glowing hot steel rods from mill to mill, without the assistance of a worker. This made the downsizing of the rods easier and safer for the factory workers. According to theelevatormuseum.org, "in 1878 Charles Hill Morgan patented a direct-action hydraulic elevator and installed the first such type in the Washburn & Moen Wire Works in Worcester, Massachusetts." Although the idea of an elevator has been around since Archimedes created a primitive one in 236 B.C., the hydraulic system that Charles Morgan designed revolutionized the concept with a new mechanism. Even though Morgan was not directly involved in the manufacturing of elevators, his ability to find a way to improve a machine in any way possible is a testament to his ingenuity. Morgan's last major patent was shared by Victor Edwards, an employee of the company. Patented in 1893, the flying shears contained sharp metallic blades that would cut the hot steel as it was moving through the assembly of machines.

Other major patents that belonged to the Morgan Construction Company were developed after Charles Hill Morgan's death, but impacted the steel industry just as strongly as his inventions had. The Morgoil bearing was patented in 1931, and, since its creation, has been the most durable and best performing load-carrying bearing worldwide. The bearing has been improved over its existence and is still being used today by many companies, including a successor to the Morgan Company, Primetals.

The next invention was patented in 1963, the no-twist mill. This mill is boasted to be one of the fastest and most efficient mills in the market at the time. After years of improvement, Primetals has demonstrated it to be able to operate at speeds up to 120 m/s, while producing at a rate of more than 150 tons of wire/hr. lastly, the Stelmor Cooling System was patented in 1964. This cooling system has become one of the most versatile, reliable, and effective controlled cooling conveyors used today. Although Morgan and his family were known for their innovations in the steel industry, their influenced extended to the city of Worcester.

4.1.3 Philanthropy & Family

Although Charles Morgan was not formally educated at any institution, he strongly believed in the power of a higher education. He was an early investor and eventual trustee of the Worcester County Free Institute of Industrial Science, which later was renamed to Worcester Polytechnic Institute. Since its creation in 1865, Charles Morgan was an appointed trustee, and he served his time with the school until his death in 1911. Although there was a short time where a member of the Morgan family was not in the board of trustees, there have been 5 generations that have served on the board. Phillip R. Morgan currently serves as a trustee. Charles Hill Morgan wanted his family and descendants to continue to support the school, by, for example, providing financial support for the Morgan-Worcester Distinguished Instructorship, scholarships for mechanical engineering faculty, and a couple projects, such as the Morgan Hall residence and the renovation of the Washburn Shops. Descendants of Charles Morgan have also donated a $2.1 million endowment, which aided the construction of Morgan Center for Teaching and Learning, located in the Gordon Library. Although the majority of the Morgan's philanthropy has gone towards WPI, they have also, over the years, donated money in order to improve the city of Worcester.

Since Charles Morgan had located his company, and its success, in Worcester, it was logical that his family lived in the city. His son, Paul, attended Worcester County Free Institute of Industrial Science, and worked alongside his father at their family company, until he was promoted to president. From its creation until it was sold, a member of Charles' family ran the company, sustaining the industrial and philanthropic vision that he was most famous for.

After his time as president of the company, Charles Hill Morgan left the company in the hands of Paul B. Morgan. He ran the company from 1911 to 1941, then was succeeded by Phillip M. Morgan to lead the industry from 1941 to 1965. The final two members of the Morgan family who were presidents of the company were Paul S. Morgan and Phillip R. Morgan. They were in power from 19665 to 1968 then from 1968 to their eventual deal with Siemens in 2011 respectively. Although many people involved with the company were not expecting them to sell the company, there were still many supported it, even though it was no longer a family business. However the excellence expected from the presidents of the company was not lost with the new directive they took under Siemens. Even after going public, the company continues to thrive as it did during the past two centuries.

4.2 Morgan Construction Company

4.2.1 Beginnings and Domestic Sales

After being established in 1888 by Charles H. Morgan, the Morgan Construction Company had a bright future ahead of it. They were first contracted by the American Steel and Wire Company in Cleveland, OH, where they built a continuous rod mill. As mentioned previously, the continuous rod mill was Charles Morgan's claim to fame, and it became his company's most widely made mill type across the world. One of their most well-known facilities that they set up was for the Ford Company in the River Rouge. This facility went on to be Ford's most used manufacturing location for years to come, as well as the biggest factory in the world. During both World Wars the facility was used by the US government for military production of tanks, planes, and weapons. Other major, still active, companies that the Morgan Company provided mills for are American Steel and Wire and US Steel. US Steel was the successor to Carnegie Steel, which made the majority of steel products for the US in the 20th century, owned by Andrew Carnegie, one of the first millionaires in American history. During the 20th century, Morgan Company also produced mills for many of the top steel companies that are still active to this day. Over their entire time running, the company provided 218 mills and serviced said mills whenever necessary. This was roughly 36.6% of their total sales. Providing mills to domestic companies was always their number one priority, but like all good businesses they had to expand outside of their own country.

4.2.2 European and Latin American Expansion

While Morgan was still working for the Washburn and Moen Company, he created many connections with steel companies across Europe. Throughout the company's early years, a large part of their work was sent to European countries such as West Germany, the UK, Netherlands, Belgium, France, etc. Some of the largest companies that they we contracted with were S.A. Cockerill in Belgium, Richard Johnson & Nephew in the UK, and Huttenwek Rheinhausen in West Germany. Their reach in Latin American extended from Mexico to Argentina. A couple of the companies that they worked with were Altos Hornos de Mexico and Tamet in Argentina. Their 123 year long run also provided 190 mills to their European and Latin American buyers. Although their first European contract with Guest, Keen & CO. was in 1899, they began frequently selling to European companies in 1919.

Their first contract with the Argentinian company Soc. Mixta Siderurgica in 1957 marked their growth into the Southern American countries. Until the time that they were sold, 31.9% of their customers were from both European and Latin American origin. Their expansion into European and Latin American industries was a massive milestone since it began, creating a worldwide reputation for the company that would experience growth into Asian, African, and Oceanic industries.

4.2.3 Growth into the Rest of the world

It did not take long for Morgan's reputation to be regarded highly worldwide, and even the largest steel companies paid to have Morgan Construction build mills for them. The list of the most successful steel companies, which are still dominating the steel industry to this day, include Baosteel and Jiangsu Shagang Group Co. in China, POSCO in South Korea, TATA I&S

Co. in India, and Nippon in Japan. Their sales extended to 40 different countries because of the high quality of mills they produced, as well as their unrivaled customer service for when their mills, used overtime, malfunctioned.

Starting to provide mills to Oceania in 1915, they quickly spread into India in 1917. Although their reach into Asia and Oceania was rapid, it wasn't until 1968 that they sold to African industries. However Morgan Construction did not sell frequently to Asian countries, besides Japan, until after the altercations from the Cold War. It also wasn't until 1999 that they began selling to the People's Republic of China, to which they sold 47 mills. This large number of mills actually helped China progress rapidly and is now a cause of the new tariff placed on imported Chinese steel. Because of the massive scale of their influence globally, they were able to provide 31.4% of their mills to Asian, African and Oceanic countries, maintaining their business for more than a century.

4.3 Future of the Morgan Construction Company

In 2008, Philip Morgan, great-great-grandson of Charles Morgan, decided to sell the Morgan Construction Company to the Austrian powerhouse Siemens AG. Philip Morgan claims that he sold the company in order to expand, not because they were going under and need to be bailed out. The company in 2008 had 1,100 employees worldwide, with 460 in Worcester, and was making $180 million in annual sales. So when Morgan chose to sell the company, it came to a surprise to some. Rolf Kuhn, controller of Nucor Connecticut in Wallingford, Conn., although initially amazed at the news, stated that it was simply a sign of the changing times where larger companies are buying smaller companies in order to stay relevant in their business. In the agreement, Siemens AG gained the rights to roughly 650 patents, all developed since the birth of the company. Although it was under new management, Morgan Construction has not left Worcester, due to their ability to innovate and improve their work. In 2012, Siemens decided to lease a section of Gateway Park, located near and inhabited by WPI and their workforce. Alongside the new "Morgan Construction" is Primetals Technologies, a cooperation between Siemens and Mitsubishi. The new company, Primetals, strives to continue Morgan's work by pioneering production methods in order to facilitate progress in the metals industry. Although their main focus remains here in the United States, they have been contracted by the same global industries that the Morgan Company was so invested in helping.

4.4 Incorporation in an Exhibit

The WPI archives contains many collections that include pictures, films, and a massive variety of documents. One such document included the list of all of the mills the company had made for other facilities, which included roughly 600 entries. (3, 97, 39-41 Morgan Archives) With the guidance of this data sheet, the massive scale that the Morgan Construction Company reached could be portrayed through a map that could be incorporated into the exhibit. Within the map could be the locations of the companies that hired the Morgan Company, pointed out by pins with different characteristics. The pin's color could represent the type of mill that was made for the company, and the size of the pin could also represent the amount of mills made for said companies. By having a time lapse during the map's portrayal, the expansion of the company's progress would be easily captured.

This could be accomplished with a computer program, which could be implanted into tablets located around the exhibit. This same type of program could be used for other sections of

Worcester's history outside of the 19^{th} to 21^{st} centuries. A spreadsheet compiled from this list can be found in appendix A.

Since the influence of the Morgan Company has not yet disappeared, visual representations of the biggest companies that contain Morgan Mills should be displayed. Whether this is done through a list of the companies or even simply through their logos, it should be a priority. The quality of their mills was so impactful that it can easily represent the still present resilience of the city of Worcester. Many historically active companies, such as Ford and Carnegie Steel, owe some of their successes to the Morgan Company, and it should be proudly displayed. The majority of domestic and exported mills were documented in the Morgan memorabilia within the WPI Archives. Two photo books were kept containing machines that were either just coming off the assembly line, or already set up in their destined factories. Many pictures of the mills also contained life-size comparisons of the mills next to the Morgan factory workers. (2, 212, 587 Morgan Archives) Alongside this should be the equipment and steel products used and produced by the steelworkers of both the Morgan Company and the Washburn and Moen District Works. Tying the progress of the companies with the evolving power of the United States as an industrialized nation should portray the significance Worcester's golden manufacturing era.

The photographs contained in the archives displaying the development of the Morgan Construction Company could be used as an expansion to the map. The pictures of the mills that were sent to the national and global companies could be presented after selecting them from the pins that locate each company. Such models can be found in the archives in massive photo albums that contain pictures of only the machines, size comparisons of the machines with workers, and even the finalized assembly of the mills in their destined factories. Similarly, the blueprints, photographs, and test videos of the weapons that the Morgan Company was assigned to create for the US government could be portrayed. Unique designs for incendiary weapons were produced and tested by the company during WWII, though it is unknown if the weapons were ever mass-produced and utilized in the battlefields of the 1940's. (4, 137, 351-365 Morgan Archives) But this could display the wide variety of production lines that the company's facilities could be modified to pursue.

Another part of the archives contains artifacts that were used in the company facilities. These artifacts can show the museumgoers what it was like to be a part of the company. There are Blue Glass furnace goggles that became standard during Charles Morgan's presidency, which could be used to show the progress that technology has offered, apart from the mill improvements.

Another artifact, which is a part of the current exhibit, is the sample of the fly shears, which are still in use in many steel companies. This demonstration can further symbolize the everlasting success that the Morgan Company had created, since this piece of machinery is still prevalent in today's world. The final section of the archives that could be implemented into an exhibit is the film part. This contains 70 mm film of machine testing and development as well as finished products. These movies could be transferred onto DVD and then even backed up into a server where they could be accessed for the exhibit. If these films are paired with more modern films of the same type of equipment, then the evolution of these machines can be juxtaposed.

Finally, the presence of the company Primetals Technologies should be presented to signify the change Worcester has undergone to flourish as it had in the Industrial Era. The patents, Morgoil and Stelmor, that Primetals owns could be displayed in order to show Worcester's current industrial innovations. Many other tech and biotech companies, such as Blue Sky Bioservices and Yurogen Biosystems, have begun to sprout throughout the city in an attempt to bring in more business. The steel industry might have evolved past Worcester, but the city still has emerging businesses. With the biotech industry, Worcester has a chance to put itself back on top, just like the Morgan Company had done for the city. Therefore a section that shows the city's progress throughout the century should include an optimistic message for its museumgoers by praising and displaying its current companies and their success.

4.5 Conclusion

Overall the genius that was Charles Hill Morgan changed the steel industries in ways that were unimaginable at the time. While many other companies tried to succeed in the same business, it was the Morgan Construction Company that monopolized the smaller, yet broader, mill production industry for over a century. His leadership and ingenuity was beyond legendary, and transcended his lifetime into the present. Many innovators and companies strived to compete with him and his company, and few succeeded, one of them being Kinefac. His ability to innovate was not his only accomplishment, his family and donations helped shape Worcester into what it is today.

Not only Worcester, but WPI also owes its inception to the Morgan family, and hopefully such a relationship between the two will last many more generations. The impact that the construction company had worldwide was so intense that even today, many factories are still using their mills, and even are reaching out to Siemens and Primetals for equipment. All of this can be encapsulated with simple museum techniques, and the information and artifacts can all be found in the WPI archives. Appendix 2 contains the specific boxes and folders that were used during the research for this chapter.

CHAPTER 5: KINEFAC

5.1 Introduction

Kinefac, founded by Howard Greis and his wife Virginia Peyton Greis in 1962, has carried Worcester's wire and wire machine manufacturing legacy into the 21th century. A serial entrepreneur when he arrived in the Worcester area, Greis started with the goal of producing the best rolling machines. He built his first machine and launched Kinefac after consulting with firms that rolled metals what they most sought in a new machine. Drawing upon the wishes of those who would purchase his special purpose machines, he eventually created a new design that earned him a patent for its originality. This careful attention to his client's needs and his willingness to customize systems to their specifications established Greis's national and then international reputation as the leading expert on metal rolling machines. His knack for innovation has guided Kinefac through tumultuous times for the American machine tool industry, growing while other firms in Worcester and across the country folded. From 1982 to 1987, Kinefac expanded, while across the country the machine tool industry lost 44,000 manufacturing jobs. In 1988, the company recorded sales of $8 million, a 30 percent increase above it previous highest earning year. In the next two decades, Kinefac expanded beyond metal rolling to wire coiling and centrifugals, carrying on work in fields that earlier Worcester firms had pioneered in the nineteenth and early twentieth centuries.

Howard Greis and Kinefac brings Worcester's wire history to the present. From the monumental to the miniscule, items crafted by his machines drive automobiles, form structural building skeletons, and save lives. Form the frame of I.M. Pei's Louvre Pyramid in Paris to the microscopic coils to treat aneurysms. Although much diminished from its dominant position in the diversified landscape of Worcester industry during the era of Washburn and Moen, Morgan Construction Company and numerous smaller firms, innovation in wire coiling, metal rolling, metal forming machinery persist at Kinefac's headquarters near the Worcester Airport on Goddard Memorial Drive. As the Fuller Gallery of Worcester's Industry History ponders the city recent past and its future, curators and designers would do well to incorporate Howard Greis as an innovator on par with Ichabod Washburn and Charles Hill Morgan as well as Kinefac as a anchoring firm in the city's industrial landscape.

5.2 Howard Greis, Innovator

Howard Greis traveled a circuitous path to Worcester through Brooklyn, New York; Providence, Rhode Island; Notre Dame, Indiana; Washington, DC; Cambridge Massachusetts; and Bloomfield, New Jersey. Born in Brooklyn, Greis entered the Navy V-12 program at Brown University before moving to midshipmen's school at Notre Dame University. Graduating first in his class of midshipmen, he served in the Naval Ordnance Lab, where his passion for innovation was nurtured developing rocket fuses.

At the end of the war, he returned to Brown University, graduating *magna cum laude* in 1948. A mechanical engineering major there, he was elected into the engineering honor societies of Tau Beta Pi and Sigma Xi. More importantly during his time at Brown Greis met Virginia Peyton Chivers, who he would later married and launch his businesses with. Within a year, Harvard University awarded him a master's degree in mechanical engineering in 1949.

A certain restlessness characterized Greis's early career. In 1949, he started work with the International Project Corporation of Bloomfield, New Jersey, but he soon launched his own consultancy, HAG & Associates, and, in 1955, a business, Control Molding Corporation. His reputation and curiosity lead him to opportunities across a range of industries. It was Reed Rolled Thread Die Company of Holden, Massachusetts, however, that brought Greis to the Worcester area. Once in the area, he stayed, settling in Holden and established Worcester's Kinefac Corporation with his wife, Virginia Peyton Chivers Greis, in 1962.

With the rise of Kinefac as a leading metalworking firm, Greis's reputation secured him a place in national conversations about American manufacturing and competitiveness. He testified before Congress and served on national commissions, including the Industry Advisory Committee to the United States Department of Energy's National Machine Tool Builders Partnership and the Government Relations Committee of the Association for Manufacturing Technology. In addition, he established a National Center for Manufacturing Science in Ann Arbor, MI and served as its first chairman.

5.3 Kine-Coil

Kine-Coil finds its roots with the Morgan Spring Company. Before the formation of Morgan Construction Company, Francis Henry Morgan and his brother, Charles Hill Morgan, founded Morgan Spring Company, which produced oil tempered wire spiral and flat springs of all sizes. As the business continued to grow, Morgan recruited Frank Henry Sleeper to join the company.

Sleeper was born in Quebec, Canada and established himself as a very successful manufacturer of special purpose machines, producing according to one account 375 machines "invented, designed, and built" by himself (Nutt, 645). Arriving in Worcester in 1907, he continued as an engineer with Morgan Spring Company for four years until October 1911 when he launched his own business. Independently employed he invented and designed a new range of special purpose automatic coiling machines.

As Sleeper's business grew, he drew upon the talents of another Canadian who had migrated to Worcester by way of New York City. Although born in Kings County, Ireland, George Downing Hartley started work as a mechanical draftsman in Montreal before taking up the study of patent law. He arrived in New York to apply himself as a patent attorney for a few years, before removing to Worcester to aid Sleeper. Worcester historian Charles Nutt, who knew both men, wrote that "each fully appreciate[ed] the talents and worth of the other, and they quickly decided upon a plan" for a new firm Sleeper and Hartley.

Although Hartley would eventually depart from the company, Sleeper carried on the business under the same name and greatly expanded its line of patented machines until his death. Describing themselves as "designers and builders of automatic wire-working machines and wire mill equipment," Sleeper & Hartley advertised a large range of specialty machine tools to coil wire. According to one January 1932 catalog in the collection of the Worcester Historical Museum, the company listed the following machines for sale:

Universal Spring Coiling Machines

Spring Hooking Machines

Torsion Spring Machines

Bed Helical Machines

Upholstery Spring Machinery

Flexible tube coiling machines

Bearing spiral machines

Spring Setting machines

Music wire straightening and bundling machines

Light rolling mill equipment

Lock washer machines

Wire nail equipment

Wire and flate strip reels

By 1933 they were also advertising new armoring machines for wires, cables, and hose for flexible metallic conduit. With such a range of products, Sleeper & Hartley earned their moniker for putting "the 'rings' in springs." (Sleeper & Hartley, Inc. General Bulletin, June 1932).

As other Worcester machine shops were slowing or closing down in the 1960s, Sleeper & Hartley continued to patent and sell new machines, just as Worcester's new company, Kinefac, was doing after being founded in 1962. In the 1940s, Frank and Dick Russell, grandsons of Frank H. Sleeper, began operating the company, eventually gaining full control of it in 1973. Frank Russell carried within him the same innovative spirit that drove his grandfather, using his engineering talent to turn around a company that had stagnated through the 1950s. Working with Elmer Halvorsen, chief engineer at the company, Frank patented the Duplex Wire Working Machine to make torsion springs around a moving spindle (Telegram Gazette, 10/2/64). The machine was able to form wire on both horizontal and vertical planes and in more precise diameters. Between 1966, the first year of its production, until 1996, they sold 550 duplex wire working machines for a revenue of approximately $19 million (Sleeper & Hartley Finding Aid).

Building upon this success Frank Russell developed and patented an improved high speed spring coiling machine in 1983. This innovation rested upon the use of non-circular gears to create a variable speed and permit higher speed operations. This machine operated at 2 and a half times the speed of previous coilers (Telegram Gazette, 2/15/83). With a patent controlling their interest in the design, the company generated considerable revenue and expanded their share of the coiling market, which was larger than the torsion spring market at the time. After acquiring Sleeper & Hartley, Kinefac continued to produce and sell these machines.

Frank Russell curiosity also drew him toward computer-controlled equipment as early as the middle 1980s. By 1989, he and Tim Hallihan, a software developer, patented the first computer-controlled coiling machine in the United States. Easy to operate and quick to set up, this improvement appealed to small shops who wanted to reset the machine. It also saved time in training and reduced the skill of operators, as the computer took over some of the work. The great cost of developing these computer numerical control (CNC) coilers, however, also led Russell to sell his grandfather's company to Kinefac on February 15, 1991. He recognized that the cost of developing and improving CNC coilers were greater than his firm could manage. In November 1990, Sleeper & Hartley closed its factory at 335 Chandler Street and auctioned off its equipment after 80 years in business, displacing its 25 employees (Telegram Gazette, 11/17/1990).

In acquiring Sleeper & Hartley in 1991, Kinefac ensure that Worcester's history of specialty wire manufacturing machines continued in the 21th century. Under Greis's guidance, the company improved upon and refined systems for CNC coiling machines. Within a decade he guided the Kine-Coil division toward building machines to spin smaller coils. Eventually launching a line of microcoiler systems in 2001. Presently, Kinefac builds the CNC Four Axes Micro-Coiler machines that produce coils for medical, electronic and miniature device applications. These machines can manufacture a range of products "from simple close wound coils to coils that have combinations of characteristics such as variable pitch, diameter and stiffness." Further the machines appeal to clients because their output requires no secondary processing and are capable of working with round, flat or shaped wire (mircocoiler.com, nd).

5.4 Kine-Spin

Kinefac came to acquire another standard bearer of Worcester's industrial history in 2004, when its purchased Barrett Centrifugals, Incorporated. This expanded the company's reach into new and existing markets for fluid reclamation, chip cleaning, and parts washing and drying. Although not the most exciting or awe-inspiring line of products, Kine-Spin aids its clients avoid costly disposal cost for many industrial liquids.

Kine-Spin technology has its roots in the hills of Springfield, Vermont, where George Curtis invented a centrifugal oil extractor (also referred to as a Chip Wringer) in 1848 to recapture lubricating oil used in the operation of his automatic screwing machine. Curtis acquired a patent and set up manufacturing extractors in his barn, before moving operations to a new shop in Brattleboro, Vermont in 1851. One of his sons moved the company to Worcester, where he would be closer to many of the machine tool firms purchasing extractors. There the firm operated under various names, until 1925 when Leon J. Barrett purchased the firm, then called Curtis Machine Company.

Curtis's early chip wringer was relatively simple, since it operated by a countershaft from a rotating axle, drawing power from a water mill or steam engine. The wringer included a solid metal pan for holding oil-saturated metal chips that was secured to a rotating spindle to produce centrifugal action, drawing the oil into a catch basin. Although simple in design, its results were impressive, drawing off 98% of the residual oil with two minutes of spinning. Compared with 30% oil recovery from gravity drain over 24 hours, the saving in oil and time made investment in extractors a wise move for tool, screw, and dye manufacturers.

Leon Barrett accelerated improvements to the Curtis extractor by adopting electricity as a power source and adding features to produce an entire line of industrial centrifuges. In addition to a direct drive motor, Barrett incorporated gyroscopic balancing and breaking systems to expand his product range into washer, dryers, chip washers, galvanizers, tinners, and enamelers. By 1936 after a period of expansion into new lines of business, he changed the name of the corporation to The Leon J. Barrett Co, which was later renamed Barrett Centrifugals, Incorporated.

Barretts improvements to the centrifuges continued into the 1960s. The Clarifuge or liquid/solid separator was developed to meet the need of grinding applications where it was essential to keep grinder oils and coolants clear of suspended solids. Later, Barrett introduced its Liquifuges or liquid/liquid separators to decant liquids of two different specific gravities, such as coolant and tramp oil.

When Curtis invented the centrifuge oil extractor the interest was in recovering expensive oil for reuse. By the time Leon Barrett expanded the product range and Kinefac acquired Barrett Centrifugals, the interest had shifted to environmental concerns of industrial fluid control and disposal. As legislation and regulation push companies to deal with oils, coolants and industrial fluids in a more environmentally sensitive manner, the reclamation, reconditioning, reuse and recycling that centrifuges make possible becomes more essential. Kine-Spin finds itself well positioned to meet these new industrial demands at the time its product line complements other Kinefac metal forming machines.

CHAPTER 6: FINDINGS AND RECOMMENDATIONS

Museums, in order to increase visitor flow and educational retention rates, must digitize and keep up with the modern times. But as Jahnke and Kumar discussed, tablets can create a distraction away from the presented information. Moore's Law statistically supports the need for a technological upgrade. Although computers have provided more powerful processes that allow programs to be used in an educational way, the average visitor might want to avoid the technology that educates and settle for mindless entertainment. Thus, the designers for the exhibit must prevent themselves from trying to only entertain their guests since it will impede retention of information. The new design should promote interactive education through new technological themes. Deep learning is essential both in museums and schools, so technology must promote it through highly interactive and reflective programs and activities. Thus, a recommendation is to implement technology not only in-gallery but also in school learning modules and curriculums.

Countless technological designs are available to the general public, so implementing them in exhibits can aid the museum staff, as well as the guests. Adaptive databases can store virtually limitless information with the correct systems, so displaying the historical data and artifacts through it permits the addition of further information in an even smaller amount of space than the older exhibit. Another benefit would be the lack of compromise within a space since much more can fit in tablets rather than multiple life size displays. However, this does not alienate physical artifacts, since they still provide a visual stimulation that is harder to portray through tablets and sometimes cannot replace the physical touching of artifacts. An app that can categorize museum artifacts provides greater accessibility, while allowing a chance for guests to explore with their own learning styles.

Technology also allows the museum to create assessments that would provide feedback on the exhibit's successes or failures, which could also be used to monitor if the guests have retained information. Visitor traffic can be influenced through the use of digitization, displaying the corresponding items of the exhibit from the entire museum collection virtually.

The history of Worcester's Wire Industry offers a compelling place to initiate the incorporation of digital museum technology. Wire's humble beginnings as clothing frames has evolved to being a component of seemingly every technological item. Its widespread use has impacted everything from simple hangers to more complicated headphones, becoming the most utilized form of metal in everyday life. In its renovations, WHM can access multiple different programs that can draw in guests. Animation and videos of machine processes can be used to present information, but technology should not be the only thing present within the exhibit.

Obvious limits should be placed for the technology that will be implemented since unnecessary applications can highly disrupt the visitor's attention towards the historical information. Forcing the tablets to only show the exhibit artifacts and data will prevent guests from deviating from the purpose of the exhibit. Another idea would be to allow the tablets to access different programs that promote learning from the displays; one program could run videos that teach through minor lectures, while another program could provide slideshows that require reading minor paragraphs.

Wiring together the wire and steel industries' artifacts would finally display the development of the city through the success of its biggest companies. A progression of the industries could be intertwined through technological or physical means. However such technological methods should not take priority over the rest of the relics and their description.

To fully understand the development of the modernized wire industry, the progression should be displayed through the Washburn and Moen Wire Works' impact and success within the city, as well as throughout the country. One new major display could be the wire that was distributed to the builders of the Golden Gate Bridge.

Additionally, the wire company was not the only company that had major success in Worcester. The Morgan Construction Company should be portrayed as the successor of the Wire Works, while giving Ichabod Washburn credit for grooming Charles Hill Morgan. Charles Morgan's legacy can be tapped into for his ingenuity, philanthropy, leadership and his family's continuation of his successes. The Morgan Construction Company and its progress throughout the world should be easily portrayed through an interactive map that allows you to expand the pins into informational facts about the mills and the factories they attended. Another method would be the typical artifact display; however, a tablet could describe the item in depth and tie it into the story of how the Wire Works was the start for Morgan's success and the later production of the Morgan Construction Company.

Finally, Howard Greis, George Hartley, Henry Sleeper, Leon Barrett, and George Curtis continued the path of endless novelty. By focusing on their biggest talents, each innovator contributed greatly to the success of their incubators before branching out to other companies, or starting their own. In their own ways they all helped Kinefac bring past industrial success to the present.

Howard Greis, after a long journey of city hopping and years of higher education, he went on to make a name of himself in Worcester through his innovative ideas. From working with rocket fuses in the Navy, to improving mills, and eventually working under national committees, Greis was able to help improve all of these fields, without running out of ideas or passion. His ability to greatly benefit any industry he worked in pushed him to found Kinefac in 1962. Kinefac has since been extremely successful by acquiring companies such as Sleeper Hartley and Barrett Centrifugals and broadening their expertise and sales into existing markets such as rolling, extrusion, and center drive turning. With the help of Sleeper, Hartley, Barrett, and Curtis, the Kine-Coil and Kine-Spin patents were created, but Kinefac over the years have improved on them immensely. Although not all four of the innovators worked together at the same time, Sleeper Hartley and Barrett Centrifugals were massive successes during their time as independent companies. The absorption into Kinefac propelled these inventions into sales that were unimaginable to their founders. Kinefac continued the industrial golden age that the Morgan Construction Company and the Washburn and Moen Wire Works had created in the 1800's. To this day Kinefac alongside Primetals thrive in Worcester, maintaining the legacy left behind by the great innovators of the Industrial Age.

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APPENDICES

Appendix A: Morgan and Smienes' Domestic, European and Latin American, Asian, African, and Oceanic Sales from 1888 to 2011. Link directs to the full mills spreadsheet provided by the WPI Archives.

Appendix B: The selected Morgan Archives from the WPI Archives that were used in the document above.

History of Morgan Mill Construction 1888-2011

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
American Wire Co.	Cleveland, OH	Rod Mill	1888		
J & L Steel Co.	Pittsburgh, PA	Billet Mill	1892		
Oliver Iron/Steel Co.	Pittsburgh, PA	Merchant Mill	1892		
J & L Steel Co.	Pittsburgh, PA	Merchant Mill	1893		
American Steel Hoop Co.	Youngstown, OH	Hoop/Tie Mill	1894		
Aetna Standard I & S Co.	Mingo Jct., OH	Merchant Mill	1895		
Carnegie Steel Co.	Dusquesne, PA	Billet Mill	1897		
Illinois Steel Co.	Joliet, IL	Rod, Tie, Spike Rod Mill	1897		
J & L Steel Co.	Pittsburgh, PA	Merchant Mill	1898		
J & L Steel Co.	Pittsburgh, PA	Merchant Mill	1898		
Grand Crossing Tack Co.	Chicago, IL	Rod Mill	1899		
Guest, Keen & Co.	ENGLAND	Roughing Mill	1899		
Carnegie Steel Co.	Dusquesne, PA	Merchant Mill	1900		
Carnegie Steel Co.	Dusquesne, PA	Merchant Mill	1900		
Carnegie Steel Co.	Dusquesne, PA	Billet Mill	1900		
National Steel Co.	Youngstown, OH	Billet Mill	1900		
Sharon Steel Co.	Sharon, PA	Billet Mill	1901		
Sharon Steel Co.	Sharon, PA	Rod Mill	1901		
Sharon Steel Co.	Sharon, PA	Rod Mill	1901		
Wickwire Brothers	Cortland, NY	Rod Mill	1901		
Grand Crossing Tack Co.	Chicago, IL	Steel Works & Billet Mill	1901		
Illinois Steel Co.	Milwaukee, WS	Roughing Mill	1901		
Deering Harvester Co.	Chicago, IL	Merchant Mill	1902		
Republic I & S Co.	Youngstown, OH	Roughing Mill	1902		
Republic I & S Co.	Youngstown, OH	Roughing Mill	1902		
Republic I & S Co.	Youngstown, OH	Roughing Mill	1902		
Republic I & S Co.	Moline, IL	Roughing Mill	1902		
Dominion I & S Co.	Sydney, NS	Rod Mill	1903		
Dominion I & S Co.	Sydney, NS	Billet Mill	1903		
J. Mouton	Paris, France	Rod Mill	1903		
Gewerkschft Deutscher Kaiser	Dinslaken, Germany	Hoop Mill	1903		
Rheinische Stahlwerke	Meiderich, Germany	Merchant Mill	1903		
Lackawanna Steel Co.	Buffalo, NY	Merchant Mill	1904		

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Sharon Steel Hoop Co.	Sharon, PA	Roughing Mill	1904		
Atlanta Steel Hoop Co.	Atlanta, GA	Bar, Hoop, Tie & Rod Mill	1904		
Youngstown Sheet & Tube	Youngstown, OH	Billet Mill	1905		
Youngstown Sheet & Tube	Youngstown, OH	Sheet Bar Mill	1905		
Morgan Spring Co.	Struthers, OH	Rod Mill	1905		
Georgs Marien Bergwerks &HV	Osnabruck, Germany	Merchant Mill	1905		
Youngstown Sheet & Tube	Youngstown, OH	Skelp Mill	1906		
International Harvester	Chicago, IL	Merchant Mill	1906		
Whitehead & Co.	Tredegar, England	Bar, Hoop, Tie & Rod Mill	1906		
Vereinigte, Koenig, Laurah.	Koenigshuette, Germany	Bar, Hoop, Tie & Rod Mill	1906		
Lackawanna Steel Co.	Buffalo, NY	Billet & Sheer Bar Mill	1906		
Soc. Anon d'Ougree-Marihaye	Ougree, Belgium	Rod Mill	1906		
Inland Steel Co.	Indiana Harbor, IN	Merchant Mill	1907		
Indiana Steel Co.	Gary, IN	Billet Mill	1907		
Indiana Steel Co.	Gary, IN	Billet Mill	1907		
Alpine Montan Gesellschaft	Vienna, Austria	Rod Mill	1907		
Pittsburgh Steel Co.	Monessen, PA	Billet Mill	1908		
Pittsburgh Steel Co.	Monessen, PA	Rod Mill	1908		
Cambria Steel Co.	Johnstown, PA	Billet & Sheer Bar Mill	1909		
Republic I & S Co.	Youngstown, OH	Skelp Mill	1909		
J & L Steel Co.	Aliquippa, PA	Rod Mill	1909		
Cambria Steel Co.	Johnstown, PA	Rod Mill	1909		
J & L Steel Co.	Aliquippa, PA	Billet Mill	1909		
J & L Steel Co.	Aliquippa, PA	Billet & Sheer Bar Mill	1909		
Republic I & S Co.	Youngstown, OH	Billet Mill	1910		
Republic I & S Co.	Youngstown, OH	Billet & Steel Bar Mill	1910		
Upson Nut Co.	Cleveland, OH	Merchant Mill	1910		
Dominion I & S Co.	Sydney, NS	Rod & Merchant Mill	1910		
Lackawanna Steel Co.	Buffalo, NY	Merchant Mill	1910		
Indiana Steel Co.	Gary, IN	Sheet Bar Mill	1911		
Republic I & S Co.	Youngstown, OH	Merchant Mill	1911		
J & L Steel Co.	Aliquippa, PA	Rod Mill	1911		
Steel Co. of Canada	Hamilton, Ont, Canada	Billet & Sheet Bar Mill	1912		
Steel Co. of Canada	Hamilton, Ont, Canada	Rod & Merchant Mill	1912		

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Atlanta Steel Co.	Atlanta, GA	Billet Mill	1912		
Pittsburgh Crucible Steel Co.	Midland, PA	Merchant Mill	1912		
Alton Steel Co.	Alton, IL	Roughing Mill	1913		
Bethlehem Steel Co.	Bethlehem, PA	Billet Mill	1913		
River Furnace Co.	Cleveland, OH	Billet Mill	1913		
River Furnace Co.	Cleveland, OH	Billet & Sheet Bar Mill	1913		
Sharon Steel Hoop Co.	Sharon, PA	Roughing Mill	1914		
Youngstown Sheet & Tube	Youngstown, OH	Merchant Mill	1915		
Youngstown Sheet & Tube	Youngstown, OH	Merchant Mill	1915		
United Steel Co.	Canton, OH	Merchant Mill	1915		
J & L Steel Co.	Aliquippa, PA	Skelp Mill	1915		
Bethlehem Steel Co.	Bethlehem, PA	Merchant Mill	1915		
Broken Hill Proprietary Co.	Newcastle, Australia	Rod Mill	1915		
United Steel Co.	Canton, OH	Billet & Sheet Bar Mill	1915		
Lackawanna Steel Co.	Buffalo, NY	Merchant Mill	1916		
Wickwire Steel Co.	Buffalo, NY	Rod Mill	1916		
J & L Steel Co.	Aliquippa, PA	Flat Mill	1916		
Mark Manufacturing Co.	Indiana Harbor, IN	Skelp Mill	1916		
Keystone Steel & Wire	Peoria, IL	Rod Mill	1916		
J & L Steel Co.	Pittsburgh, PA	Merchant Mill	1916		
Steel, Peech & Tozer, Ltd.	Rotherham, England	Billet Mill	1916		
Templeborough Rolling Mills	Rotherham, England	Rod Mill	1916		
Donner Steel Co.	Buffalo, NY	Billet Mill	1916		
Bethlehem Steel Co.	Sparrows point, MD	Billet Mill	1917		
Bethlehem Steel Co.	Sparrows point, MD	Billet & Sheet Bar Mill	1917		
Trumbull Steel Co.	Warren, OH	Billet & Sheet Bar Mill	1917		
Steel, Peech & Tozer, Ltd.	Sheffield, England	Billet Mill	1917		
TATA Iron & Steel Co.	Jamshedpur, India	Billet Mill	1917		
TATA Iron & Steel Co.	Jamshedpur, India	Billet & Sheet Bar Mill	1917		
TATA Iron & Steel Co.	Jamshedpur, India	Merchant Mill	1917		
Wickwire Steel Co.	Buffalo, NY	Billet Mill	1917		
Sharon Steel Hoop Co.	Sharon, PA	Sheet Bar & Slab Mill	1918		
Trumbull Steel Co.	Warren, OH	Billet Mill	1918		
Acme Steel Goods Co.	Chicago, IL	Hoop Mill	1918		

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Acieries de Firminy	Dunkerque, France	Merchant Mill	1919		
Weirton Steel Co.	Weirton, WV	Billet Mill	1919		
Weirton Steel Co.	Weirton, WV	Billet & Sheet Bar Mill	1919		
United Steel Co.	Sheffield, England	Merchant Mill	1919		
United Steel Co.	Sheffield, England	Strip Mill	1919		
Whitaker-Glessner Co.	Portsmouth, OH	Billet & Sheet Bar Mill	1919		
Trumbull Steel Co.	Warren, OH	Strip Mill	1919		
Interstate I & S Co.	Chicago, IL	Merchant Mill	1919		
Acieries de Longwy	Mont-StMatrin, France	Billet Mill	1919		
Acieries de Longwy	Mont-StMatrin, France	Billet & Sheet Bar Mill	1919		
Acieries de Longwy	Mont-StMatrin, France	Rod Mill	1919		
Whitehead I & S Co.	Tredegar, England	Hoop Mill	1919		
Homecourt, Forges & Acieries	Homecourt, France	Billet Mill	1919		
Homecourt, Forges & Acieries	Homecourt, France	Billet & Sheet Bar Mill	1919		
United Alloy Steel Corp.	Canton, OH	Merchant Mill	1920		
Kansas City B & N Co.	Kansas City, MO	Rough & Finish Mill	1920		
Denain & Anzin	Denain, France	Billet Mill	1920		
Denain & Anzin	Denain, France	Billet & Sheet Bar Mill	1920		
Broken Hill Proprietary Co.	Newcastle, Australia	Billet & Sheet Bar Mill	1920		
Whitaker-Glessner Co.	Portsmouth, OH	Rod Mill	1921		
Alfred Hickman, Ltd.	Bilston, England	Skelp Mill	1921		
Labelle Iron Works	Steubenville, OH	Sheet Bar Mill	1921		
Inland Steel Co.	Indiana Harbor, IN	Merchant Mill	1922		
Inland Steel Co.	Indiana Harbor, IN	Billet & Slab Mill	1922		
Ford Motor Co.	River Rouge, MI	Blooming Mill	1922		
Ford Motor Co.	River Rouge, MI	Billet Mill	1922		
Ford Motor Co.	River Rouge, MI	Merchant Mill	1922		
Soc.Anon d'Ougree-Marihaye	Ougree, Belgium	Merchant, Rod & Strip Mill	1923		
Republic I & S Co.	Youngstown, OH	Billet Mill	1923		
Republic I & S Co.	Youngstown, OH	Billet & Skelp Mill	1923		
Youngstown Sheet & Tube	Youngstown, OH	Billet Mill	1923		
Youngstown Sheet & Tube	Indiana Harbor, IN	Sheet, Bar & Skelp Mill	1923		
Soc. Anonyme de la Chiers	Longwy-Bas, France	Strip & Rod Mill	1924		
Bethlehem Steel Co.	Johnstown, PA	Merchant Mill	1924		

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Bethlehem Steel Co.	Sparrows point, MD	Rod Mill	1924		
Tennessee Coal, Iron & RR	Birmingham, AL	Billet & Sheet Bar Mill	1924		
McKinney Steel Co.	Cleveland, OH	Billet Roughing Mill	1924		
McKinney Steel Co.	Cleveland, OH	Sheet Bar Mill	1924		
McKinney Steel Co.	Cleveland, OH	Sheet Bar Mill	1924		
McKinney Steel Co.	Cleveland, OH	Merchant Mill	1924		
McKinney Steel Co.	Cleveland, OH	Merchant Mill	1924		
Ford Motor Co.	River Rouge, MI	Billet & Sheet Bar Mill	1925		
Ford Motor Co.	River Rouge, MI	Spring Mill	1925		
Inland Steel Co.	Indiana Harbor, IN	Billet & Sheet Bar Mill	1926		
American Steel & Wire	Worcester, MA	Billet Mill	1926		
American Steel & Wire	Worcester, MA	Rod Mill	1926		
Ford Motor Co.	River Rouge, MI	Merchant, Rod & Strip Mill	1926		
Bethlehem Steel Co.	Sparrows point, MD	Skelp Mill	1926		
Llanelly Steel Co. Ltd.	Llanelly, Wales	Sheet Bar Mill	1926		
American Steel & Wire	Cuyahoga, OH	Strip Mill	1927		
Interstate I & S Co.	Chicago, IL	Billet Mill	1927		
John A. Roebling's Sons	Trenton, NJ	Billet Mill	1927		
John A. Roebling's Sons	Trenton, NJ	Rod Mill	1927		
Sheffield Steel Co.	Kansas City, MO	Billet Mill	1928		
Sheffield Steel Co.	Kansas City, MO	Rod & Merchant Mill	1928		
Sharon Steel Hoop Co.	Sharon, PA	Strip Mill	1928		
Youngstown Sheet & Tube	Indiana Harbor, IN	Rod & Merchant Mill	1928		
Youngstown Sheet & Tube	Indiana Harbor, IN	Merchant Mill	1928		
Soc.Anon d'Ougree-Marihaye	Ougree, Belgium	Sheet Bar & Skelp Mill	1928		
Interstate I & S Co.	Chicago, IL	Rod & Merchant Mill	1929		
Youngstown Sheet & Tube	Indiana Harbor, IN	Billet & Slab Mill	1929		
Whitehead I & S Co.	Newport, Montmoushire,	Merchant Mill	1929		
Friedrich Krupp, AG	Rheinhaussen, Germany	Billet & Slab Mill	1929		
Friedrich Krupp, AG	Rheinhaussen, Germany	Billet & Sheet Bar Mill	1929		
Illinois Steel Co.	Chicago, IL	Merchant & Strip Mill	1930		
J & L Steel Co.	Pittsburgh, PA	Merchant Mill	1930		
Whitehead I & S Co.	Newport, Montmoushire,	Rod & Merchant Mill	1932		
Lancashire Steel Co.	Irlam, UK	Rod & Merchant Mill	1932		

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Broken Hill Proprietary Co.	Newcastle, Australia	Merchant, Skelp & Strip Mill	1932		
Guest, Keen, Nettlefolds Ltd.	Scunthorpe, UK	Rod & Merchant Mill	1934		
Biritsh (GK Baldwins) Ltd.	Cardiff, Wales	Billet & Sheet Bar Mill	1934		
Laclede Steel Co.	Alton, IL	Rod Finishing Mill	1935		
Stewarts & Lloyds, Ltd.	Corby, UK	Skelp Mill	1936		
Amtorg Trading Co.	Makeevka, Russia	Rod Mill	1936		
Guest, Keen, Nettlefolds Ltd.	Cardiff, Wales	Merchant & Strip Mill	1936		
Bethlehem Steel Co.	Sparrows point, MD	Rod & Merchant Mill	1936		
Australian I & S Co.	Port Kembla, Australia	Billet & Sheet Bar Mill	1936		
Australian I & S Co.	Port Kembla, Australia	Merchant, Rod & Strip Mill	1937		
New Jarrow Steel Co.	Jarrow, Durham, UK	Merchant & Strip Mill	1938		
Bethlehem Steel Co.	Sparrows point, MD	Rod Finishing Mill	1939		
Youngstown Sheet & Tube	Youngstown, OH	Billet & Slab Mill	1940		
Sheffield Steel Co.	Houston, TX	Rod & Merchant Mill	1941		
Columbia Steel Co.	Pittsburgh, PA	Rod Mill	1941		
Aluminum Co. of America	Massena, NY	Rod & Merchant Mill	1941		
Bethlehem Steel Co.	Lackwanna, NY	Merchant Mill	1945		
Bethlehem Steel Co.	Lackwanna, NY	Billet Mill Alterations	1945		
Laclede Steel Co.	Alton, IL	Rod Mill	1945		
Bethlehem Steel Co.	Los Angeles, CA	Rod & Merchant Mill	1946		
Sheffield Steel Co.	Kansas City, MO	Merchant Mill	1946		
Nederlandsche Kabelfabrieken	Alblasserdam, Netherlands	Rod Finishing Mill	1946		
John Lysaght, Ltd.	Scunthorpe, UK	Billet & Sheet Bar Mill	1947		
Guest, Keen, Nettlefolds Ltd.	Cardiff, Wales	Rod & Merchant Mill	1947		
Acindar Industries Argentina	Villa Constitucion, Argentina	Merchant, Rod & Skelp Mill	1947		
Colorado Fuel & Iron	Pueblo, CO	Rod Mill	1947		
Stewarts & Lloyds, Ltd.	Corby, UK	Skelp Mill	1947		
Sheffield Steel Co.	Houston, TX	Merchant Mill	1948		
Soc. Miniere et Metal de Rodange	Rodange, Luxembourg	Rod Finishing Mill	1948		
Domnarvets Jernverk	Domnarfvet, Sweden	Merchant, Rod & Strip Mill	1948		
Lancashire Steel Co.	Warrington, UK	Rod & Merchant Mill	1948		
Oesterreichisch Alpine	L-Donawitz, Austria	Billet & Sheet Bar Mill	1949		
Ilva Alti Forni Acc. D'Italia	Bagnoli, Italy	Rod & Merchant Mill	1949		
Consett Iron Co., Ltd.	Durham, UK	30" Billet & Slab Mill	1950		

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Consett Iron Co., Ltd.	Durham, UK	24" Billet & Slab Mill	1950		
Algoma Steel Co., Ltd.	Sault St. Marie, Canada	Merchant & Strip Mill	1950		
Steel Co. of Bengal	Burnpur, India	Billet & Sheet Bar Mill	1950		
National Tube Co.	Morrisville, PA	Skelp Mill	1951		
U.S. Steel Corp.	Morrisville, PA	Merchant Mill	1951		
Norsk Jernverk	Mo-I-Rana, Norway	Merchant, Rod & Strip Mill	1951		
TATA Iron & Steel Co.	Jamshedpur, India	14" Skelp Mill	1952		
American Steel & Wire	Cleveland, OH	4-Strand Rod Mill	1952		
Bethlehem Steel Co.	Johnstown, PA	Rod Mill	1954		
Broken Hill Proprietary Co.	Newcastle, Australia	Strip & Skelp Mill	1954		
Atlantic Steel Co.	Atlanta, GA	Rod & Merchant Mill	1955		
Huttenwerk Rheinhausen	Rheinhausen, West Germa	10-Strand Billet Mill	1955		
Republic Steel Co.	Cleveland, OH	11" Merchant Mill	1956		
Dorman Long (Steel) Ltd.	Middlesborough, UK	Merchant, Rod & Strip Mill	1956		
Dorman Long (Steel) Ltd.	Middlesborough, UK	Billet Mill	1956		
Nueva Montana Quijano, SA	Santander, Spain	Rod Mill	1956		
Indian Iron & Steel Ltd.	Burnpur, India	Billet Mill Addition	1956		
Indian Iron & Steel Ltd.	Burnpur, India	Rod & Merchant Mill	1956		
Government of India Steelworks	Durgapur, India	Merchant Mill	1957		
Government of India Steelworks	Durgapur, India	Billet Mill	1957		
Soc. Mixta Sider. Argentina	San Nicolas, Argentina	Billet & Slab Mill	1957		
Armco Steel Co.	Kansas City, MO	10" Rod Mill	1957		
Bethlehem Steel Co.	Steelton, PA	11" Merchant Mill	1959		
Felton & Guilleaume AG	KolnMulheim, West Germa	Rod Mill	1959		
Soc. Anonyme Cock.-Ougree	Ougree, Belgium	Rod Mill	1959		
Republic Steel Co.	Canton, OH	8" Merchant Mill	1959		
Acieries Reunies de Burbach	Esch, Luxembourg	Rod Mill	1959		
Guest, Keen I & S, Ltd.	Cardiff, Wales	Billet Mill Addition	1960		
Broken Hill Proprietary Co.	Newcastle, Australia	Rod Mill	1960		
Lancashire Steel Co.	Warrington, UK	Rod Mill	1960		
Altos Hornos de Vizcaya SA	Bilbao, Spain	Rod & Merchant Mill	1960		
Soc. des Hautes Fourneaux	Longwy-Bas, France	Rod & Merchant Mill	1960		
Neunkirchen Eisenwerk AG	Neunkirchen, West Germa	Rod & Merchant Mill	1960		
Compan Sider. Belgo Mineira	Monlevade, Brazil	Rod Mill	1960		

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Huttenwerk Salzgitter AG	Salzgitter, West Germany	Rod & Merchant Mill	1961		
Bethlehem Steel Co.	Johnstown, PA	Merchant Mill	1961		
Republic Steel Co.	Cleveland, OH	Merchant Mill Alterations	1961		
Usinor	Longwy-Bas, France	Stelmor Lines	1961		Yes
Usinor	Saulnes, France	Rod Mill	1961		Yes
Inland Steel Co.	East Chicago, IN	Billet Mill	1963		
British Steel Co.	Middlesborough, UK	Shut Down	1963		
Dorman Long (Steel) Ltd.	Middlesborough, UK	Rod Mill	1963		Yes
Steel Co. of Canada	Hamilton, Ont, Canada	Rod Mill	1964	Yes	Yes
Kawasaki Steel Co.	Kobe, Japan	Rod Mill	1964		
Southwire Company	Carrollton, GA	Copper Rod Mill	1964	Yes	
Reynolds Metals Co.	Lister Hill, AL	Aluminum Rod Mill	1965	Yes	
J & L Steel Co.	Aliquippa, PA	Rod Mill Alterations	1965	Yes	Yes
Westinghouse Electric Co.	Buffalo, NY	Copper Rod Mill	1965	Yes	
Broken Hill Proprietary Co.	Newcastle, Australia	Merchant Mill	1965		
Bethlehem Steel Co.	Sparrows point, MD	Rod Mill	1965	Yes	Yes
Armco Steel Co.	Kansas City, MO	Rod Mill Alterations	1965	Yes	
Niederrheinische Huette AG	Duisburg, West Germany	Rod Mill	1965	Yes	Yes
Soc. des Hautes Fourneaux	Longwy-Bas, France	Rod Mill Alterations	1966		Yes
U.S. Steel Corp.	Joliet, IL	Rod Mill Alterations	1966	Yes	
U.S. Steel Corp.	Fairless Hills, PA	Rod Mill	1966	Yes	Yes
Southwire Company	Hawesville, KY	Aluminum Rod Mill	1966	Yes	
Scaw Metals, Ltd.	Germinston, South Africa	Bar & Rod Mill	1966	Yes	Yes
Wendel-Sidelor	Rombas, France	Rod Mill Alterations	1966	Yes	Yes
Transvaal Copper Rod Co.	Palabora, South Africa	Copper Rod Mill	1966	Yes	
CF&I Steel Co.	Pueblo, CO	Rod Mill Alterations	1967	Yes	Yes
Kawasaki Steel Co.	Kobe, Japan	Rod Mill	1967		Yes
Inspiration Consol. Copper	Inspiration, AZ	Copper Rod Mill	1967	Yes	
Sumitomo Electric Ind. Ltd.	Osaka, Japan	Copper Rod Mill	1967	Yes	
Altos Hornos de Mexico	Monclova, Mexico	Rod Mill	1968	Yes	Yes
CF&I Steel Co.	Pueblo, CO	Bar Mill	1968		
South African I&S Ind. Co.	Pretoria, South Africa	Rod Mill	1968	Yes	Yes
Sumitomo Metal Ind. Ltd.	Kokura, Japan	Rod Mill	1968	Yes	Yes
Capital Wire & Cable Co.	Plano, TX	Copper Rod Mill	1968	Yes	

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Laminoir Trefileries de Lens	Lens, France	Copper Rod Mill	1968	Yes	
Trinecke Zelezarny N.P.	Trinec, Czech	Rod Mill	1969	Yes	Yes
Mitsubishi Metal Mining, Ltd.	Osaka, Japan	Copper Rod Mill	1969	Yes	
Furukawa Electric Co.	Tokyo, Japan	Copper Rod Mill	1969	Yes	
Hitachi Wire Rod Co.	Tokyo, Japan	Copper Rod Mill	1969	Yes	
Nippon Steel Co.	Kimitsu, Japan	Rod Mill	1969	Yes	Yes
Tamet	Buenos Aires, Argentina	Rod Mill	1969	Yes	Yes
Richard Johnson & Nephew	Manchester, UK	Rod Mill Alterations	1970	Yes	
Magma Copper Co.	San Manuel, AZ	Copper Rod Mill	1970	Yes	
Felton & Guilleaume AG	Bruck ad Mur, Austria	Rod Mill	1970	Yes	Yes
Kawasaki Steel Co.	Kobe, Japan	Rod Mill Addition	1970		Yes
Sumitomo Metal Ind. Ltd.	Kokura, Japan	Rod Mill Addition	1970	Yes	Yes
Acindar Industries Argentina	Villa Constitucion, Argenti	Rod Mill	1970		
Compan Sider. Belgo Mineira	Monlevade, Brazil	Rod Mill Addition	1970	Yes	Yes
Soc. des Acieries Trefileries	Nueves-Maison, France	Rod Mill	1970	Yes	Yes
Arbed Roechling (Burbach)	Saarbrucken, West Germa	Rod Mill	1970	Yes	Yes
Huta Cedlera	Sosnowiec, Poland	Rod Mill	1970	Yes	Yes
Huta Metali Niezelaznych	Szopienice, Poland	Copper Rod Mill	1970	Yes	
Kennecott Copper Co.	Baltimore, MD	Copper Rod Mill	1970	Yes	
Soc. Metall. de Normandie	Mondeville, France	Rod Mill	1971	Yes	Yes
Broken Hill Proprietary Co.	Newcastle, Australia	Merchant Mill Addition	1971		
Georgetown Steel Co.	Georgetown, SC	Rod Mill Alterations	1971		Yes
S.A. "Cockerill"	Seraing, belgium	Rod Mill Alterations	1971		Yes
Ugine Aciers	Fos-sur-mer, France	Rod Mill	1971	Yes	Yes
Neuva Montana Quijano SA	Santander, Spain	Rod Mill Addition	1971	Yes	Yes
Kobe Steel, Ltd.	Kakogawa, Japan	Rod Mill	1971	Yes	Yes
Azuma Steel Works	Sendai, Japan	Rod Mill	1971	Yes	Yes
South African I&S Ind. Co.	Newcastle, South Africa	Rod Mill	1971	Yes	Yes
U.S. Steel Corp.	Chicago, IL	Rod Mill	1972	Yes	Yes
Templeborough Rolling Mills	Rotherham, England	Rod Mill Alterations	1972	Yes	
Rudarsko-Metalurski Komb.	Zenica, Yugoslavia	Rod Mill	1972	Yes	
Armco Steel Co.	Kansas City, MO	Rod Mill Alterations	1972	Yes	Yes
U.S. Steel Corp.	Pittsburgh, PA	Rod Mill Addition	1972		Yes
Western Electrical Co.	Chicago, IL	Copper Rod Mill	1972	Yes	Yes

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Brit. Insul. Callender's Cable	Prescot, UK	Copper Rod Mill	1972	Yes	
Enfield Rolling Mills, Ltd.	Brimsdown, UK	Copper Rod Mill	1972	Yes	
British Steel Co.	Rotherham, England	Bar Mill Alterations	1972	Yes	
Georgetown Steel Co.	Georgetown, SC	Rod Mill Alterations	1973		
British Steel Co.	Rotherham, England	Bar Mill	1973	Yes	
S.N. Oporto	Oporto, Portugal	Rod Mill Alterations	1973		Yes
Ivaco, Inc.	L'Orignal, Canada	Rod Mill Alterations	1973	Yes	Yes
S.A. "Cockerill"	Seraing, belgium	Rod Mill	1973	Yes	Yes
Kloeckner Werke AG	Hagen Haspe, West Germa	Rod Mill Alterations	1973		Yes
Furukawa Electric Co.	Tokyo, Japan	Copper Rod Mill	1973	Yes	
Metal Manufactureres	Port Kembla, Australia	Copper Rod Mill	1973	Yes	
U.S. Steel Corp.	Cleveland, OH	Rod Mill Alterations	1973	Yes	Yes
Bethlehem Steel Co.	Lackwanna, NY	Bar Mill Pouring Reel	1973		
Nippon Steel Co.	Kamaishi, Japan	Rod Mill Alterations	1973	Yes	Yes
GKN South Wales, Ltd.	Cardiff, Wales	Rod Mill	1973	Yes	Yes
Sicartsa, S.A.	Las Truchas, Mexico	Rod Mill	1973	Yes	Yes
British Steel Co.	Scunthorpe, UK	Rod Mill	1974	Yes	Yes
China Steel Co.	Kaohsiung, Taiwan	Rod Mill	1974	Yes	Yes
Cosigua	Sao Paulo, Brazil	Rod Mill	1974	Yes	Yes
Broken Hill Proprietary Co.	Newcastle, Australia	Rod Mill Addition	1974	Yes	
Georgetown Texas Steel Co.	Beaumont, TX	Rod Mill	1974	Yes	Yes
Altos Hornos de Mexico	Monclova, Mexico	Rod Mill Addition	1974	Yes	Yes
Carpenter Technology Co.	Reading, PA	Rod Mill Addition	1974	Yes	
Magma Copper Co.	San Manuel, AZ	Copper Rod Mill	1974	Yes	
Colata Continua Italiana SpA	Milan, Italy	Copper Rod Mill	1974	Yes	
Sumitomo Metal Ind. Ltd.	Kokura, Japan	Bar Mill	1974		
Usinor	Longwy-Bas, France	Rod Mill Addition	1974	Yes	Yes
Laclede Steel Co.	Alton, IL	Rod Mill Addition		Yes	Yes
Forges de Thy-Marcinelle	Charleroi, Belgium	Rod Mill Addition		Yes	Yes
Acciaierie di Piombino, SpA	Livorno, Italy	Rod Mill		Yes	Yes
Walsin Lihwa	Taipei, Taiwan	Copper Rod Mill		Yes	
Deutsche Giessdraht GmbH	Emmerich, West Germany	Copper Rod Mill		Yes	
Aluminum Company, Ltd.	Kaohsiung, Taiwan	Aluminum Rod Mill		Yes	
GKN South Wales, Ltd.	Cardiff, Wales	Bar Mill Addition	1975		

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Ensidesa	Verino, Spain	Rod Mill	1975	Yes	Yes
Tech. for ZNP Dimitar Blagoev	Vrabniza Sofia, Bulgaria	Copper Rod Mill	1975	Yes	
Ardal og Sunndal Verk AS	Ardal, Norway	Aluminum Rod Mill	1976	Yes	Yes
C.F.G. Sidor, C.A.	Mantanzas, Venezuela	Rod Mill	1976	Yes	Yes
Acciaierie di Bolzano SpA	Bolzano, Italy	Rod Mill Addition	1976	Yes	Yes
Voest-Alpine AG	Leoben-Don, Austria	Rod Mill	1977	Yes	Yes
Charter Rolling Division	Saukville, WI	Rod Mill Addition	1977	Yes	
Rabak	Istanbul, Turkey	Copper Rod Mill	1977	Yes	
Furukawa-Indonesia	Jakarta, Indonesia	Copper Rod Mill	1977	Yes	
Sural	Puerto-Ordaz, Venezuela	Aluminum Rod Mill	1977	Yes	Yes
Raritan River Steel Co.	Perth Amboy, NJ	Rod Mill	1977	Yes	Yes
Kobe Steel, Ltd.	Kobe, Japan	Rod Mill Addition	1978	Yes	Yes
Iscott	Trinidad, West Indies	Rod Mill	1978	Yes	
Gold Star Cable Co.	Seoul, Korea	Copper Rod Mill	1978	Yes	
Taihan Electric Co.	Seoul, Korea	Copper Rod Mill	1978	Yes	Yes
Von Moos Stahl	Luzern, Switzerland	Rod Mill Addition	1978	Yes	
North Star Steel Co.	Monroe, MI	Bar Bundling Equipment	1978		
Norddeutsche Affinerie	Hamburg, West Germany	Copper Rod Mill	1979	Yes	
Sural	Puerto-Ordaz, Venezuela	Aluminum Rod Mill	1979	Yes	
Walsin Lihwa	Taipei, Taiwan	Copper Rod Mill	1979	Yes	
Fujikura Cable Works, Ltd.	Numazu, Japan	Copper Rod Mill	1979	Yes	
Atlantic Steel Co.	Atlanta, GA	Rod Mill Addition	1979	Yes	
Fratelli Stefana	Nave, Italy	Rod Mill Addition	1979	Yes	Yes
Special Steels, Ltd.	Bombay, India	Rod Mill	1979	Yes	Yes
Florida Steel Co.	Jackson, TN	Bar Mill	1979		
Federal Republic of Nigeria	Oshgbo, Nigeria	Rod & Bar Mill	1979	Yes	Yes
Siderurgica Riograndense	Rio do Sinos, Brazil	Rod Mill Addition	1979	Yes	Yes
Nippon Steel Co.	Kamaishi, Japan	Rod Mill Addition	1980	Yes	Yes
Nippon Steel Co.	Hikari, Japan	Rod Mill Addition	1980	Yes	Yes
Nippon Steel Co.	Muroran, Japan	Rod Mill Addition	1980	Yes	Yes
Nakayama Steel Works, Ltd.	Osaka, Japan	Rod & Bar Mill	1980	Yes	Yes
Godo Steel, Ltd.	Osaka, Japan	Rod Mill	1980	Yes	Yes
Colata Continua Italiana SpA	Milan, Italy	Copper Rod Mill Addition	1980	Yes	
Siderurgica Nacional, E.P.	Seixal, Portugal	Rod Mill	1980	Yes	Yes

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Pacific Electric Wire & Cable	Taipei, Taiwan	Copper Rod Mill	1980	Yes	
Siderugica Mendes Jr.	Belo Horizonte, Brazil	Rod & Bar Mill	1980	Yes	Yes
Saudi Iron & Steel (Hadeed)	Al-Jubail, Saudi Arabia	Rod Mill	1980	Yes	Yes
Acindar Industria, SA	Argentina	Rod Mill Addition	1980	Yes	Yes
Sonasid	Nador, Morocco	Rod & Bar Mill	1980	Yes	Yes
Cosigua	Sao Paulo, Brazil	Rod Mill Addition	1980	Yes	Yes
Sumitomo Metal Ind. Ltd.	Kokura, Japan	Pouring Reel Addition	1980		
Laclede Steel Co.	Alton, IL	Bar Bundler Addition	1981		
Marathon Steel Co.	Tempe, AZ	Bar Mill Addition	1981		
Southwire Company	Carrollton, GA	Copper Rod Mill	1981	Yes	
Arbed	Esch, Luxembourg	Rod Mill Addition	1981	Yes	Yes
Neunkirchen Eisenwerk AG	Neunkirchen, West Germa	Rod Mill Addition	1981	Yes	Yes
Hylsa de Mexico SA	Puebla, Mexico	Rod Mill Addition	1981		Yes
Acepar	Asuncion, Paraguay	Rod Mill	1982		Yes
Daido Steel Co.	Chita Works, Japan	Billet Mill	1982		
Northwestern Steel & Wire	Sterling,IL	Rod Mill Addition	1982	Yes	Yes
Russia	Shlobin, USSR	Rod Mill Addition	1982	Yes	Yes
AM Rod Co.	Kearny, NJ	Copper Rod Mill	1983	Yes	
Continental Steel Co.	Kokomo, IN	Rod Mill Addition	1983	Yes	Yes
Daido Steel Co.	Chita Works, Japan	Rod Mill Addition	1983	Yes	Yes
Kawasaki Steel Co.	Mizushima, Japan	Rod Mill Addition	1983	Yes	Yes
Sumitomo Electric Ind. Ltd.	Osaka, Japan	Rod Mill Alterations	1983		
Steel Authority of India	Visakhapatnam, India	Rod Mill	1983	Yes	Yes
Inspiration Consol. Copper	Inspiration, AZ	Copper Rod Mill Addition	1983		
Maanshan Iron & Steel Co.	Maanshan, PRC	Rod Mill	1984	Yes	Yes
Shanghai No. 2 I&S Works	Shanghai, PRC	Rod Mill	1984	Yes	Yes
TATA Iron & Steel Co.	Jamshedpur, India	Rod Mill	1984	Yes	Yes
Magma Copper Co.	Chicago, IL	Copper Rod Mill Addition	1984		
Aichi Steel Works	Nagoya, Japan	Rod Mill Addition	1985	Yes	Yes
Aichi Steel Works	Nagoya, Japan	Bar Mill Addition	1985		
Alexandria National I&S Co.	Alexandria, Egypt	Rod Mill	1985	Yes	Yes
China Steel Co.	Kaohsiung, Taiwan	Rod Mill Addition	1985	Yes	Yes
Yunnan Smeltery	KunmingYunnan, PRC	Copper Rod Mill	1985	Yes	
Kawasaki Steel Co.	Mizushima, Japan	Bar & Rod Mill	1985		

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Companhia Siderurgica Pains	Divinopolis, Brazil	Bar Mill Alterations	1986		
Belgo Mineira, SA	Monlevade, Brazil	Rod Mill	1986	Yes	Yes
Broken Hill Proprietary Co.	Newcastle, Australia	Rod Mill Alterations	1986		Yes
Nueva Montana Quijano, SA	Santander, Spain	Rod Mill Alterations	1986		Yes
Connecticutt Steel Co.	Wallingford, CT	Rod Mill Alterations	1986	Yes	Yes
Sarkuysan Elek	Gebze, Turkey	Copper Rod Mill	1986	Yes	
Sural Aluminum	Puerto-Ordaz, Venezuela	Aluminum Rod Mill	1986	Yes	
Elektrokoppar	Helsingborg, Sweden	Copper Rod & Roughing Mill	1986	Yes	
Nippon Steel Co.	Muroran, Japan	No-Twist Mill	1986	Yes	
Keystone Steel & Wire	Peoria, IL	Rod Mill Alterations	1987	Yes	Yes
Pohang Iron & Steel Co.	Pohang, South Korea	Rod Mill	1987	Yes	Yes
Auburn Steel Co.	Auburn, NY	Bar Mill Alterations	1987		
Mitsubishi Metal Co.	Osaka, Japan	Copper Rod Mill	1987	Yes	
Gold Star Cable Co.	Seoul, Korea	Copper Rod Mill Addition	1987		
Shanghai Copper Plant	Shanghai, PRC	Copper Rod Mill	1987	Yes	
Ivaco Rolling Mills	L'Orignal, Canada	Rod Mill Alterations	1987		Yes
Companhia Siderurgica Pains	Divinopolis, Brazil	Rod Mill Alterations	1987	Yes	Yes
Thai Yazaki Elec. Wire, Ltd.	Samuth Prakar, Thailand	Copper Rod Mill	1987	Yes	
Hindustan Copper, Ltd	Maharashta, India	Copper Rod Mill	1988	Yes	
American Steel & Wire	Cleveland, OH	Rod Mill Alterations	1988		
Acindar Ind. Argentina SA	Villa Constitucion, Argentii	Rod Mill Alterations	1988		Yes
Riyadh Cable Co.	Riyadh, Saudi Arabia	Copper Rod Mill	1988	Yes	
Elkat	Moscow, Russia	Copper Rod Mill	1988		
Sammi Steel	Changwon, South Korea	No-Twist Mill & Stelmor Lines	1988	Yes	Yes
Solac	Sao Paulo, Brazil	Copper Rod Mill	1989		
Great China Wire	Taipei, Taiwan	Copper Rod Mill	1989		
Sidbec-Dosco	Canada (ex USS Sochic)	No-Twist Mill	1989	Yes	
Acerias Paz del Rio	Colombi (ex USS SoChic)	No-Twist Mill & Stelmor Lines	1989	Yes	Yes
Yieh Hsing	Kaohsiung, Taiwan	No-Twist Mill & Stelmor Lines	1989	Yes	Yes
Hylsa de Mexico SA	Puebla, Mexico	No-Twist Mill & Stelmor Lines	1990	Yes	Yes
Orbegozo	Zummarago, Spain	No-Twist Mill & Stelmor Lines	1990	Yes	Yes
P.T. Krakatau Steel	Cilegon, Indonesia	No-Twist Mill & Stelmor Lines	1990	Yes	Yes
Nakorn Thai Steel	Bangkok, Thailand	No-Twist Mill & Stelmor Lines	1990	Yes	Yes
Sumitomo Metal Ind. Ltd.	Kokura, Japan	Rod Mill Alterations	1990		

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Kok Hong	Taipei, Taiwan	Copper Rod Mill	1991		
Tianjin Steel Works	Tianjin, PRC	Single Strand Rod Mill	1991	Yes	Yes
Sredazcable (Uzbekkable)	Tashkent, Uzbekistan	Copper Rod Mill	1991		
Xiangtan Steel	Xiantan, PRC	Single Strand Rod Mill	1992	Yes	Yes
Kazkat	Dzhez, Kazakhstan	Copper Rod Mill	1992		
Artemovsk	Ukraine	Copper Rod Mill	1992		
TDT	India	Copper Rod Mill	1993		
CF&I Steel Co.	Pueblo, CO	Mill Alterations	1993	Yes	Yes
GST Steel	Kansas City, MO	Rod Mill Alterations	1993	Yes	Yes
TOA Steel Works	Sendai, Japan	Rod Mill Alterations	1993		
Anshan Iron & Steel	Anshan, China	Rod Mill Alterations	1993		Yes
New Jersey Steel	Sayreville, NJ	Bar Mill Alterations	1993	Yes	
Rosskat	CIS	Copper Rod Mill	1993		
USS/Kobe Steel	Lorain, OH	NTM/RSM/Stelmor lines	1993	Yes	Yes
Amalgamated Steel Mills	Selangor, Malaysia	Rod Mill Alterations	1993		Yes
Acindar Ind. Argentina SA	Villa Constitucion, Argentii	Rod Mill Alterations	1994		
Belgo Mineira, SA	Monlevade, Brazil	Rod Mill Alterations	1994		Yes
Charter Rolling Division	Saukville, WI	Rod Outlet Addition	1994	Yes	Yes
South African I&S Ind. Co.	Newcastle, South Africa	RSM Addition	1994		
Special Steels, Ltd.	Bombay, India	Rod Mill Alterations	1994		
American Steel & Wire	Cleveland, OH	Rod & Bar Mill	1994	Yes	Yes
P.T. Krakatau Steel	Cilegon, Indonesia	Rod Mill Alterations	1994		
Beijing Best	Beijing, China	Copper Mill	1994		
Baotou Steel	Baotou, PRC	Single Strand Rod Mill	1994	Yes	Yes
Zhangjiagang Steel	Jianzou, PRC	Single Strand Rod Mill	1994	Yes	Yes
Kia Steel Co., Ltd.	Kunsan, Korea	Rod Outlet	1994	Yes	Yes
Walsin Lihwa	Taiwan	Copper Mill	1994		
Thai Special Steel Ind. Ltd.	Bangkok, Thailand	Single Strand Rod Mill	1995	Yes	Yes
Nueva Montana Quijano, SA	Santander, Spain	Rod Mill Alterations	1995		
LG Cables	Korea	Copper Mill Upgrade	1995		
Yazaki	Japan	Copper Mill	1995		
Sun Jin	Korea	Copper Mill	1995		
Transkat	Russia	Copper Mill	1995		
Indo-Gulf	India	Copper Mill	1995		

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Elektrokoppar	Sweden	Copper Mill Upgrade	1995		
Dong Ho	Korea	Copper Mill	1996		
Kobrex	Mexico	Copper Mill	1996		
CHAU	PRC	Copper Mill	1996		
Univertical	USA	Copper Bar Mill	1996		
Ivaco Rolling Mills	L'Orignal, Canada	Rod Mill Alterations	1996		Yes
P.T. Krakatau Steel	Cilegon, Indonesia	Rod Outlet Addition	1996	Yes	Yes
Sanyo Special Steel	Japan	Rod Mill Alterations	1996	Yes	Yes
Co-Steel Sheerness	Sheerness, UK	Rod Mill Alterations	1996		Yes
Baoshan Steel	Shanghai, PRC	Single Strand Rod Mill	1997	Yes	Yes
Kobe Steel, Ltd.	Kobe, Japan	Rod Mill Addition	1997	Yes	Yes
Aceralia	Spain	2-Strand Rod Mill	1998		
Ivaco Rolling Mills	Canada	2-Strand Rod Mill	1998		
Global Steel Wire	Spain	2-Strand Rod Mill	1998		
NSC Kamaishi	Japan	2-Strand Rod Mill	1999		
Saarstahl Neunkirchen	Germany	Rod Mill	1999		
Belgo Mineira, SA	Brazil	High Speed Rebar Mill	1999		
Zhangjiagang Steel	PRC	Single Strand Rod Outlet	1999		
Hangzhou	PRC	Single Strand Rod Outlet	1999		
Hylsa de Mexico SA	Mexico	Single Strand Rod Outlet	1999		
Anyang	PRC	Single Strand Rod Outlet	1999		
BMX Shlobin	Belarus	Rod Mill	1999		
NSC Muroran	Japan	Single Strand Rod Outlet	2000		
Marion Steel	USA	Bar Mill	2000		
Daido Steel Co.	Japan	Single Strand Rod Outlet	2000		
Barra Mansa	Brazil	High Speed Rebar Mill	2000		
China Steel Co.	Taiwan	Single Strand Rod Outlet	2000		
POSCO #3	South Korea	2-Strand Rod Mill	2001		
Liuzhou	PRC	Single Strand Rod Outlet	2201		
Zhangjiagang Steel	Yongxin, PRC	Rebar Mill	2002		
Fundia	Nedstahl, Netherlands	Single Strand Rod Mill	2002		
Baosteel	Shanghai, PRC	Single Strand Rod Mill	2002		
Sterling Steel	USA	2-Strand Rod Mill	2002		
Haixin	PRC	Single Strand Rod Outlet	2002		

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
NSC	Kimitsu, Japan	4-Strand Rod Mill	2002		
Zhangjiagang Steel	PRC	Single Strand Rod Outlet	2003		
Siderugica Anon	Spain	Single Strand Rod Outlet	2003		
Echeng Iron & Steel	PRC	Bar Mill	2003		
Shandong Shiheng I&S	PRC	Single Strand Rod Outlet	2003		
Lantai	PRC	Single Strand Rod Outlet	2003		
Zhangjiagang Steel	PRC	Coil Mill	2003		
Timken	Lastrobe, USA	Bar Mill	2003		
Sonasid	Morroco	Rod & Bar Mill	2003		
TATA Iron & Steel Co.	India	High Speed Rebar Mill	2004		
Wuhan	PRC	2-Strand Rod Mill	2004		
Chicago Heights	Chicago, IL	Section Mill	2004		
CORUS	Scunthorpe, UK	4-Strand Rod Mill	2004		
Ares	Luxembourg	Bar Mill	2004		
Belgo Mineira, SA	Brazil	2-Strand Rod Mill	2004	Yes	
Brandenburg	Germany	4-Strand Rod Mill	2004		
Siderurgica Anon	Spain	Single Strand Rod Outlet	2004		
Acelor Alambron	Zummarago, Spain	2-Strand Rod Mill	2004		
CORUS	UK	4-Strand Rod Mill	2005		
Sibasa	Mexico	No-Twist Mill	2005	Yes	
BMX Shlobin	Belarus	Rod Mill	2005		
SISCOL	India	Rod Outlet	2005	Yes	
Thamesteel	UK	Rod Outlet	2005		
Xing Cheng	PRC	Bar Mill	2005		
Global Steel Wire	[redacted]	2-Strand Rod Mill	2005		
Changwon	South Korea	Rod Mill	2005		
Acelor Alambron	Zummarago, Spain	2-Strand Rod Mill	2006		
Acindar	Argentina	Rod & Bar Mill	2006		
Zhejiang Yuanli	PRC	Rod Outlet	2006	Yes	
CORUS	UK	4-Strand Rod Mill	2006		
Jindal South West	India	Rod Mill	2006		
Jindal South West	India	Bar Mill	2006		
Ovako	Netherlands	Rod & BIC	2006		
Jindal Steel & Power	India	Rod Mill	2006		

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Jindal Steel & Power	India	Bar Mill	2006		
Zhangjiagang Steel	PRC	Rod Outlet	2006	Yes	Yes
Sidenor	Greece	2-Strand Rod Mill	2006		
Trinecke Zelezarny N.P.	Czech	Bar Outlet	2006		
Tsingshan	PRC	Rod Outlet	2006	Yes	Yes
Tianjin Steel Works	RockCheck, PRC	Rod Outlet	2006	Yes	Yes
CMC	Zawiercie, Poland	Rod Outlet	2006	Yes	Yes
Changli Auto Spring	PRC	Rod Outlet	2007	Yes	
Tianjin Steel Works	PRC	Rod Outlet	2007	Yes	Yes
Zhangjiagang Steel	PRC	Rod Outlet	2007	Yes	Yes
Dongbei	PRC	Rod Outlet	2007		
Visakhapatnam Steel Plant	India	2-Strand Rod Mill	2007		Yes
China Steel Co.	Taiwan	2-Strand Rod Mill	2007		Yes
Votorantim	Brazil	2-Strand Rod Mill	2007	Yes	Yes
Smorgon	Australia	Combination Mill	2007		
QASCO	Dubai	Rod Mill	2007		
Tianjin Steel Works	PRC	Rod Outlet	2007	Yes	Yes
Shanxi Xintai	PRC	Rod Outlet	2008	Yes	Yes
Dongbei	PRC	Rod Outlet	2008	Yes	
Liuzhou	PRC	Single Strant Rod Outlet	2008	Yes	Yes
Electrosteel	India	Rod Outlet	2008	Yes	Yes
Shougang Baoye I&S	PRC	Rod Outlet	2008	Yes	Yes
Shougang Baoye I&S	PRC	Rod Outlet	2008	Yes	Yes
Shougang Baoye I&S	PRC	Rod Outlet	2008	Yes	Yes
Nanjing I&S Co.	PRC	Rod Outlet	2008		
Celsa Atlantica	Spain	Rod Outlet	2008		
Jiangsu Shagang Group Co.	PRC	Rod Outlet	2008	Yes	Yes
Jiangsu Shagang Group Co.	PRC	Rod Outlet	2008	Yes	Yes
CSP Planalto	Brazil	Bar & Rod Mill	2008	Yes	Yes
China Steel Co.	Taiwan	Bar & Rod Mill	2008		
Handan I&S Co. Ltd.	PRC	Single Strand Rod Outlet	2009	Yes	Yes
Sterling Steel	USA	Rod Mill	2009		
Zhongtian	PRC	Single Strand Rod Outlet	2009		Yes
Zhongtian	PRC	Single Strand Rod Outlet	2009	Yes	Yes

Company	Location	Mill Type	Year	No-Twist Rod Finishing Mill	Stelmor Lines
Qingdao I&S Co. Ltd.	PRC	Single Strand Rod Outlet	2009	Yes	Yes
Yuanli Metal Products Co.	PRC	Bar Mill	2010		
Herbei Xuanhua I&S Co. Ltd.	PRC	Rod Outlet	2010	Yes	Yes
Jiyuan I&S Co. Ltd.	PRC	Rod Outlet	2010	Yes	Yes
Herbei Xuanhua I&S Co. Ltd.	PRC	Rod Outlet	2010	Yes	Yes
Tianjin Steel Works	PRC	Rod Outlet	2010	Yes	Yes
GUSA Nordeste SA	Brazil	Bar & Rod Mill	2010	Yes	Yes
Jiangsu Shagang Group Co.	PRC	Rod Outlet	2010	Yes	Yes
Jiangsu Shagang Group Co.	PRC	Rod Outlet	2010	Yes	Yes
Gerdau Cosigua	Brazil	Rod Mill	2010	Yes	Yes
Shanxi Zhongyang	PRC	Rod Mill	2011		
Shanxi Zhongyang	PRC	Rod Mill	2011		
Shanxi Zhongyang	PRC	Rod Mill	2011		
Jiangsu Shagang Group Co.	PRC	Rod Outlet	2011		
Wuhu XinXing Ductile Pipe Co.	PRC	Rod Outlet	2011	Yes	Yes
Badische Stahlwerke	Germany	2-Strand Rod Mill	2011	Yes	Yes
Hanzhong I&S Co.	PRC	Rod Outlet	2011	Yes	Yes
POSCO	South Korea	Rod Mill	2011		

Artifacts and Documents from Morgan Construction Company's Archives

Series	Box	Folder	Contents
2	29	15	Mills list
2	44	230-245	European Bar mills
3	97	40	tally of mills
3	96	39	brochures of evolution
3	97	41	siemens mill plants
3	97	43	advertisements
3	97	53	examples
3	109	126	machine design
2	212	587	rolling mills photos
2	214	588	mills photos
2	244	618	flying shears photos
2	245	619	flying shears photos
2	246	620	bloom shears photos
2	325	707	rod mill photos
3	98	55	sport teams photos
3	98	54	correspondence photos
3	111	140	correspondence photos
3	112	148	morgan company photos
4	136	351	flage gun
4	137	354	incendiary bomb
4	137	355	e-19 incendiary bomb
4	137	356	alarm for navy
4	137	357	experimental unit
4	137	361	tank storage
4	137	362	experimental flame thrower
4	137	365	E13R1 gun barrel
4	137	365	Godo steel
3	351	239	flying shears
3	352	240	rod reformed
3	352	240	flying shears
3	352	240	steel rolling mill
3	352	240	12" crop and cobble shear
3	352	240	blooming and billet mill

Series	Box	Folder	Contents
3	352	240	S african steel corp
3	352	240	vertical mill
3	353	241	no twist mill
3	353	241	billet and sheet bar mill
3	353	241	flying shear
3	353	241	roller and pinch roler
3	353	241	flying shears
3	355	243	continuous bar and rod mill atlantic
3	355	243	Atlantic #3
3	356	244	continous ckelp mill #2
1	204	147	manual calculator
2	212	587	rolling mill parts pictures
3	356	244	modern merchant mill