

AN INQUIRY ON THE ARCHITECTURE OF PRODUCTION:
FROM MILLS TO MACHINE LANDSCAPES

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FROM MILLS TO MACHINE LANDSCAPES**

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ABSTRACT

AN INQUIRY ON THE ARCHITECTURE OF PRODUCTION: FROM MILLS TO MACHINE LANDSCAPES

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Anthropocene is the present geological epoch in which human-built infrastructures dominate the resources of the world and highest levels of human intrusion to the ecosystems have been accumulated since the Industrial Revolution. Utilisation of the steam engine initiated change in energy sources and extraction of raw materials that altered the existent means of production and led to the hegemony of industrial activities. The spread and growth of industry prevailed onto the practice of architecture to construct rapidly developing bases of production, storage, and distribution. Therefrom, physical embodiments of these bases as an overall system enable to relate energy, labour, and technology as fundamental elements of industry with the discourse of architecture. Hence, this thesis studies three determined architectural typologies - mills, daylight factories, machine landscapes- for the evolution of production by a historical literature survey and comparative analysis of multiple cases with the compiled architectural documentation including photographs, drawings, and diagrams. Chronologically organised cases from different industrial periods reflect the altering nature of energy, labour, and technology regarding means of production, construction techniques, and materials. Acting as design parameters through the spatial transformation from mills to daylight factories, and now to machine

landscapes, these relations indicate the interdependency between architecture and industry, and allow to formulate further spatial entities for production.

Keywords: Mill Buildings, Daylight Factories, Machine Landscapes, Architecture of Production, Labour.



ÖZ

ÜRETİM MİMARİSİ ÜZERİNE BİR ARAŞTIRMA: İMALAHATHANELERDEN MAKİNE BÖLGELERİNE

Güler, İlayda
Yüksek Lisans, Mimarlık
Tez Danışmanı: Dr. Öğr. Üyesi Esin Kömez Dağlıoğlu

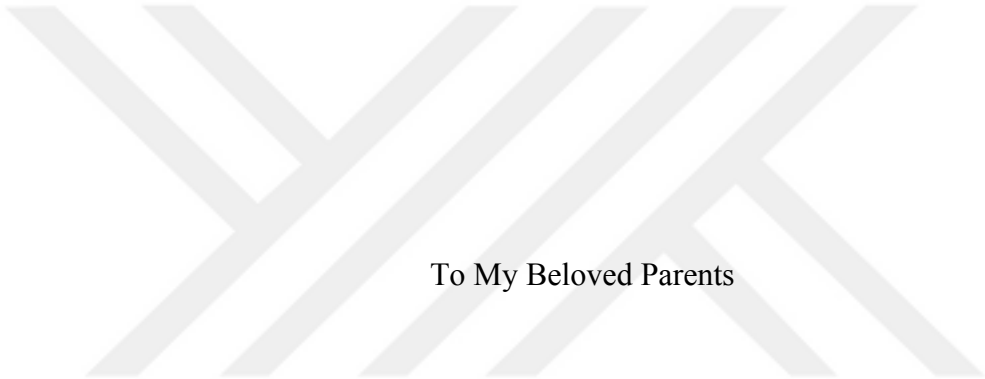
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Antroposen, insan yapımı altyapıların Dünya kaynaklarına hâkim olduğu ve Sanayi Devrimi'nden bu yana ekosistemlere en yüksek düzeyde insan müdahalesinin biriktiği mevcut jeolojik çağdır. Buhar makinesinin kullanımıyla başlayan enerji kaynaklarında ve hammaddelerin çıkartılmasındaki değişim, mevcut üretim araçlarının farklılaşmasına ve endüstriyel faaliyetlerin hegemonyasına yol açtı. Endüstrinin yayılımı ve büyümesi, hızla gelişen üretim, depolama ve dağıtım temellerini inşa etmek için endüstriyi mimarlığın uygulanma aşamasına yönlendirdi. Bu noktadan yola çıkarak, genel bir sistem halinde bu temellerin somutlaştırılmış düzenlemeleri, endüstrinin temel unsurları olan enerji, emek ve teknolojiyi mimarlık söylemiyle ilişkilendirmeyi mümkün kılar. Bu nedenle, bu tez, üretimin evrimi için belirlenmiş üç mimari tipolojiyi -imalathaneler, gün ışığı fabrikaları, makine bölgeleri- tarihsel bir literatür taraması ve birçok örneğin mimari belgesi olan fotoğrafları, çizimleri ve diyagramları aracılığıyla karşılaştırmalı analizi üstünden çalışır. Farklı endüstriyel dönemlerden seçilmiş ve kronolojik olarak organize edilmiş bu örnekler, enerji, emek ve üretim araçları, inşaat teknikleri ve malzemelerle ilgili olarak teknolojinin değişen doğasını yansıtır. Tasarım parametreleri olarak imalathanelerden gün ışığı fabrikalarına ve güncel olarak da makine bölgelerine doğru mekânsal dönüşümü

sağlayan bu ilişkiler, mimari ve endüstri arasındaki karşılıklı bağıllığı gösterir ve üretim için daha fazla mekânsal varlıkları formüle etmeye izin verir.

Anahtar Kelimeler: İmalathaneler, Gün Işığı Fabrikaları, Makine Bölgeleri, Üretim Mimarisi, Emek.





To My Beloved Parents

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realised as an accumulation of various narrations ranging from the memories of my grandfather as a foreman in a textile factory where he met my grandmother and then, raised my mom ve uncle in the lodgement of the factory to the master's thesis of my father who similarly worked on industrial zones. And last but not least, to my many childhood memories while going to the factory with my mother at first to the kindergarten and then to the workshops and laboratories to spend time. Thus, this thesis offers a closure for the dear narrations surrounded the life of our family and a new departure for further studies.



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CHAPTER 1

INTRODUCTION¹

In the beginning of the twenty-first century, an atmospheric chemist and Nobel laureate, Paul J. Crutzen introduced a new geological epoch called the Anthropocene.² Although there are different approaches toward the initial action to surpass the threshold of the Earth's environmental systems and how to define this new epoch from various disciplines, Crutzen raised that the Anthropocene started with the Industrial Revolution and perpetuated its effects for two centuries. He defines the Anthropocene as an epoch in which humans dominate the biological, chemical, and geological processes on Earth through land use changes, deforestation, and high dependency on non-renewable energy sources such as fossil fuels and nuclear energy since the invention of the steam engine.³ The Industrial Revolution radically increased the effluvium (carbon dioxide, methane, nitrous oxide, etc.) due to the utilisation of coal and maintained the rise of human-intrusion to the Earth's ecosystems via industry, however, the 'Great Acceleration' of the Anthropocene occurred in 1945 by the spread of radionuclides over the Earth's surface.⁴ Consensus on the year of 1945 and reality

¹ First outputs of this study was presented in a virtual conference, 2021 ACSA/EAAE Teachers Conference under the title, Curriculum for Climate Agency: Design (in)Action on June 25, 2021. Conference proceedings will be published in the upcoming months.

² Joseph Stromberg, "What is the Anthropocene and Are We In It?", *Smithsonian Magazine*, (January 2013), <https://www.smithsonianmag.com/science-nature/what-is-the-anthropocene-and-are-we-in-it-164801414/>.

³ Paul J. Crutzen, *Earth System Science in the Anthropocene* (Berlin: Springer, 2006), 13-18.

To comprehend in detail, this reference for the open seminar in AA can be viewed.

John Palmesino, Ann-Sofi Rönnskog, Hilary Koob-Sassen, Charlie Kronick, Jan Zalasiewicz and Catherine Russell, "Plan the Planet – Anthropocene: When are we?", Open Seminar in AA Lecture Hall, November 4, 2019, <https://www.aaschool.ac.uk/VIDEO/lecture.php?ID=4148>.

⁴ Clive Hamilton, Christophe Bonneuil and François Gemenne, "Thinking the Anthropocene," in *The Anthropocene and the Global Environmental Crisis: Rethinking Modernity in a New Epoch*, (New York: Routledge, 2015), 1-15.

of the output of nuclear energy made Crutzen to backtrack his initial dating of 1784 as the beginning of the Anthropocene and acknowledged 1945 as the date of huge data spike in human involvement.⁵

Two centuries long and continuing duration of the Anthropocene brought new conditions into the twenty-first century. Exponentially growing industrial activity that started with coal and steam turbines as power sources to the invention of electricity and reliance on fossil fuels and nuclear energy resulted in exceeding level of human intrusion with the increased population. Thence, the threshold of the Earth's ecosystems experienced an expected transgression. In other words, the Earth reached a tipping point in terms of its resources after facing industrial transitions. Therefore, discourses regarding industry and environmental systems cannot be separated in the realm of the Anthropocene.

On January 30, 2020, the World Health Organization (WHO) declared that the outbreak of COVID-19 virus was a Public Health Emergency of International Concern, and then, a pandemic on March 11, 2020.⁶ Covid-19 pandemic caused fundamental changes in living and working conditions and altered how individuals socialise, gather, produce, consume, work, and learn. It introduced quarantines, masks, and distance to the lives of individuals around the world. This pandemic changed means of production and led to “a global recession of a magnitude that has not been experienced before.”⁷ It reverberated across numerous industries and institutions beside the extraordinary load and responsibility it induced on the health sector. Furthermore, the pandemic gave rise to economic disruption particularly in tourism, service sector, and common industries due to the necessitated shutdowns, and also, it had multifaceted impact on environmental conditions and digitalisation. The unknown

⁵ Lesley Le Grange, “The Anthropocene: Becoming-Imperceptible of Environmental Education,” *On Education: Journal for Research and Debate* 2, no.4 (April 2019): 4, https://doi.org/10.17899/on_ed.2019.4.4.

⁶ “Coronavirus disease (COVID-19) pandemic,” World Health Organization (WHO), accessed on April 25, 2021, <https://www.who.int/emergencies/diseases/novel-coronavirus-2019>.

⁷ Marcus Fairs, “Coronavirus offers ‘a blank page for a new beginning’ says Li Edelkoort,” *Dezeen*, (March 9, 2020), <https://www.dezeen.com/2020/03/09/li-edelkoort-coronavirus-reset/>.

duration of the pandemic and each nation's similar yet diverse coping mechanisms accelerated the orientation toward a digital lifestyle such as online meetings, conferences, lessons, and leisure activities as streaming shows and video talks. While shutdowns and incremental digitalisation resulted in clear skies without carbon emissions and pollution stemmed from industrial activities and travel-related energy consumptions, escalating Internet use has hidden environmental footprints to consider in the reality of emergent branches of industry.⁸ Although consumption habits of individuals altered without their awareness due to current conditions of the pandemic, adopted industrial activities rise and continue with their embedded components of energy, technology, and labour. The foremost aspect regarding the industry as it has been observed throughout the pandemic is its adaptation and continuance as a human-built infrastructure in a reciprocal proportion with the resources of environmental systems.

"The infrastructures of conquest, business, and governance have made – and continue to make – the Anthropocene. CO₂ overproduction begins with fuel-burning factories."⁹ This statement validating the direct and continuous relationship between spaces of production and the Anthropocene belongs to a collective study called *Feral Atlas: The More-than-Human Anthropocene*.¹⁰ It was introduced by Anna L. Tsing in the keynote lecture of "Istanbul Unbound: Environmental Approaches to the City" conference on April 8, 2021 that she exemplified the existence of feral entities in the human infrastructural world by referring to their study. *Feral Atlas* emphasizes the magnitude of nonhuman entities for environmental systems and links the causation behind their

⁸ Renee Obringer, Benjamin Rachunok, Debora Maia-Silva, Maryam Arbabzadeh, Roshanak Nateghi and Kaveh Madani, "The Overlooked Environmental Footprint of Increasing Internet Use," *Resources, Conservation & Recycling* 167, (2021): 1.

⁹ "Introduction to Feral Atlas," Feral Atlas Stanford University Press (SUP) Digital, accessed April 9, 2021, <https://feralatlas.supdigital.org/world/acceleration?cd=true&rr=true&cdex=true&text=introduction-to-feral-atlas&tttype=essay>.

¹⁰ Anna L. Tsing, Jennifer Deger, Alder Saxena Kelemen and Feifei Zhou, *Feral Atlas: The More-than-Human Anthropocene* (Stanford University Press, Fall 2020), A Stanford Digital Project, <https://feralatlas.org/>.

emergence within ‘feral’ ecologies that have been surfaced due to human-built infrastructure projects and spread uncontrollably.¹¹ The atlas relates the consequential developments either tangible or intangible as the Anthropocene and examines many field reports from anthropologists, ecologists, historians, and geographers to formulise an understanding of feral ecologies and totality of all relations. For instance, plantations and slave ships became incubators for pests and pathogens that resulted in unknown diseases through the deprivation of space and its convenience for the sprawl of germs and viruses.¹² The exploitation of slaves for the sake of production and growth of industries relied on manual labour enabled the conditions for an urban phenomena of yellow fever to arise through the involvement of non-human entities in human-built infrastructures as feral beings. Similarly, the cholera pandemic emerged as a result of the incremental industrial activity since the nineteenth century and sprawled through trade and advancing methods of transportation. Thus, the interdependency and correlation of events led the study of Feral Atlas and strengthens the assemblages of non-human entities and humans through the extensive investigation of cases and acknowledges the necessity of historical analyses and field-based observations to comprehend with the exigencies of Anthropocene.

Human-made infrastructures have feral effects. In the last 500 years, the planet has been made over by the ecological-transformation projects of long-distance conquest, governance, and investment for the accumulation of wealth. Feral Atlas calls the material features of those projects, which actively remake land, water, and air, ‘infrastructures.’¹³

Since the invention of steam engine marked a beginning for the ongoing industrialisation efforts with a new and efficient model of power supply and transferred the World from Holocene -geological epoch of relatively stable climate

¹¹ Notes from the keynote lecture called “The Particular in the Planetary: Reimagining Cosmopolitanism Beyond the Human” in Istanbul Unbound: Environmental Approached to the City conference by Anna Lowenhaupt Tsing on April 8, 2021.

¹² Tsing, “The Particular in the Planetary: Reimagining Cosmopolitanism Beyond the Human.”

¹³ “Introduction to Feral Atlas,” Feral Atlas Stanford University Press (SUP) Digital.

that started from 11 700 years ago- to Anthropocene, spaces of production and their transformation through industrial periods have been the physical reflections of these changes. Their architecture mirror the conditions of the century in terms of construction techniques, materials, technology, power supply, distribution of power, and etc. The cohesion between parameters of architecture mostly derives from the intricate relations that production spaces hold. In addition to the system of relations involving stages from raw materials to the end product, another agent to regulate architecture of production spaces is labour dialectics. The exhaustive infrastructure industry embodies as elaborated and exemplified through cases of Feral Atlas, notion of labour and struggles inside the production space independent from the branch of industry has been a fixed determinant of its architecture. Although mechanisation and electrification ameliorated the means of production, human agents and their labour were the actualizers of the processes. Thus, it is clear that industry requires advancements of technology and mechanisation to continue production, an enclosure to contain each operation from the storage of raw materials to the transportation of products, and most importantly, labour to actualise and sustain processes. Consequently, every agent of production needs to be integrated to establish a comprehensive understanding of industry and its architectural embodiment as spaces of production. Therefore, this thesis aims to analyse the architectural transformation and evolution of production spaces to unfold the causations of Anthropocene through the relations between energy, labour, and industry.

The vast architecture of the factory is perhaps the only means of translating the immeasurable reality of production into a present and tangible form. From the extraction and transportation of materials thousands of miles away, to the assembling of products and their final distribution across foreign lands, it is the colossal nature of the factory which enables such a particular architecture to represent all modes of industry. Rather than a building, the factory resembles a system of relations that extends far beyond the limits of any enclosure.¹⁴

¹⁴ Francesco Marullo, "Typical Plan: The Architecture of Labor and the Space of Production" (PhD diss., TU Delft, 2014), 103.

As Francesco Marullo emphasizes the colossal nature of the factory to enclose all processes of industry within itself from the initial stage of raw materials to the end-product, he also asserts that intangible components of operations solidify in the physical entity of production. Hence, spaces of production depend on the economical and logistical circumstances, necessities of power and its transmission to machineries, lighting and ventilation systems, articulated layout of operations integrated with workers, and rest of the systematic conditions to assure the required quality and quantity of goods. These constants of industry have been configured under the spatial limitations of architectural practice, restricted knowledge of engineers, and interminable expectations of owners since the Industrial Revolution. Thus, historical overview of production spaces with respect to industrial periods relates the evolution of energy, technology, and labour with architectural discourse. Furthermore, chronologically constituted overview indicates the developmental continuum of industry through its spatial reflections. Industry and revolutions ahead since the eighteenth century represent an accumulating duration of progress in a broadly inclusive spectrum. It encompasses not only ameliorations of technology, energy, and conditions of labour but also, as the historical overview exhorts, the failing aspects of industry.

The effect of continuous innovation, however, is to devalue, if not destroy, past investments and labour skills. *Creative destruction* is embedded within the circulation of capital itself. Innovation exacerbates instability, insecurity, and in the end, becomes the prime force pushing capitalism into periodic paroxysms of crisis.¹⁵

In accordance with David Harvey's perspective on creative destruction, as industry advances from the first Industrial Revolution and utilisation of steam engine to the second by electrification and emergence of assembly line, it fails the upbringing of labour power and development of accommodating spaces of industry. Improvements in the spatial conditions and technological enhancements may create the illusion of a linear evolution, however, introduction of new technology or energy source did not

¹⁵ David Harvey, *The Condition of Postmodernity: An Enquiry into the Origins of Cultural Change* (Oxford: Basil Blackwell, 1980), 105-6.

replace former systems. For instance, electrification did not entirely displace steam engine, dependency on the steam power and seeking for alternative energy sources in consideration of the growth of industry led to the invention of the incandescent electric light bulb, and thus, electricity. In a similar manner, labour power of individuals mechanised with machineries and electrification offered healthier work environments but in the meantime, shifts lengthened due to uninterrupted production conditions. Therefore, relations of energy, technology, and labour do not gradually ameliorate and replace the weaknesses out of production spaces, it sometimes devalues or destroys the past improvements. However, every parameter necessary to embody industry in an enclosure is intertwined with each other and evolve as they find ground on former means and relations of production.

Consequently, the objective of this thesis is to comparatively examine spaces of production through changing sources of energy, technological advancements, and dynamics of labour to interpret the evolution of architectural typologies. In order to form a comparison between these spaces, multiple cases are determined from different industrial periods and territories in many functions and sizes to complement the historical framework structured with the literature survey. Through the chronological guidance initiated with the Industrial Revolution, analysis of the compiled architectural documentation including photographs, drawings, and diagrams of cases and their further editing enable to recognise distinct qualities of cases separating them and categorise them into three architectural typologies of mill buildings, daylight factories, and machine landscapes.

In accordance with the objectives of the thesis, there are three chapters to refer to the predetermined architectural typologies with regard to the chronological timeline of industrial activities. Even though some sources suggest that there are only two industrial revolutions and third one is developing to occur, majority of publications support the existence of four industrial periods and also referred these periods as revolutions (Industry 1.0 – the Industrial Revolution, Industry 2.0 – second industrial revolution, Industry 3.0 and 4.0 follows the same manner due to technological

advancements and industrial transformations).¹⁶ Nevertheless, in this thesis, to avoid theoretical conflict from different disciplines, periods of Industry 1.0 and 2.0 are introduced as the Industrial Revolution and Second Industrial Revolution respectively whereas, Industry 3.0 and 4.0 are attributed as industrial periods even though they are also perceived as revolutions. Therefore, in the body section of the thesis, it continues with three chapters which start with industrial frameworks and followed by altering notions of labour. While characterising the conditions of the related centuries with ameliorations and constraints, each chapter concentrates on the relevant architectural typologies (mill buildings, daylight factories, and machine landscapes respectively). The same pattern in each chapter allow to easily navigate through the historical overview of industry and change in societal dynamics in spaces of production.

After introduction, in second chapter, the Industrial Revolution and prior models of production initiate the historical structure of the thesis and examines mill buildings. These buildings accommodated every stage of the colossal nature of the factory within their boundaries. From the storage of incoming raw materials to the distribution of products, mills were the spatial reflections of industries in the most inclusive configuration. Then third chapter, as aforementioned, starts with the description of Second Industrial Revolution and delves into the characteristics of daylight factories. In a similar structuring of operations with mill buildings, daylight factories also contained each stage to actualise production including storing raw materials, manufactured goods to be assembled, or products to be shipped within its singular entity. To conclude the typologies, in the fourth chapter, machine landscapes are exhibited after the section on Industry 3.0 and 4.0 as current cases of spaces of production and precedents for future spatial developments of industry. However, it is crucial to acknowledge that machine landscapes do not exhibit similar configuration as mill buildings or daylight factories even though they are the current point of destination after years of accumulation of industrial activity. Machine landscapes

¹⁶ Jeremy Rifkin, *The Third Industrial Revolution: How Lateral Power Is Transforming Energy, the Economy, and the World* (New York: Palgrave Macmillan, 2011).

framed in this study illustrate the broad range of architectures of production in Industry 4.0, and since industry evolved, in some of these cases, production does not occur in a material sense, yet storage and distribution of goods took place. The transition from inclusive organisation of each layer in one production space to the dispersed network of industry that are concretised in separate built environments validates the reasoning of the thesis, aim of analysing architecture of production spaces through industrial periods, and exigencies regarding machine landscapes as unknown territories in architectural discourse.

As a last remark, the scope of this thesis does not reside in the social, economic, engineering, or industrial disciplines based on the historical examination of industrial advancements through energy, labour, and means of production, but it is an architectural thesis that comprised of small sections of broad discourses. It values the intricate relations in between energy, labour, and technology that industry incorporates and concretises within its entity through the practice of architecture. Moreover, this thesis tries to include architectural theory in the sphere of industry through analyses of three typologies since the eighteenth century to evidence architecture's unifying nature and necessity to comprehend the dichotomies grounded in spaces of production.



CHAPTER 2

MILLS AND PRELIMINARY FACTORIES

2.1. The Industrial Revolution | Invention of Steam Engine

In the beginning of the eighteenth century, before mechanisation and thus, the Industrial Revolution; products of agriculture, textile, and other industries such as coal mining and metal production were manufactured in small scales, as needed, and based on regions. On the basis of an introductory article, *The Industrial Revolution* by Matthew White; taking British industries into consideration during the early eighteenth century, textile production depending on the spinning and weaving of raw materials was centred either in workshops or in the homes of working individuals in rural settlements. White elaborates on regional production concerning the British industries and asserts that for the metal production, region of Midlands was highly specialised, and coal mining took place in the North-East region. Since there were limited sources of power, industries relied upon waterwheels, windmills and horsepower to sustain their energy requisites.¹⁷ Under these conditions, in 1712, Thomas Newcomen developed the first viable steam engine for the purpose of pumping water out of mine shafts by the principle of atmospheric expansion and condensation to create a vertical beam motion. The operational mechanism of the steam engine was referred as “The Engine for Raising Water by Fire” and illustrated by Sutton Nichols. According to Nichols, although ‘the system of raising water by fire’ put to work in coal mining, it had some deficiencies which caused it to be

¹⁷ Matthew White, “The Industrial Revolution,” British Library, Georgian Britain Articles (October 14, 2009), <https://www.bl.uk/georgian-britain/articles/the-industrial-revolution#>.

expensive, limited in its application (approximately ten strokes per minute), and eventually too weak to be employed.¹⁸ Therefore, even though steam engine was developed in 1712 by Thomas Newcomen, it was revolutionised by James Watt, a tool maker (engineer) in years between 1764-85 and led to the Industrial Revolution itself.

In 1763, Watt was entrusted to prepare a model for steam engine and ideally, an efficient one to ease the manufacturing process in certain industries. He identified the issue inducing Newcomen's model to be inefficient as a thermal energy loss caused by rapidly cooling of steam in the cylinder.¹⁹ Hence, Watt improved the existing model in a way that it used less coal to generate more energy by adding a condenser outside of the cylinder. This way condensation activity substantiates in a separate and perpetually cooled chamber; whereas, steam condenser accelerates, and the cylinder remains constantly hot.²⁰ Consequently, Watt's steam engine succeeded rotary motion after it was built out of iron, and progressively initiated a new era in power generation. "... and all this machinery was made doubly important by James Watt's steam-engine, invented in 1764, and used for supplying motive power for spinning since 1785."²¹ The Industrial Revolution, started in England and spread around other countries in time, marked a new epoch with the introduction of steam engine in many industries, and pave the way for further advancements.

Sixty, eighty years ago, England was a country like every other, with small towns, few and simple industries, and a thin but *proportionately* large agricultural population. Today it is a country like *no* other, with a capital of two and a half million inhabitants; with vast manufacturing cities; with an industry that supplies the world, and produces almost everything by means of the most complex machinery; ... The industrial revolution is of the same importance for England as the political revolution for France, and the philosophical revolution for Germany; and the difference between England in

¹⁸ Sutton Nicholls, "A Description of the Engine for Raising Water by Fire," illustrated in 1725, located under title of "Early 18th century Depiction of a Steam Engine," Collection Items, British Library. Received online September 7, 2020, <https://www.bl.uk/collection-items/early-18th-century-depiction-of-a-steam-engine#>.

¹⁹ "Uncover the Mechanism for James Watt's Steam Engine," Britannica, accessed September 7, 2020, <https://www.britannica.com/video/180124/James-Watt-steam-engine>.

²⁰ Ibid.

²¹ Friedrich Engels, *The Condition of the Working Class in England* (New York: Penguin Books, 1886), 54.

1740 and in 1844 is at least as great as that between France under the *ancien régime* and during the revolution of July.²²

As Friedrich Engels, a political philosopher, asserts the magnitude of the Industrial Revolution for England in his book, *The Condition of the Working Class in England*, he reveals how steam engine and development of new machineries built up a country like no other in the nineteenth century. Industry as a means of production, channel of income and energy was not emerged with the Industrial Revolution; it existed in few and simple manufacturing facilities within mostly agrarian population. Yet, industry was transformed from the level of craftsmanship to mechanisation by the revolution, and thus, acts of labour started to assimilate in various notions of work. Industry gave way to vast cities filled with increased and diversified population by terminating small scale, according to need production, and self-sufficiency of rural inhabitants. The utilisation of steam as a power source in the development of machineries not only changed the quality and quantity of production, but also, accelerated the coal and iron industry, as well as textile and agriculture. The progress in coal and iron industry affected other fields such as construction, rail, and water transportation. In the process of advancing industries, be acquainted of new materials and techniques, there arose the necessity of assembling all machines under the same roof, in a factory. Therefrom, nineteenth century mill building typology in architecture started to appear.

2.2. Labour | Main Drive of Production

Before elaborating on the mill buildings, labour-power as the primary component of the means of production requires an assessment to incorporate relations in production,

²² Engels, *The Condition of the Working Class in England*, 61.

storage, and distribution spaces. In the absence of labour, mechanisation alone would not be sufficient to realise an industrial revolution but with the labour-power of individuals, industry exponentially grew in an exploitive manner. Labour, in spite of its simplest and inadequate dictionary definition as work, is thoroughly theorized discourse with contribution of many individuals. There are disparate definitions and perspectives regarding labour since it equates itself to life through the acts of mankind, not solely work. Starting from ancient times to the Industrial Revolution, and concurrently the generation of the proletariat and to the twenty-first century; labour exists in the constant struggle of living. “Men are generic beings. Not having a nature, they constantly produce themselves and their own environment. Labor is their life-engendering activity: the struggle to become and persist into being.”²³ As Francesco Marullo proposes in his doctoral thesis that labour is the life-long activity of creating an individual and a surrounding environment, through this proposition, two separate definition of labour can be referred by Hannah Arendt and Karl Marx. Thence, both approaches need an inclusion in this part to evaluate further relations of labour with production spaces and their architecture.

In many publications whether books, journal articles, or manifestoes that Karl Marx had written as a single author or with a collaboration, he weighed on the importance of upheaval of society, not solely in religious or political layers, but also, in societal and economic balances. He concentrated on labour itself and wrote against the growth and spread of dichotomies as tools for exploitation.²⁴ These dichotomies can be exemplified as the proletariat and the bourgeoisie, craftsmanship and mass production, labour and labour sans phrase, base and superstructure, etc. Origins of these dichotomies were predicated by the inevitability of economic modernization, and also,

²³ Marullo, “Typical Plan: The Architecture of Labor and the Space of Production,” Propositions, I.

²⁴ *The German Ideology* (written in 1845-6, published in 1932), *The Communist Manifesto* (1848), *The Critique of Political Economy* (1859), *Value, Price and Profit* (1865), *Capital – Volume I* (1867) are some of the sources mentioned in which Karl Marx thoroughly elaborated on means and relations of production with statistical data and case studies.

the Industrial Revolution and following industrial advancements accelerated the process, even if not initiated.²⁵

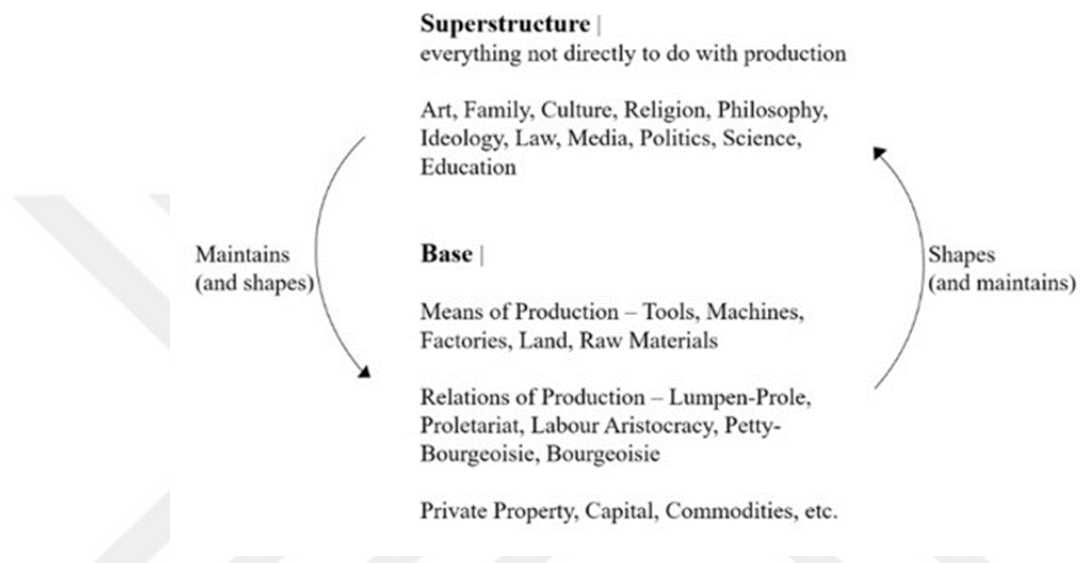


Figure1. Diagrammatic Relationship of Marxist Distinction between Base and Superstructure. In the distinction, base adverts means and relations of production as well as private property, capital and commodities. Means of production include tools, machines, factories, land and raw materials whereas, relations of production attribute proletariat, bourgeoisie and labour aristocracy. While base comprises of everything related with production, content of superstructure is the opposite. It consists of ideology, art, family, culture, religion, philosophy, law, media, politics, science and education. Base shapes superstructure and superstructure maintains base in return. This dialectic relationship eases to understand how base and superstructure find balance with each other.²⁶

²⁵ In comparison, Hannah Arendt embraced the minatory nature of economic modernization to the human world with the capability to destroy stability as Marx pointed out, however, she did not place confidence in its inevitableness. According to Arendt, there exists a misconception in political philosophy that sources from traditions of Western political thought and to comprehend the existence of a misinterpretation differs Arendt's attitude from Marx. Hannah Arendt believed political action cannot be associated with making since it dismisses the plurality of individuals. She did not support the foresight of individuals revolutionizing for the realm of freedom due to every distinct individuality among collective life of a society. Therefore, their definition of labour differentiates from each other, and Marx's perception of labour better fulfil the dynamics in the production space.

²⁶ This diagrammatic relationship refers to Marxist distinction between base and superstructure which grounds itself in *The German Ideology*, a book by Friedrich Engels and Karl Marx. It was written in 1845, however published in 1932.

One of the most prominent and fundamental of compiled dichotomies is Marx's distinction between base and superstructure which indicates a dialectical relationship to sustain balance between agents.²⁷ The dialectical relationship between the base and superstructure reifies Marx's view of the indicative role of production in societal relations, and emphasizes the contradiction arising between forces and relations of production through historical advancements regarding industry.

For Marx man is the only animal able to negotiate with the eternal traits of his species and the contingencies of his immediate life at the same moment. The human 'labor-power' represents the constant development of such an innate biological indeterminacy, which allows man to become what he is and everything he aspires to.²⁸

Marx valorised labour as the strength of 'man'; vast source of possibilities offered to 'man' to explore both as an individual and a collective to sustain the constant struggle of being and becoming in a restricted surrounding. Labour of each individual and its collection in a society define its subjects. Nevertheless it holds a Janus-faced entity due to production and consumption equilibrium that shifted with the Industrial Revolution. Once the introduction of machinery coincided with capitalist incentives, the instrument of labour became the material embodiment of capital in production spaces and provoked an antagonism between labourer and the instrument of labour. If machineries were freed from the service of capital, then they would shortened the hours of labour and lightened the workload.²⁹ However, in service of the capital, machineries competed with manufactures of craftsmanship, and converted labour-power of individuals into forced instruments of production. "The object of improved machinery is to diminish manual labour, to provide for the performance of a process

²⁷ For the description of base and superstructure, a study titled *Is Architecture Part or Parcel of Capitalism?* prepared for the course ARCH526: Politics and Space is referred. ARCH526 course is coordinated and instructed by Prof. Dr. Güven Arif Sargin, and the written work has been developed in Spring2020. For explaining base and superstructure distinction, it is referred.

²⁸ Marullo, "Typical Plan: The Architecture of Labor and the Space of Production," 28.

²⁹ Karl Marx, *Capital Volume I*, ed. Friedrich Engels (ElecBook London, 2011), 634, Adobe Digital Editions.

or the completion of a link in a manufacture by the aid of an iron instead of the human apparatus.”³⁰ Therefore, relations of production gained the proletariat, and their manual labour integrated with machineries was denoted as work in production spaces due to the mechanisation.

The history of the proletariat in England begins with the second half of the last century, with the invention of the steam-engine and of machinery for working cotton. These inventions gave rise, as is well known, to an industrial revolution, a revolution which altered the whole of civil society; one the historical importance of which is only now beginning to be recognized. England is the classic soil of this transformation, which was all the mightier, the more silently it proceeded; and England is therefore, the classic land of its chief product also, the proletariat.³¹

The narrative in production spaces altered, wage-labourers started to be referred as workmen or working class and their labour was framed as work. The subtle transition of labour to work, in other words, near disappearance of labour notion to perceive labourers as workers to deprive them from their potential and power continued as production and industry evolved. The shift at the base of the distinction in terms of means and relations of production shaped the path of capitalism, yet the Janus-faced nature of labour struggle maintained the working class. According to Marx, the pressure of the working class can dominate the development of capitalism and its higher forms of integration, advanced processes of production and systems of valorization were reactions against the struggle of labour force.³² On the one hand, labour force of the working class coalesced to determine the evolution of capitalism through strikes and disorders which obtained a place in the production sphere and altered the architecture of production spaces. On the other hand, the architecture of production spaces became an apparatus of capitalist exploitation to be further elaborated in subsequent sections of the study.

³⁰ Marx, *Capital Volume I*, 621.

³¹ Engels, *The Condition of the Working Class in England*, 50.

³² Marullo, “Typical Plan: The Architecture of Labor and the Space of Production,” 8.

As the latter publication in time, Hannah Arendt's *The Human Condition* offers a variant definition of labour from the rooted foundation of political discourse against the economic modernization. *The Human Condition*, a kind of prolegomena according to its author, defines and thoroughly elaborates three terms to explain how humans exist, survive, and create their own conditions to adapt in the existing ones of the earth.³³ Arendt defines labour as the totality of activities that the human body goes through such as birth, growth, metabolism, and unavoidable decay to fulfil the vital necessities of life.³⁴ In contrast, she identifies work as activities to create artificial things which are considered as manifest to human existence due to unnaturalness.³⁵ "... the artificial world of objects that human beings build upon the earth."³⁶ Although this distinction between labour and work does not correspond to the transition of labour into work in production spaces, it draws a line between the two notions. Arendt excludes labour from the sphere of production by attributing labour as the life itself. However, in a similar manner with dictionary definitions, Arendt's definition of labour remains deficit in the context of production spaces and their architecture.³⁷ It lacks labour struggles throughout industrial revolutions while centring upon human conditions in a general manner, therefore Marx's definition of labour and introduction of capitalism in the production and consumption dynamics offer a clarification for labour and its relevancy in the architectural discourse upon production spaces.

³³ In this part of the paper, a study titled *Labour in Architectural Discourse: Examination of Labour Spaces* prepared for the course ARCH724: Architecture and Discourse is referred. ARCH724 course is coordinated and instructed by Assoc. Prof. Dr. Inci Basa. *Labour in Architectural Discourse: Examination of Labour Spaces* is a study developed as a term paper for the course in Spring 2019. For explaining labour and work, it is referred.

³⁴ Hannah Arendt, *The Human Condition* (Chicago: University of Chicago Press, 1958), 7.

³⁵ Ibid.

³⁶ Canovan, "Introduction," ix.

³⁷ Arendt's perspective has formed with consideration and at the same time in defiance of Marx. Despite their difference of opinions, Arendt agreed in the inevitability of processes of production and consumption and their constant effect on human life through increasing correlation to automation. The main diversion in between their perspectives relied in the genericness versus specificness of the issue. They both valued the base of craftsmanship and borrowed its terminology, yet Arendt distanced herself from solely labour to convene a general understanding of labour, work and action, human conditions as she perceived.

The process always starts afresh with production. That exchange and consumption cannot be the decisive elements, is obvious, and the same applies to distribution in the sense of distribution of products. Distribution of the factors of production, on the other hand, is itself a phase of production. A distinct mode of production thus determines the specific mode of consumption, distribution, exchange and the specific relations of these different phases to one another... Production is, finally, determined by the demands of consumption.³⁸

Therefore, on the established grounds of the base, affinity of the means and relations of production substantiates the relevancy of labour in the context of architecture of production, storage, and distribution through primarily Marx's definition of labour.

2.3. Mill Buildings of the Nineteenth Century



Figure2. Photograph of Old Woolen Mill (1812) on the grounds of the duPont Powder Works. The building now accommodates the Hagley Museum in Greenville, Delaware.

³⁸ Karl Marx, "Introduction to a Critique of Political Economy," in *The German Ideology*, ed. C J Arthur (ElecBook London), 192, Adobe Digital Editions.

The nineteenth century industrial landscapes were mainly dominated with mill buildings; long, narrow, multi-storey buildings constructed with masonry or wood, and powered by a water wheel early in the century, then steam engine until the twentieth century.³⁹ An abrupt appearance of one building, a factory, generally typified by a mill building in the nineteenth century was drawn by the motive of the Industrial Revolution and limitations of the century. “The mill building style accommodated most manufacturing operations of the period and became the standard factory building, merely built large or small according to a company’s production volume.”⁴⁰ Industry required central power system to generate energy for machines, workers to operate them, sufficient amount of light for workers to assess the quality of products, and above all a building to fit every part in. Thus, three main concerns came into existence for the organisation and design of mill buildings: power distribution, construction, and lighting.

In the first half of the nineteenth century, one of the most restrictive part out of this three was the power transmission technology; how to supply power for either one or more floors of the building and to plan a network of gears and shafts for the process of carrying power from water wheel to each machinery.⁴¹ Rather than generation, power transmission and distribution process was the problematic part, and planning of it guided the running of the building. It led to the segregation of operations by floor and arrangement of machines in rows.

³⁹ Lindy Biggs, *The Rational Factory: Architecture, Technology, and Work in America’s Age of Mass Production* (London: The John Hopkins University Press, 1996), 18-20.

In the early beginning of industrialism, production spaces were relatively small compared to further spaces at the end of the nineteenth century, and powered by a water mill, which produces energy by the mechanical process of a water wheel. Since this action was commonly adopted for the purpose of generating energy to power machines in the nineteenth century, production spaces were called mills. However, by the course of time with advanced machineries and enlarged spaces for production, mills transformed into factories (larger complexes powered by steam engine and later electricity). Yet it is crucial to acknowledge that they are similar in their functions as buildings where manufacturing and production processes occur.

⁴⁰ Ibid.

⁴¹ Biggs, *The Rational Factory*, 19.

The water wheel or steam engine turned a vertical shaft that extended upward through each floor and connected to a cumbersome system of shafting, gears, and belts to deliver energy from the power source to individual machines. On each floor a line shaft, attached to the ceiling, connected to the main shaft and extended the length of the floor; it turned as the main shaft turned. Belts and gears, attached to the line shaft, powered individual machines. Machines had to be placed parallel to the shafting, and the shaft turned constantly.⁴²

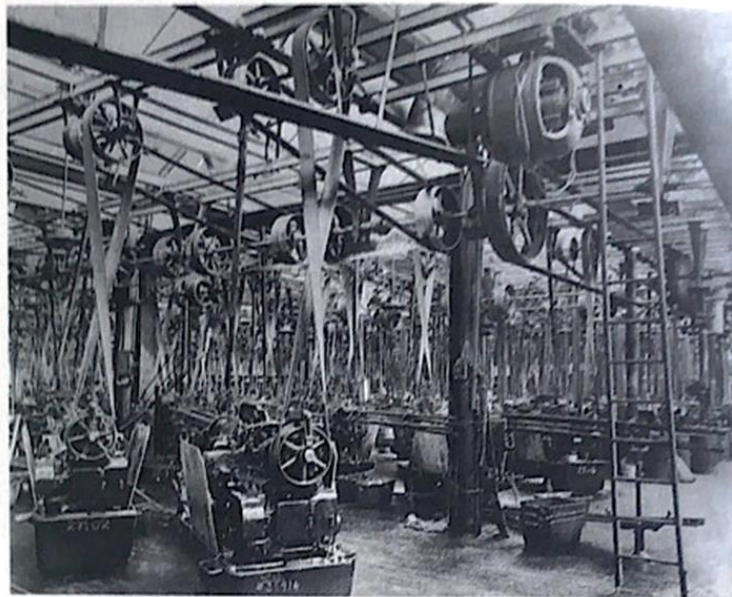


Figure3. Working Mechanism and Organisation of Machines with Belts and Gears, Photograph of Acme Screw Machine Company Machine Shop.

⁴² Biggs, *The Rational Factory*, 85.



Figure4. Photographs of two Distinct Mills, Unoccupied versus Occupied (On the left, Clinton Mill in Rhode Island, operated in between 1849-76 and brief periods as a textile mill and discount store until 1960's. On the right, Woonsocket Company Mill 2 in Rhode Island, operated since 1833 under the ownership of many companies in textile industry.) Both photographs were taken in 1969. Long and narrow structure of mills while being visible, from the photographs, comparison of natural and artificial light can be made, and from the number of artificial light fixtures in Woonsocket Company Mill 2, its necessity for the production process can be detected.

In addition to power issues reflecting on the interior organisation of the building, concern of lighting, also projected itself on the working environment as another layer. During the nineteenth century, for the purpose of lighting, factories mostly depended on natural light and gas lighting (oil light) as supplementary. Textile mills that were one of the most rapidly enlarged and mechanised industry of the century, in particular, relied on natural light to see and control their products because artificial light was not ideal due to its illumination radius and competence. However, in cloudy weathers and short winter days, factories resorted to artificial lighting for the continuance of production.⁴³ Lighting needs and preference of natural light affected design of buildings, not solely in the interior spaces, but also, in terms of size, facades, and directions. Design of factory buildings prioritised the amount of sunlight they can capture on the shop floor; so rather than wide buildings where centre section would

⁴³ Biggs, *The Rational Factory*, 19.

generally be dark, narrow buildings were built.⁴⁴ Minimized width dimensions and arrangement of directions of the building helped factories to make use of natural light as much as possible in the limited construction technology of the nineteenth century. Since in the nineteenth century, buildings were constructed out of either wood, masonry, or combination of two, mill buildings were built by wood or masonry. Thus, walls were mostly load-bearing and high in thickness that caused facades of the building to be designed to capture light while providing a safe working environment (stable walls, weather protection, proper amount of ventilation) by measures and placements of windows.

The Durfee Mill in Massachusetts, typical for its time, was built in 1875 by mill engineer Frank P. Sheldon. It consisted of a five-story stone building, 376 feet 6 inches long and 72 feet wide. The first-story walls were 2 feet 6 inches to 3 feet thick; the second-story walls were slightly less thick, measuring 2 feet 6 inches to 2 feet 8 inches; upper-story walls continued to narrow until the fifth story, where they were 1 foot 10 inches thick. The size of the windows followed the same pattern: all were 4 feet 5 inches wide, but their height decreased from 8 feet 4 inches on the ground floor to 7 feet 4 inches on the fifth.⁴⁵

⁴⁴ Biggs, *The Rational Factory*, 19-20.

In average mill building while length of the building depended on the production needs and rate, width of the building measured approximately 30 feet (9.1 meters).

⁴⁵ Ibid.

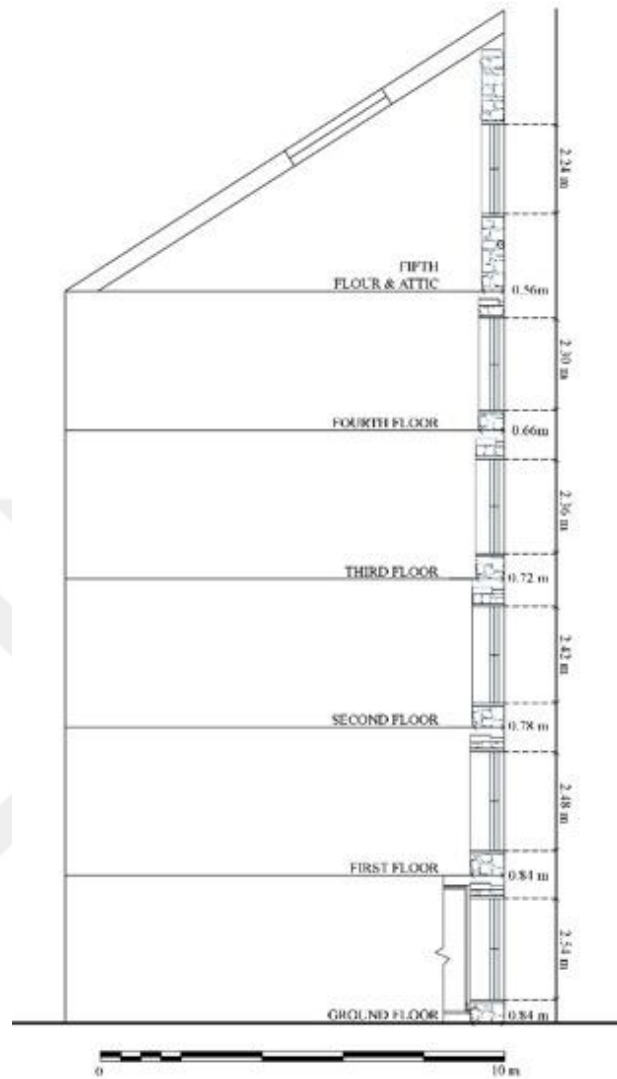


Figure5. Semi-wall section of Mill No.2 in Durfee Mills in Fall River, Massachusetts, highlighting the change of wall thickness and height of windows. Drawn by the author.

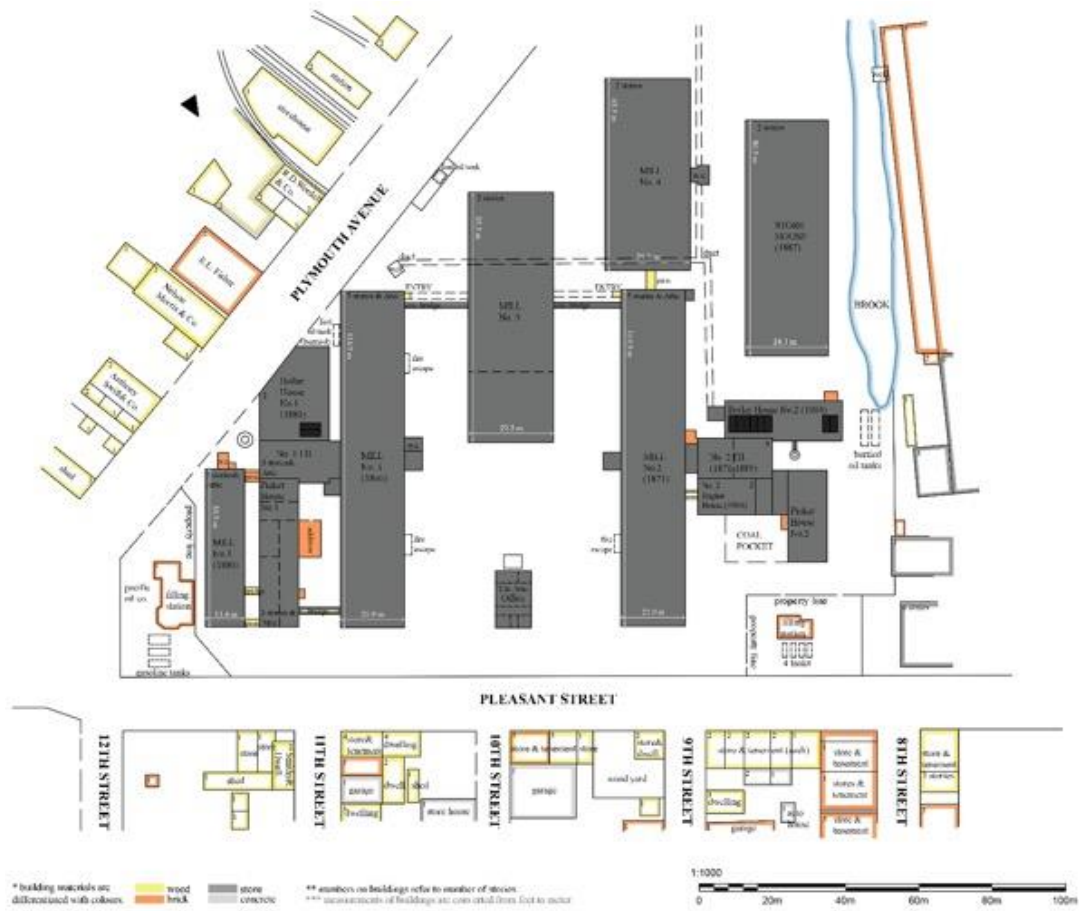


Figure7. Site Plan of Durfee Mills in Fall River, Massachusetts (with material information and measurements), redrawn by the author based on the insurance map surveyed in 1925.



Figure8. Aerial Photographs of Durfee Mills, August 1968, Toward North (left) and Southeast (right) capturing all buildings with their surrounding environment.

Concurrently with industrial developments in the nineteenth century, organisation and running of factories were started to be examined to increase commercial success and profits. One approach that some owners, engineers, and builders embraced was to consider the factory as a whole rather than a space for machines and workers. It is the entity containing all operations, materials, and knowledge; yet itself is the greater machine to be planned and designed. Even in the eighteenth century, this view was believed in as a powerful metaphor and an ultimate aim for industrial improvements. Engineers spent more than a century to plan a factory working like a machine with the minimized labour turnover, maximum efficiency, and efficient use of materials until the twentieth century. Although the consequences over time of these efforts were disputable, engineers' work was to rationalise every process to be more efficient, including workers' routines and behaviours.

Rationalization has been described as systemizing, as centralization, as deliberate and careful planning toward a specific goal, as planning that will allow a business to function in a predictable and secure environment... *Rationalization* in industry has a more specific meaning: it refers to the introduction of predictability and order – machinelike order – that eliminates all questions of how work is to be done, who will do it, and when it will be done.⁴⁶

As Lindy Biggs, an associate professor of history, defines rationalisation in her book, *The Rational Factory: Architecture, Technology, and Work in America's Age of Mass Production*, she introduces her own interpretation of a factory. Rooted in mechanistic philosophy of the Enlightenment: decisions or activities based on reason, standardised, scientific, predictable, machinelike; Biggs denotes the envisioned great machine as the rational factory. "The Rational Factory is an examination of an idea as it developed from the end of the eighteenth century to the early twentieth century and of the engineers who used the idea as they built new factories."⁴⁷

⁴⁶ Biggs, *The Rational Factory*, 6.

⁴⁷ Ibid.

Biggs exemplifies the first rational factory in the United States as an automatic flour mill designed in the 1780s by Oliver Evans, an inventor, and patented his design later a decade.⁴⁸ Even though owners, engineers, and builders aimed to rationalise every movement in the factory and mechanise each process possible to provide predictability for over a century, Evans had already designed an automatic mill in the eighteenth century. It ensured a prior knowledge for many industries ranging from meatpacking, printing of newspapers, textile to automobiles.

2.4. Textile Mills and Primary Developments

Weaving, earlier carried on in the country by the peasants as a secondary occupation to procure their clothing, was the first labour to receive an impetus and a further development through the extension of commerce. Weaving was the first and remained the principal manufacture. The rising demand for clothing materials, consequent on the growth of population, the growing accumulation and mobilisation of natural capital through accelerated circulation, the demand for luxuries called forth by the latter and favoured generally by the gradual extension of commerce, gave weaving a quantitative and qualitative stimulus, which wrenched it out of the form of production hitherto existing.⁴⁹

Textile in the nineteenth century was one of the most enlarged and mechanised industry by the motive of the Industrial Revolution as Karl Marx asserted in *The German Ideology*. Depending on the need and demand, textile industry rapidly sprawled in England as well as other countries. Many textile mills started to appear in the industrial texture of the century, and the dissemination of mills in other countries brought both similarities and differences in the architectural module of mill building

Biggs explores the concept of rational factory based on diverse sources on definitions of rationale, rational, and rationalise supplied with extended research about mechanisation and factory organisation. She mainly focuses on the growth of Ford Motor Company in the first half of the twentieth century.

⁴⁸ Biggs, *The Rational Factory*, 8.

⁴⁹ Marx, *The German Ideology*, 104.

typology. Due to many reasons such as cultural differences, economy, politics, management styles, etc. architecture of mill buildings undergone some changes while organisation model in the initial stages reflected variations of “typical plan.”

... long before the industrial revolution and the rise of mass production, the particular convergence of technical rationality, military representation and civic organisation produced a first modern formulation of the typical plan as a technical device to administer space at any scale, from the single tool to the city at large.⁵⁰

The typical plan is the most deployed yet the least theorized architectural apparatus.⁵¹ Primarily, it had emerged for the configuration of settlements in terms of walls surrounding the perimeter of cities as military fortifications, and then, for organisation of public buildings with the Renaissance utilitarian architecture. “...a ‘technical frame,’ which would be gradually assessed during the 18th and 19th century in the passage from the manufacture to the factory.”⁵² Through structural simplification and projection of the abstraction of intricate dynamics onto the architectural floor plan of an enclosure, the typical plan constitutes what it contains and what it performs by acting as an index.⁵³ Its incompleteness allows typical plan to be an empty layout to position any necessary part of a whole to exist and fulfil through the collaboration of architecture, abstraction and function.

To exemplify the variation of typologies for mill buildings, textile mills in England and Germany (two leading countries in industry) can be examined. They differed in terms of floor plans, gateways, and circulation based on the surveillance strategies and organisation of production. Richard Biernacki, a sociologist and labour historian,

⁵⁰ Marullo, “Typical Plan: The Architecture of Labor and the Space of Production,” 25.

⁵¹ Though the dependence and utilisation of the typical plan started even before the Industrial Revolution, it was conceptualised and coined as an architectural agent in 1993 by Rem Koolhaas. Rem Koolhaas (founder of Office for Metropolitan Architecture, OMA) elicited the notion of a typical plan in a short text while analysing the repetitive homogeneity of the twentieth century Manhattan office buildings in his book, *S, M, L, XL*. Koolhaas’ inclination toward these office buildings relied mostly on their layouts, which progressively evolved with the development of financial capitalism and became emblems of utmost indeterminacy restricted in a space. The required space, to own and adapt itself to the fluctuations of the growing market had to be configured in an architectural frame, that is typical plan.

⁵² Marullo, “Typical Plan: The Architecture of Labor and the Space of Production,” 73.

⁵³ Marullo, “Typical Plan: The Architecture of Labor and the Space of Production,” 4.

reviews floor plans and circulation schemes of mill buildings located in England and Germany in his book, *The Fabrication of Labor: Germany and Britain, 1640-1914*, to form a comparative study on the cultural specifications of labour as quantifiable, monetised, and marketable commodity in two countries.⁵⁴ Biernacki describes that working places were organised with regard to two countries' understanding of labour power. In Germany, the working day was defined by the use of actual labour-time in the production process whereas, in England, it was defined by the presence of workers in the factory.⁵⁵ Sourcing from the dissimilar appropriation of labour, British textile mills were resembled fortress-like structures with only one entrance to the factory to be in control of punctuality and presence of workers. On the other hand, textile mills in Germany had multiple entrances and various circulation points since they valued time and emphasized the presence of workers on the machines operating rather than their presence within the space of employment.

Technical manuals of the nineteenth century treated the selection of mill architecture as part of the 'science' of manufacturing. Modern British woollen and worsted mills stereotypically were arranged like closed, defensive fortresses: the various rooms for spinning, for assembling the warps, and for weaving formed a ring enclosing a central courtyard or 'mill yard.' The entrance gate, often set under an archway, offered the only opening from the outside that led into this yard and into the workrooms. Otherwise, the factory presented a solid barrier to the surrounding world, sometimes with no windows on the ground floor.⁵⁶

⁵⁴ Tilo Amhoff, "The Electrification of the Factory: Or the Flexible Layout of Work(s)," in *Industries of Architecture*, ed. Katie Lloyd Thomas, Tilo Amhoff and Nick Beech (London and New York: Routledge, 2016), 269.

⁵⁵ Ibid.

⁵⁶ Richard Biernacki, *The Fabrication of Labor: Germany and Britain, 1640-1914* (California: University of California Press, 1995), 128-30.

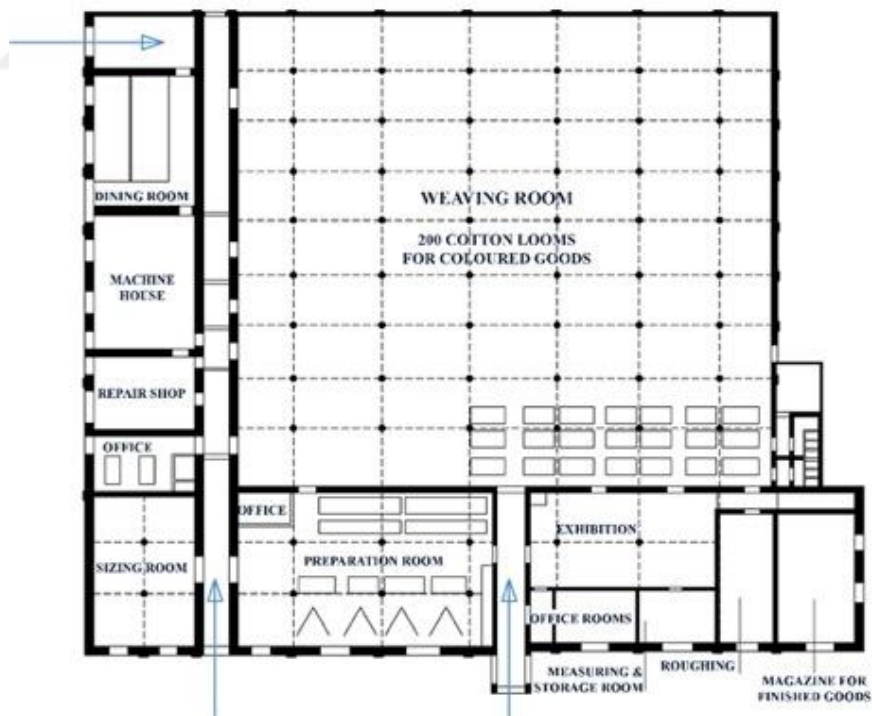
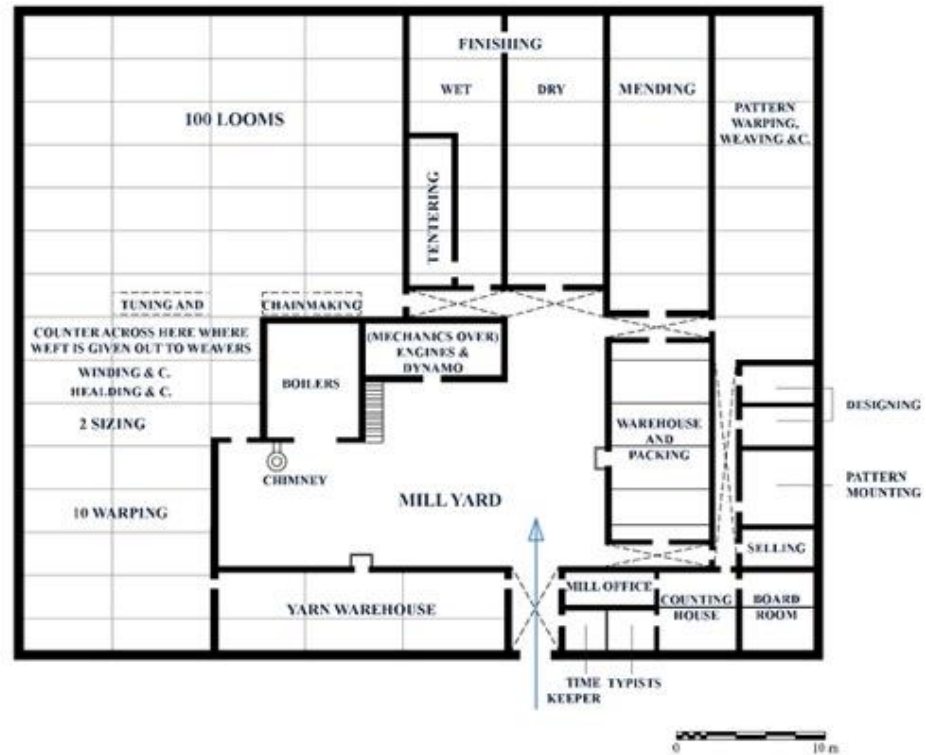


Figure9. Model British and German Weaving Mill -respectively-. Arrows to indicate entrance points of the mills are added on the redrawn model plans by the author. Different number of gates as well as the interior configuration of production spaces show British and German dissimilar appropriation of labour.

The reason behind the fortress structure development for enveloping design was to demark owner's territory and guard against possible intrusions. Hence, in urban areas due to the high likelihood of these concerns, fortress-like industrial developments were more common than in the isolated rural areas. Nevertheless, it was accepted as an architectural stereotype and a representative of British thinking. Independent from land values, landscape, and infrastructure, fortress-like industrial complexes realised in various geographies. "For example, in his treatise on mill construction William Fairbairn presented a blueprint for building woollen factory in the open countryside of a foreign country, Turkey."⁵⁷ British mills were designed around a courtyard (mill yard), a nodal point where all workrooms opened up to and circulation of the mill always flowed through. It also utilised as a storage and unloading area for products and raw materials. Following the modular rule that courtyards in fortresses implemented on the whole building, the length and width of the main hall changes and the positioning of access points and staircases settle to reduce spatial proportions from main hall to other rooms.⁵⁸ With this information in mind, structurally simplified plan of the mill centred by a mill yard and reduced circulation durations to access work rooms reflect the qualities of an actual fortress settlement, and thence, the floor plan evokes specific qualities of typical plan in its figure-ground relationship model. The modularity and simplicity of the plan of model British weaving mill interprets a variation of the typical plan in response to the appropriation of labour in the work environment. Since priorities in the work environment lies heavily on being punctual and present, typicality of the plan of this mill generated from the mill yard, a void surrounded with the work rooms. Thus, after entering from the main gate (only gate) into the mill yard, both workers and goods gather in and disperse from the yard. By the design of a fortress structure and inclusion of a mill yard, British mills surrounded their perimeter while allowing rapid movement and exchange in the inner areas. In

⁵⁷ Biernacki, *The Fabrication of Labor: Germany and Britain, 1640-1914*, 131.

⁵⁸ Marullo, "Typical Plan: The Architecture of Labor and the Space of Production," 47-51.

addition, active mill yard that all workrooms faced to, and a single gateway eased the general surveillance of workers within mill boundaries.

Although German textile mills followed the English methods of power transmission and distribution, they structurally and plan-wise differed themselves.

Rather than arrange workrooms as a fortress to accentuate the frontier between outside and in, the German facilities emphasized the constriction of movement once laborers were engaged in the labor process. Except for the essential transport of materials, the German building layout segregated the principal workrooms from each other and from the ancillary rooms that housed processes such as carding raw cotton or preparing warps for the looms. Moving from one corner of the mill to another required workers to proceed through intermediate chambers of the interior... In contrast to the British mills, traffic does not converge on a nodal point but flows among links on a chain.⁵⁹

As necessitated by time, engineers studied on methods to rationalise textile mills, beginning from the arrival of raw materials into the factory to its efficient movement through various manufacturing processes and output as a product. Even though developing textile mills in the nineteenth century either located in Germany or England were not considered as a rational factory regarding to Lindy Biggs's denotation, they were the initial stages of it. When former mills became inadequate and amount and size of machines increased in the second half of the century, fortress-like mills in England experienced an architectural change by the efforts of owners and mostly engineers (employed or consultant). Previously segregated workrooms to form the fortress wings, separate workers from each other, and enable direct surveillance of each department needed to be unified to accommodate enlarged machines and thus, escalated numbers of machineries and workers. Unifying separate spaces and creating an extended workroom led up to improvements in the construction methods and materials. "The introduction of steel girders and new techniques for supporting weight in the 1890s permitted the development of huge, squarish rooms that used space efficiently but were no longer arrangeable around a yard."⁶⁰

⁵⁹ Biernacki, *The Fabrication of Labor: Germany and Britain, 1640-1914*, 135.

⁶⁰ Biernacki, *The Fabrication of Labor: Germany and Britain, 1640-1914*, 140.

In conclusion, textile mills built in the leading industrial countries of the century diversified from each other while utilising same methods of power generation and transmission. German textile mills portrayed a cellular design in contrast to circumferential design of British mills (based on the significance of outer boundaries).⁶¹ Two distinct versions of typical plan, which differentiated with the priorities of two separate cultures and labour appropriations enhance the presence of the least theorized architectural index for the configuration of production spaces, and its infinite possibilities to be generated with changeable concerns, priorities and conditions. In spite of the differences in design, they were steps in the industrial developments and rationalisation. Every formation represented an iteration of advanced technology, plans of engineers and construction methods, and concretised structures of industry were milestones to narrate these changes. Rather than a specific perspective regarding textile industry, this understanding applied to industry and its realised buildings in general. For instance, meatpacking industry was one of the first industries to adapt Oliver Evans's strategy of mechanising flour mill after over a century.

By the end of the nineteenth century, individuals concerned with advancements of industry, introduction of new technology and materials, and growth of industrial complexes and production volumes realised that the most important concern was the planning of operations.

Special-purpose machines were already helping to build guns, sewing machines, bicycles, and other goods, and handling technologies were revolutionizing the processing industries. In many industries a new kind of engineer also knew that mechanization had to go farther than special-purpose machines, beyond individual operations.⁶²

⁶¹ Biernacki, *The Fabrication of Labor: Germany and Britain, 1640-1914*, 141.

Diagrammatic floor plans of British and German textile mills with circulation maps can be found in appendix as Figure 3, 4, 5, 6 and 7.

⁶² Biggs, *The Rational Factory*, 35.

As Lindy Biggs expresses by the end of the century, industrialists figured machineries fell short and the key to success of their production depended on the ways to organise the shop floor, coordination of processes, and the plan of turning raw materials into products. The plan of manufacturing and production mirrored itself on the architectural floor plan in the twentieth century after the Second Industrial Revolution in the form of daylight factories.





CHAPTER 3

DAYLIGHT FACTORIES

3.1. The Second Industrial Revolution | Electrification of Industry

In the ends of the nineteenth century, the effects of new inventions such as telephone and telegraph, utilisation of electricity for lighting, heating, and power, and also, improvements in transportation with the emergence of cars and planes guided industry to the Second Industrial Revolution. Determinative of this revolution was electrification, mass production enabled by new inventions and transportation advancements, and thus, necessitated assembly line.⁶³ All three determinants were correlative to each other and transformed the architecture of factories (mills morphed into factories) starting from the last quarter of the nineteenth century and continued to develop in the twentieth century.⁶⁴ Therefore, in order to delve into wavering architectural qualities of factories after the Second Industrial Revolution, respectively processes of electrification and assembly line needs comprehension.

In the development of electricity including Benjamin Franklin's experiments in the eighteenth century, and Michael Faraday's studies in the early nineteenth century, Thomas Edison's invention of incandescent electric light bulb in 1870s was the major breakthrough for industry.⁶⁵ Utilisation of electricity for the purpose of lighting led the way for more advancements both for the industry and in the daily life of individuals.

⁶³ Notes from "Transformation in Manufacturing Industry Toward Industry 4.0" lecture by Assoc. Prof. Dr. Sedef Meral, METU, October 2, 2019.

⁶⁴ Notes from "Mimarsan Bilirsin 250 Serisi – 13 (Arzu Gönenç Sorguç ve Benay Gürsoy)" conference by Arkitera, featured August 5, 2020 on Youtube, <https://www.youtube.com/watch?v=eTIpT40oSKw>.

⁶⁵ "History of Electricity," Institute for Energy Research, accessed September 26, 2020, <https://www.instituteforenergyresearch.org/history-electricity/>.

As Friedrich Engels presented the alteration that England went through “from any other country to country like no other”⁶⁶ with the steam engine and the Industrial Revolution (first); with electricity, the United States began a similar transition.

The public encountered electrification in many guises. It was a political issue, an element of spectacle, a means of transportation, a motive force, and a source of profit. Yet despite its ubiquity, electricity seemed to defy definition, and remained mystery to the citizenry who saw it every day in the street.⁶⁷

In the years between 1870 and 1930, many issues arose regarding electrification; whether to use direct or alternating current, whether to continue using steam and water-power or prefer electricity, and how to choose between direct drive, group drive or unit drive, etc.⁶⁸ Despite the emergent variety, these issues shaped the path of industries when they were encountered with electricity.

⁶⁶ Engels, *The Condition of the Working Class in England*, 61.

⁶⁷ David E. Nye, *Electrifying America: Social Meanings of a New Technology* (Cambridge, Massachusetts: The MIT Press, 1997), 157. First edition published in 1992.

⁶⁸ According to Nye, the issue of determining who to have the control over electrification systems and periods (either politicians or technicians) also generated differences in utilisation. Every country and industry had diverse perspectives and approaches on these issues. For instance, after the Russian Revolution, Lenin pursued a ten-year plan to completely electrify the Soviet Union to accomplish the true meaning of socialism. However, in a contrasting way, South Africa preferred to electrify solely gold, coal and diamond mines.

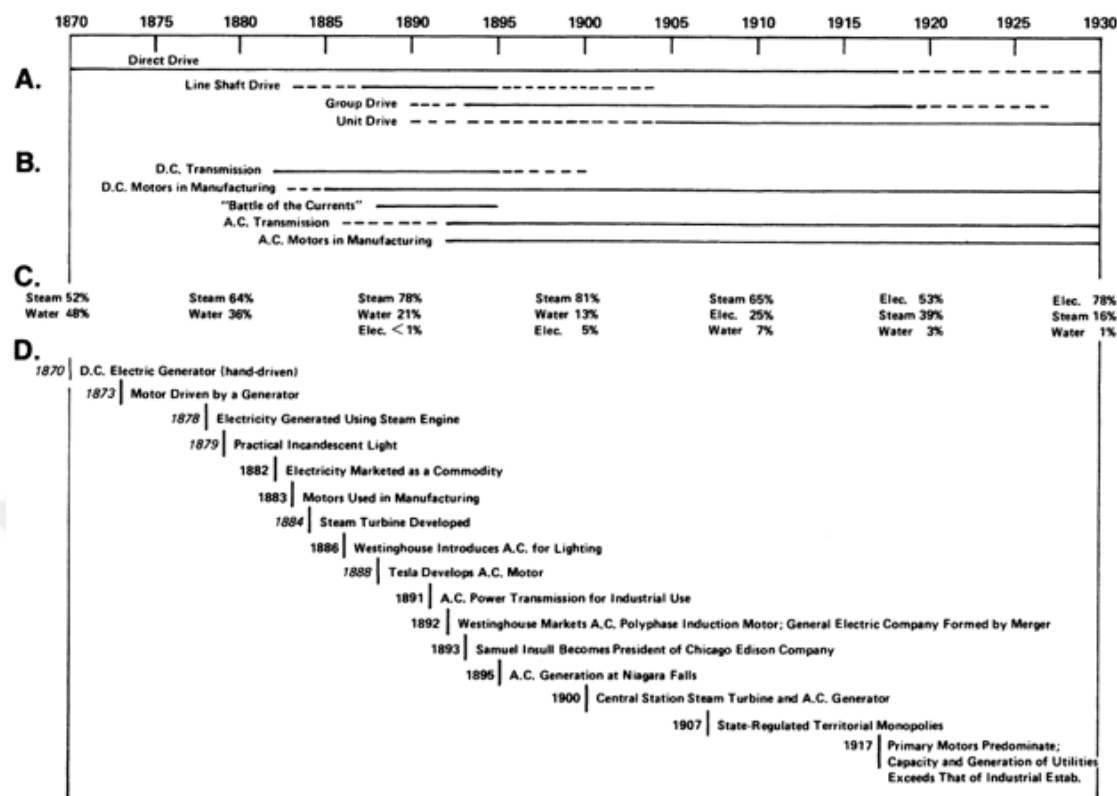


Figure 10. Chronology of Electrification of Industry; A – Methods of Driving Machinery, B – Rise of Alternating Current, C – Share of Power for Mechanical Drive provided by Steam, Water, Electricity, D – Key Technical and Entrepreneurial Developments. By the introduction of hand-driven D.C. electric generator in 1870, as issues arose so did ameliorations. In 1884, steam turbine was developed; in 1895, A.C. generation occurred at Niagara Falls; in 1900, industry met with central station steam turbine and A.C. generator.

While electrification actualised some key technical and entrepreneurial improvements, reliance on electricity as a power source trailed after steam and even water-power.⁶⁹ After 1900s, electricity gained industry's trust as a power source and dependence with a stark difference in the ratios of share of power for mechanical drive. The stark difference had its source in a small elite (mostly contributed with engineers) who

⁶⁹ Warren D. Devine, Jr., "From Shafts to Wires: Historical Perspective on Electrification," *The Journal of Economic History* 43, no.2 (June 1983): 354.

deemed electricity as an instrument for rationality and social reform.⁷⁰ By the late nineteenth century, industrial engineers evaluated the current conditions of the century – special-purpose machines, high-speed steel, scientific management, and electricity – and applied their knowledge on every element of factory design to run operations more efficiently. Ranging from building design, shop floor layout, machines and materials handling to lighting and ventilation, engineers prepared factories for mass production with the mechanical ideal of eighteenth century – factory as a great machine – in mind.⁷¹

Just as the trolley line did not merely replace horsecars but became an integral part of the redesigned modern city, and just as electrical lighting quickly became far more than a mere replacement for gaslight, so too it would be impossible to run modern factories from a water wheel or a steam engine, no matter how inexpensive their power might be.⁷²

David E. Nye, a professor of American Studies, declares with developing technologies, antecedent tools and inventions lost their actuality and replaced with enhanced versions. Consequently, the Second Industrial Revolution offered many new applications that engineers exploited for the sake of industry and generation of new modes of production. Varied in use electrical time clocks, control devices, lighting, motors, electric machine tools and furnaces instilled into factories to eliminate waste and inefficiency, and to construct enormous facilities that created economies of scale.⁷³ These new applications originated with electricity replaced the predecessor power systems, machineries, and tools. Moreover, they had effects on the lasting methods of organisation and management. The more advanced technologies invented and put to use in different branches of industry, the more owners counted on engineers to plan and manage production in their properties. Therefore, engineers reshaped factories'

⁷⁰ Nye, *Electrifying America: Social Meanings of a New Technology*, 157.

⁷¹ Biggs, *The Rational Factory*, 36-7.

⁷² Nye, *Electrifying America: Social Meanings of a New Technology*, 188.

⁷³ Ibid.

form including its location, construction, and shop floor organisation with the flexibility that the electricity presented.

In the first period of electrification, many industries eager to increase their production volume and quality, and in need of ameliorations adopted electric lighting and heating.⁷⁴ Foremost among these industries was textile because quality of light, its steadiness, illumination radius and competence were highly indicative for their production. Inside of the factory, the long rows of looms were illuminated by incandescent electric light bulbs to ensure a standard quality of light that would not be obstructed by weather conditions or flicker. In addition, lack of oil light in the interior spaces of a textile factory lowered the room temperature of the work environment, and quality control of products quickened and stabilised by the artificial light. Along with textile factories, industries that required non-flickering, steady light for precise work, safety from fire, and cool temperatures chose to electrify. Moreover, incandescent lighting provided a healthier work environment compared to gas. Since gas lowered the oxygen level in a room while increasing humidity and releasing acidic fumes into the air of work environment, both workers and owners favoured electric lighting better than oil lights. It also reduced the possibilities of accidental fires in factories, and thus, fire-insurance costs.⁷⁵ After the first period of electrification, industries that rapidly adopted electric lighting weighed its costs over advantages and were the pioneers to embark on electrical drive.

Electrification brought two main changes to the factory; namely, electrical lighting and heating that enabled the extension of the working day, and electrical drive that made possible the transition to electrical power transmission... It is generally agreed that electrical power transmission allowed for a new flexibility in the layout of the factory, in the arrangements of the individual machines, and hence also in the organisation of the work processes.⁷⁶

⁷⁴ As stated previously, electrification of industry varied in years between 1870 and 1930. David E. Nye divides it into two periods in his book, *Electrifying America: Social Meanings of a New Technology*. From 1880s to 1900, in the first period of electrification, factories employed electric lighting, but not electric power withal, after 1900, electric drive rapidly adopted in factories and scaled up productivity.

⁷⁵ Nye, *Electrifying America: Social Meanings of a New Technology*, 192.

⁷⁶ Amhoff, "The Electrification of the Factory: Or the Flexible Layout of Work(s)," 259.

Complementary to each other, David Nye and Tilo Amhoff, senior lecturer in University of Brighton, assess electrification of factory in two perspectives, one from lighting and heating benefits and the other, in terms of a power source. The latter perspective converted power transmission process from a mechanical system of gears, shafts, and belts to an electrical system of generators, wires, and motors. The shift took place gradually from line-shaft drive, then to group drive, and conclusively to single unit drive. At the initial stage of power transmission, factories were organised with respect to the placement of central power source and where shafts, belts and gears were located to carry the generated power. "... while the old factory buildings to be arranged according to the location and distribution of the power source, the new workshops could be organised according to the work processes."⁷⁷ In a similar path from self-sufficient production in small ateliers or homes to mill buildings and then factories, the Second Industrial Revolution motivated new designs of factories. These new factories designed and built during the late nineteenth and early twentieth century not only operated differently, but also, looked distinctive. The multi-storey, narrow, brick or masonry buildings of the nineteenth century left their place in the industrial texture to single-storey, enlarged factories built by concrete and steel. New architectural module for industrial buildings represented the emphasized mass production ideal of the time after the second revolution. As a whole both with the interior organisation and exterior appearance, transformed factories reflected contributions of electrification. Used to be cluttered work environments with gears, shafts, belts, and supplementary lighting equipment to natural light were freed by the new arrangement of machineries according to work-flow and electrical applications. The starkest difference visible due to electrification was the invisibility of appliances and uncluttered space within factories.⁷⁸ It enabled the possibility to engineer whole

Since engineers were the small elite that supported the transition to electrical drive, Lindy Biggs associated their acts towards the rational factory. However, in contrast to Biggs's "rational factory", David E. Nye suggests "flexible factory" due to the flexibility that electricity provided for the layout of factories and works. It will be detailed in the next chapter of the study.

⁷⁷ Amhoff, "The Electrification of the Factory: Or the Flexible Layout of Work(s)," 268.

⁷⁸ Amhoff, "The Electrification of the Factory: Or the Flexible Layout of Work(s)," 261-2.

factory and every manufacturing process from raw materials to end-product within to reach efficiency. Engineers and owners realised the significance the building hold with the advancements of electrification and mass production ideal of theirs to maximise production volumes while minimised waste ratios. The factory needed to be planned, and its design could increase productivity. “No longer a passive shell simply to house machines, tools, and workers, the new factory embraced a more complex vision: it became ‘the master machine,’ organizing and controlling work.”⁷⁹

There are two distinct approaches regarding the new production spaces. Daniel E. Nye exemplifies the new layout as ‘flexible factory’ in opposition to Lindy Biggs’ ‘rational factory’.⁸⁰ As Nye asserts electrification of the industry enabled flexibility both for the layout of operations and planning of the floor plan, Biggs denotes rather than flexibility, electrification of industry and its gradual singularisation rationalised the production space. Although they defended contrasting arguments, neither Biggs nor Nye was thoroughly accurate. Electrification of industry structured the need for new production spaces and permitted the input of architects who could change the floor plan, structural system, organisation of work sequence through the guidance of engineers and ameliorate working conditions. Yet, mass production ideals and capitalist incentives of the time favoured rationalisation and standardisation instead of flexibility and spatial improvements. Therefore, it is true that electrification and its invisibility in the production space granted flexible and free space, but also, experiments to achieve a master machine and highest efficiency rates of production specified stricter design parameters.

The strictness of design parameters that physicalised by electricity moderately manifested itself in the discontentment of workers too.

From the workers’ point of view, although electric lighting greatly improved the luminous environment, reduced the danger of fires, and did not pollute the air, it also brought less desirable changes in working conditions. For if the electric light ensured

⁷⁹ Biggs, *The Rational Factory*, 2.

⁸⁰ Amhoff, “The Electrification of the Factory: Or the Flexible Layout of Work(s),” 259.

a healthier work place, it also made possible round-the-clock shifts, which disrupted family and community life.⁸¹

Electrical lighting eliminated the distinction between day and night-time while providing 24/7 production. “This expansion of the day might have offered labor choices about when and how long to work, but simultaneous changes in factory organization moved in the opposite direction, toward more rigid control.”⁸² As it is disclosed, in the renewal of production spaces, rearrangement of working conditions in a humane way was not among the design concerns. Instead of looking after workers and their engagement with production processes; engineers, owners, and architects prioritised the growth of production, its expansion within the market, and maximising profits as wastes and costs were minimised. Thus, “gains in productivity came at the cost of low worker morale and high turnover.”⁸³ Consequently, welfare movements were incorporated as preventative measures such as medical services, pension plans, seniority systems, safety programs, lunchrooms for workers, and organisation of company social activities.⁸⁴ Measures were varied; however, it was a corporate way to scale down the labour turnover by giving back some of the profits that workers enabled for the company. One of the first acts of welfare movements took place in Germany in the form of the Deutscher Werkbund where capitalist incentives and mass production realities converged with the theory and practice of architecture with the hopes of relating producers, designers, and consumers on the basis of standard and accessible products.

⁸¹ Nye, *Electrifying America: Social Meanings of a New Technology*, 193.

⁸² Ibid.

⁸³ Nye, *Electrifying America: Social Meanings of a New Technology*, 215.

⁸⁴ Ibid.



Figure11. Photograph of AEG Appliance Factory in Ackerstrasse (1888-95), showing a workshop powered by mechanical transmission. The confluence above workers with the transmission and lighting appliances is visible.



Figure12. Photograph of AEG Large Machines Factory in Brunnenstrasse (1895-97), showing a workshop powered by electrical single motor drive.

3.2. Peter Behrens and the Collaboration with AEG

In the context between 1870-1914, after the invention of the incandescent electric light bulb, Germany challenged the places of the two leading countries (England and the United States) in the industrial hegemony pursuit. Peggy Deamer describes the context during the Second Reich (1871-1918) in her edited book, *Architecture and Capitalism: 1845 to the Present* and elaborates on the Deutscher Werkbund (German Work Federation) to justify the means, which unified German government initiated; a movement in the intersection of economic politics, design and consumerism.⁸⁵

The Werkbund is symptomatic of the many worker organizations that came with the upsurge in population, energy, and territory following German unification. In thirty years, exports and chemicals tripled, manufacturing quadrupled, coal production and machinery exports quintupled, and steel production multiplied 12 times.⁸⁶

The Werkbund was presented as an initiative for both the welfare of Germany's industry and the continuance of workers' welfare legislation which was signed by the Chancellor Otto von Bismarck in 1880.⁸⁷ Although the legislation became one of the first written document to accept and put forward the rights of workers, the agenda behind was to increase production rates and sustain the advancement of industry by pleasing the 'lower and middle class' which alienated from their products and themselves inside of production spaces by the forces of capitalist estrangement. As anticipated benefits offered through the legislation strengthened workers' connections to the production space and their products. Their concern for what they produce each day and devotedness to the place of work gradually converted workers into consumers, more than producers as an outcome of balancing the quantity of inceptive mass production with the consuming habits of the society. The expansion in the realm of

⁸⁵ Peggy Deamer, "Context: 1870-1914" in *Architecture and Capitalism: 1845 to the Present* (New York: Routledge, 2014), 48.

⁸⁶ Ibid.

⁸⁷ Marullo, "Typical Plan: The Architecture of Labor and the Space of Production," 175.

The first modern welfare legislation provided national health insurance, minimum wages, pensions, vacations, labour regulations, unemployment insurances, special laws for women and children.

production and exchange with the increasing effect of capitalist incentives generated the environment for the cultivation of the Werkbund.

Consequently, The Deutscher Werkbund founded in 1907 with the input from artists, architects, critics, entrepreneurs, and politicians in the search for a large-scale reform of the artistic and economic practices that prevailed in the German applied arts.⁸⁸ The members of the Werkbund such as Herman Muthesius, Peter Behrens, Henry van de Velde, Karl Schmidt, Karl Scheffler, Friedrich Naumann, George Simmel, and many more individual gathered due to their shared concerns about the notion of ‘art’ and its inaccessibility from work environment and marketplace. With the awareness of producing for a capitalist economy and obstructed dialectic relationship of base and superstructure, their products symbolised the consequences of the division of labour and alienation of workers from their roles as creators and producers, and at the same time from their working environment and skills. Thus, their program for the Werkbund intersected artistic and business aims by valuing the collaboration of artists with the everyday objects. Though the alliance of a new applied arts association aimed to improve the quality of goods manufactured in Germany and members’ general support against deskilling workers and alienating them to their work and products, their primary aim for standardized products designed by artists and architects polarised their stand in the capitalist economy and led to a controversial demise in 1914.⁸⁹

One of the well-known case to prioritise machine aesthetics and physicalised the ideals of the Werkbund is Peter Behrens’s Turbine Factory and his collaboration with the Allgemeine Elektrizitäts-Gesellschaft (AEG). The AEG was founded in 1883 as the Deutsche Edison Gesellschaft für angewandte Elektrizität by Emil Rathenau, an engineer-businessman who procured the German rights for the Edison patents after

⁸⁸ Frederic J. Schwartz, *The Werkbund: Design Theory and Mass Culture before the First World War* (New Haven and London: Yale University, 1996), 8.

⁸⁹ The Werkbund did not last for a long time, however, its effects on German arts and architectural discourses and on both national and international industrial economies sustained and affected latter developments. The organisation funded lectures, coordinated exhibitions, published the *Werkbund Jahrbücher*, and most significantly distressed themselves with an establishment of a theoretical basis and justification of their practical aims.

learning about his work at the Philadelphia Exposition in 1876.⁹⁰ In 1896, the AEG laid foundation for its first settlement as an industrial site on a large terrain on the Humboldthain in northern Berlin, where the Turbine Factory will be constructed in 1909. The inclusion of new production spaces and the projection of industrial growth displays AEG's level of apprehension and conformity with the conditions of the century. As it is depicted before in the chapter, industrial complexes in the nineteenth century tended to get over-crowded due to engineers' or owners' lack of foresight which can be deducted from their production rates and requirements of additional spaces while constructing and occupying an available building. Thus, from the settlement strategy of the AEG, it can be observed that in the turn of the century companies adopted new perspective about their production spaces. It may have resulted from the desire to avoid additional costs of relocating, construction, and mostly hiring, however, it led to a crucial step for development and design of production spaces as well as theoretical framework, which had begun to formulate since the Industrial Revolution.

The modernity of the machine, of industry, and of electricity was apparent. The power that was shaping modern politics and modern civilization was manifest in these great technological developments. Through his charter membership in the Deutsch Werkbund, Behrens was linked to the political thought of the leader of the National Social Union, Friedrich Naumann, who had provided the intellectual impetus for the founding of the Werkbund in 1907.⁹¹

Both Peter Behrens and the AEG were involved in the Werkbund, and Walter Rathenau's appointment of Behrens as an artistic consultant in 1907 exemplified a kind of cultural-economic intersection. Charles Edouard Jeanneret (later Le Corbusier) articulated the connection between power and culture relied in the essence of the Werkbund, and criticised AEG's involvement as 'authoritarian intervention' in the

⁹⁰ Stanford Anderson, *Peter Behrens and a New Architecture for the Twentieth Century* (Cambridge, Massachusetts: The MIT Press, 2000), 96.

⁹¹ Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*, 39.

realm of art by the ‘realization of beautiful industry.’⁹² Behrens employed to be in charge of every visual manifestation of the AEG, varying from product design (teapots, clocks, lamps, furniture, etc.), logo and other graphical materials, exhibitions to architecture, actual design and construction of production spaces. The configuration of the layout and integration of energy sources into use were far more significant from the design and construction process. The architecture of the production space is an overall hard-work and requires collaboration of many disciplines. In the case of Peter Behrens, he was chosen for his works that “sublimated the faceless spirits of industrialization within a geometric and abstract idealism” by Rathenau. He considered Behrens to be perfect for interpreting art into the world of machine aesthetic with a totalitarian approach and influence of abstraction.⁹³

⁹² Schwartz, *The Werkbund: Design Theory and Mass Culture before the First World War*, 116.

⁹³ Marullo, “Typical Plan: The Architecture of Labor and the Space of Production,” 187.

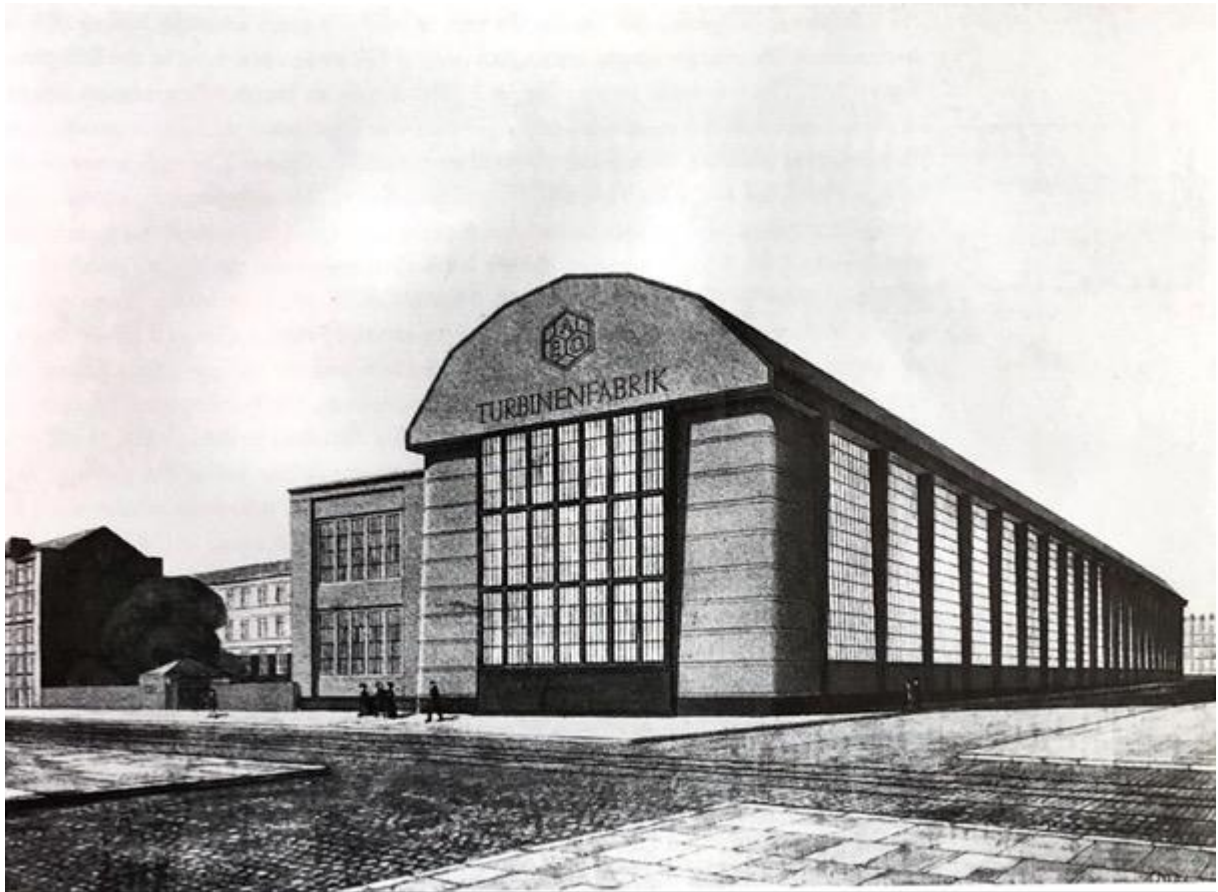


Figure13. Rendered Perspective of the AEG Turbine Factory from the view of southeast, drawn by Peter Behrens.

Therefore, Behrens first architectural project for the AEG, the well-known Turbine Factory, which was designed in 1908-1909 and started to operate in 1910 was a comprehensive task in some respects to be detailed. First of all, it emerged from necessities. In the beginning of turbine production, as Stanford Anderson explains in his book, *Peter Behrens and a New Architecture for the Twentieth Century*, the AEG started to produce the Curtis steam turbine under General Electric patents and their own patents from the work of professors Riedler and Stumpf of the Technische Hochschule, Berlin in 1902.⁹⁴ After their merger with the Union Elektrizitätsgesellschaft in 1903, the AEG had to replace its turbine fabrication to the former union factory site in the Moabit district of Berlin (where the Turbine Factory will be built in). In the new location, in 1904 the first AEG-Curtis steam turbine was assembled and then three years later, the company needed more and larger turbine construction area.⁹⁵ Then, Behrens was employed to design his first factory, and at the same time, his first architectural project for the AEG, the *Turbinenhalle Fabrik*. With the consultancy of Karl Bernhard, an engineer and directives from Oskar Lasche, the director of turbine fabrication for the AEG, Behrens designed a giant hall sited at the southeast corner of the Moabit factory site at Hutten and Berlichingenstrasse.

⁹⁴ Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*, 134-5.

⁹⁵ Ibid.

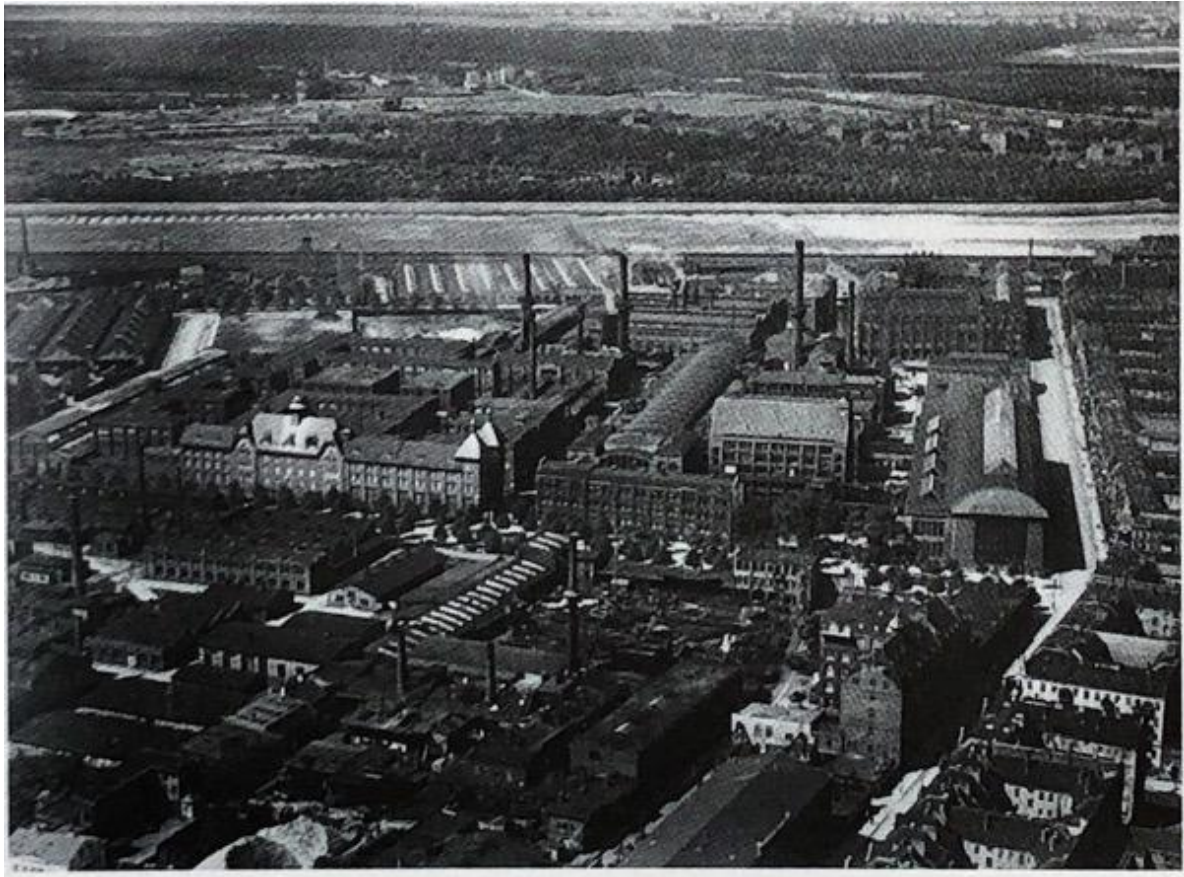


Figure14. Aerial View of the Berlin-Moabit Industrial Site (1910), the AEG Turbine Factory at the right side.

Oscar Lasche, ... specified the physical requirements for the new factory: full utilization of the available site; a main assembly hall of large dimensions; two relatively fast-traveling cranes capable of lifting almost 100 tons together... a smaller flanking construction to accommodate storage and secondary manufacturing operations (also equipped with travelling cranes); and the maximum amount of natural light consistent with the strength demanded in a building for such heavy and dynamic utilization.⁹⁶

In light of these physical requirements, Behrens's design for the Turbine Factory generated from a main assembly hall (207.38 meters long and 39 meters wide) with

⁹⁶ Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*, 136.

approximately at 28.5 meters high skylight and large glazing areas on facades to naturally illuminate the workspace in addition to electrical power and lighting. In connection with the main hall, there is a side hall, which includes a basement and two-story superstructure. Another crucial aspect of the design of the factory besides its floor plan and layout is the structural design that Karl Bernhard created. The transverse section best exhibits the blueprint of asymmetrical three-hinged arch with a tie-rod as the structural system to be detailed on the reinforced concrete foundation. It allows the roof to have a long skylight for natural lighting and supplementary electrical lighting fixtures to be hung from a convenient height to avoid cluttering in the workspace and glare from light sources. The developed structural system, also enables the placement of uninterrupted cantilevered crane mechanism to carry heavy loads from place to place to ease the production process.



Figure15. Interior View of the Main Assembly Hall of the Turbine Factory. Modular replacement of machineries with prominently visible iron structure and utilisation of glass inside the factory.

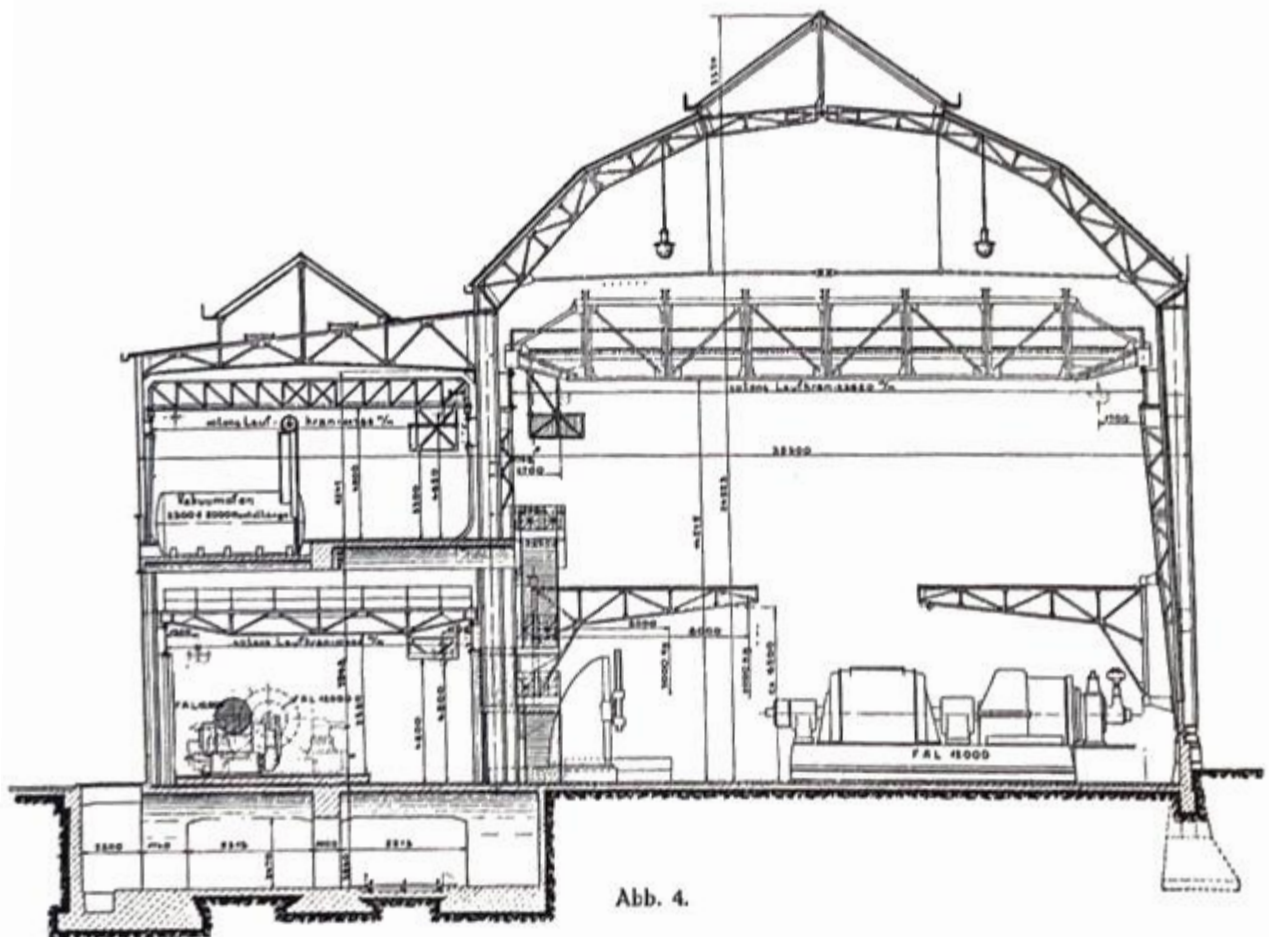


Figure16. Transverse Section of the AEG Turbine Factory, Peter Behrens.

Another dimension of the comprehensiveness of the Turbine Factory sources from Behrens's desire to design functional yet symbolical production space where everyday objects were designed by himself produced as an end-product of his planned schematic operation mechanism. He viewed the AEG Turbine Factory as a 'cathedral of labour'⁹⁷ where he materialised the ideology of labour into the longitudinal technical form of the Halle.⁹⁸ He reflected his ideals toward the workspace through the massiveness of the building, material choice to complement the ideals rather than the structure, and facade design since it was face of the company visible to its surroundings from the industrial complex and to the World.

For Behrens, modern industry in alliance with central government constituted the prime agency of that power at the beginning of the twentieth century. Its factories and office buildings must then be the architectural touchstones of their age – receiving adequate representational form through the imaginative intersection of architectural convention and new conditions.⁹⁹

All thoughts and requests combined and concretised in the form of the Turbine Factory. He stated that the architectonic concept of the main body of the building was to draw the construction together into an emphatic mass of iron instead of allowing the dematerialisation of iron framing in a dispersed network.¹⁰⁰ Behrens corresponded to the materials of the twentieth century, iron and glass with a distance and preferred concrete walls, however, he utilised concrete as a plastic material rather than benefit from its load-bearing capacities. Behrens and Bernhard carried the load of the massive structure through the supports of iron members and points of concrete infills. Therefore, material choices and functions attributed to the materials conflicted with the general construction strategies of the century. On contraries, Behrens favoured the symbolic presence of the factory as long as it followed the functional directness,

⁹⁷ Schwartz, *The Werkbund: Design Theory and Mass Culture before the First World War*, 181.

⁹⁸ Marullo, "Typical Plan: The Architecture of Labor and the Space of Production," 187.

⁹⁹ Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*, 111.

¹⁰⁰ Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*, 139.

space requirements, and economical-cultural unity embodied from the Werkbund and AEG.

Behrens could not have been more specific about his rejection of normal factory construction in iron and glass; nor could he have been more frank about his endeavor to bring these materials into the elevated tradition of architecture. In the side elevation on Berlichingenstrasse, Behrens and Bernhard fulfilled the architect's aims with a minimum of technological compromise: the large scale, industrial materials, and machinelike details are technically appropriate, but also achieve an intensified character.¹⁰¹

Last but not least, Peter Behrens and collaboration with the AEG as an artistic consultant brought a distinct change to the hegemonic presence of engineers in the design of production spaces since the eighteenth century. It is another important aspect to consider when analysing the Turbine Factory. Even his design concerns highlighted his devotion to the social and cultural background of the Werkbund and regard for the cohesion of art in the realm of production and exchange through the brand of the AEG which he helped to build and marketize, the architectural drawings of the Turbine Factory portrays more valid point in the discourse of architecture of the production spaces. In the beginning of a new century, mill buildings of the nineteenth century transformed to luminous and spacious production spaces powered by a reliable source of energy. It affected the working conditions and morale of workers in a dichotomous way, but the floor plan to organise every operation for fabrication and interaction of workers with machineries to stage the gaze of the architect to an industrial world. It forces him to work accordingly to a structural system and necessities to get through the amount of production while freeing his mind to figure out a wholesome solution to the layout. And that led Behrens to design a three-dimensional space restricted from width, length, and height, which preferably be modular to suit with machineries and evidently, generated a new version of the typical plan.

¹⁰¹ Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*, 143.

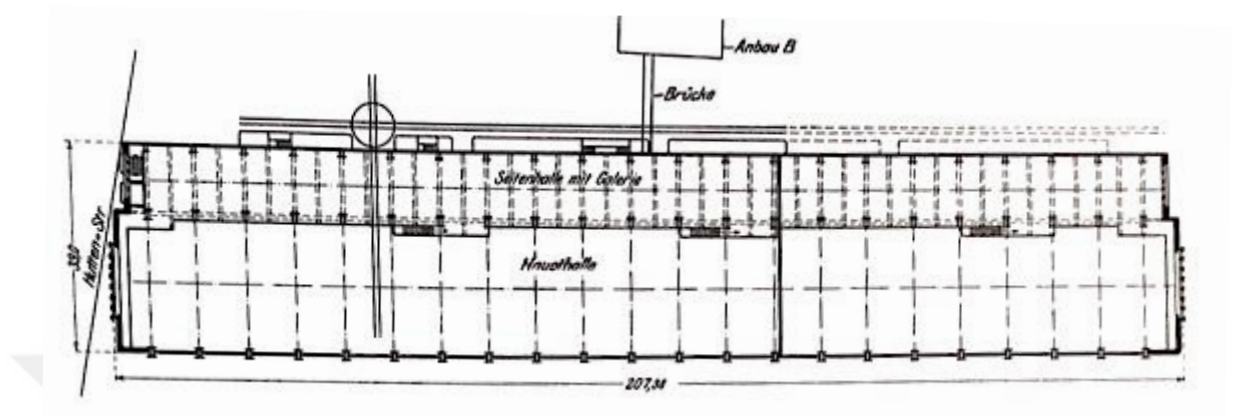


Figure17. Floor Plan of the Turbine Factory, Peter Behrens.

In the bright, high-ceilinged rooms of the new factories, the workers of the AEG must have a completely different feeling for their work and their dignity as do those many industrial workers who spend their working life in horrid barracks and cheap makeshift structures... A great mind [Sinn] was necessary, not only to give these buildings the architectural form that they have, but also simply to accept them as patron.¹⁰²

It may seem that it is a standard floor plan to accommodate workers and machines to produce an outcome to facilitate itself in a capitalist economy, yet the interior environment and composition of stages of production demonstrate new technologies, structures, and construction techniques through the architectural entity. It set forth the appropriation of labour by the replacement of gate, changing rooms, circulation patterns, break rooms, main assembly hall, and machineries to observe workers' perspectives. In a similar manner with the model German mill (aforementioned), in the Turbine Factory, the appropriation of labour did not reside with punctuality and presence in the factory, it corresponded with the actual working time. German

¹⁰² Schwartz, *The Werkbund: Design Theory and Mass Culture before the First World War*, 58.

factories like the mills valued the time spent on the machines, therefore, they organised the interior mechanism of the factory to systematically focus on the production process rather than the social relationships of individuals. Functions beside the operations of the factory were monitored through the circulation patterns in the corridors and passages from entrance to the working station. Interior organisation sustained the cellular design concept of the previous mills with the modularity and structurally simplified main assembly hall that the typical plan provided.



Figure18. Entrance of the AEG Turbine Factory.

To finalise, the Turbine Factory holds a controversial but crucial place in the architectural history regarding industrial buildings. On the one hand, it influenced many architects, some masters of the next generation, Walter Gropius, Mies van der Rohe and Le Corbusier who were in Behrens's studio during the AEG factories were in process, and more relevant to the study, Albert Kahn, the Ford architect.¹⁰³ Moreover, there are many supporting opinions related with the Turbine Factory. To exemplify, Nikolaus Pevsner, an architectural historian, referred to the factory as the most beautiful industrial building and stressed Behrens's imagination and visualisation. And also, Sigfried Giedion claimed that "Behrens consciously transformed the factory into a dignified place of work."¹⁰⁴ As significant as this claim, on the other hand, there are opposing arguments regarding the Turbine Factory. In 1940, the editor of the Swiss journal, *Werk*, Peter Meyer asserted,

‘In its time, the Turbine Factory of the AEG was felt to be epoch-making; one saw in it the epitome of a modern functional architecture of the Machine Age. Today, with our fingers burned, we have a sharper ears for slogans; we feel the false pathos of the ponderous Egyptian-like stylization even in the apparent ‘simplicity’ of this machine shop. Or, more specifically: it is genuine pathos in the wrong place, sacred glorification of the machine; that is, idolatry.’¹⁰⁵

Although the criticism of the Turbine Factory can be evaluated as valid and in the potential of major impact, arguments either supporting or opposing cultivate architectural discourse and contribute with new discussions in respect to the earlier line of thoughts. AEG's establishment in the beginning of the twentieth century and involvement in the Werkbund, advanced primarily means of production in Germany and spread other countries. The invention of their own steam turbine allowed the ground for a new production space that was spacious enough to accommodate both the product and producers who turned into consumers in latter production spaces. As an architectural output, it introduced a new material -concrete- and distinct way of utilising it instead of accustomed iron and glass structures. Thus, the Turbine Factory

¹⁰³ Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*, 27.

¹⁰⁴ Ibid.

¹⁰⁵ Anderson, *Peter Behrens and a New Architecture for the Twentieth Century*, 27-8.

can be perceived as an architectural passage to daylight factories. It concretised the collaboration of an architect and engineer in the design of production spaces and structured contributions of architects into the space. Moreover, from the perspective of labour while it was evaluated as a dignified place of work with illuminated and naturally ventilated interior, invisible organisation of electrical power, and layout planned accordingly to the production operations, it constituted of ameliorated conditions while accelerating the service of capital. Although restoring the connection between producers and the product was stated in the ideals of the Werkbund, inclination toward sustaining production volume and raising the demand lied heavy on the valorisation of labour and labourer. To conclude, AEG Turbine Factory laid foundation for further advancements in construction techniques and materials, layout configurations, articulation of operations, and spatial simplification of production spaces.

3.3. Division of Labour

Since the Industrial Revolution and incidents both lead up to and occurred in response to it, changed production models, living and working conditions of individuals, and inevitably affected the whole order of the world, there is a significant concept in the discourse of labour. That is, the division of labour. In 1776, Adam Smith introduced the term, industrial capitalism in his book, *The Wealth of Nations*, and described an analogy in favour of the division of labour called the pin analogy. Smith declared that if eighteen specialized tasks could be assigned to particular workers, then ten workers could produce 48000 pins per day and in the absence of the division of labour, Smith indicated, a worker could (barely) produce one pin per day.¹⁰⁶ Therefore,

¹⁰⁶ Deamer, *Architecture and Capitalism: 1845 to the Present*, 5-6.

the division of labour means the segregation of one task into many minute parts and causes the routinisation of the production space and forcing workers to follow the rhythm of machines that was arranged by owners' requisite to accelerate the production process to an inhuman pace. Thus, workers were controlled and treated as another part of machines present in the production space without the acknowledgement of their skills and appreciation of their labour.

...the modern ideal of workman seems to be a man or a woman, or even a girl or a boy, without the knowledge of any handicraft, without any conception whatever of the industry he or she is employed in, who is only capable of making all day long and for a whole life the same infinitesimal part of something: who from the age of thirteen to that of sixty pushes the coal cart at a given spot of the mine or makes the spring of a penknife, or 'the eighteenth part of a pin.'¹⁰⁷

The division of labour alienated men from their work, body, intellect, and common interaction with their surroundings. It fixed them in a particular spot and the rhythm of machineries picked up their pace (as it was criticised in one of Charlie Chaplin's movies, *Modern Times*).¹⁰⁸ It existed before the Industrial Revolution in ateliers of craftsmen and as a concept was applicable to many production processes. Marx detailed a comparison between rural and urban manufacturing in medieval times to further comprehend to the conditions of the industry of the eighteenth century in *The German Ideology*. Accordingly, every 'workman' who desired to be a master required to be proficient in his craft, make everything that can be generated with his tools and be creative and open for the invention of new instruments. Even in the presence of a narrower sense of division of labour under the conditions of lack of resources and population, medieval craftsmen who were utterly absorbed in their work that they discovered and learned everything about and supported their manual labour with the immaterial differed from modern worker.¹⁰⁹ However, the work of craftsman mattered

¹⁰⁷ Pyotr Kropotkin, *Fields, Factories and Workshops* (New Jersey: Transaction Publishers, 1993), 18-9. Originally published in 1912 by Thomas Nelson and Sons, Ltd.

¹⁰⁸ "Charlie Chaplin – Factory Scene – Modern Times (1936)," Youtube, accessed on March 5, 2021, <https://www.youtube.com/watch?v=6n9ESFJTnHs>. In many similar scenes inside the factory reflects various problems caused by the rhythm of machineries, surveillance, adjusted pace, and etc.

¹⁰⁹ Marx, *The German Ideology*, 101.

for him as the designer/inventor/producer of it, whereas in production spaces of the new industry, workers were indifferent to their work due to the extensive application of division of labour. “The life-long speciality of handling one and the same tool, now becomes the life-long speciality of serving one and the same machine.”¹¹⁰

The instrument of labour, when it takes the form of a machine, immediately becomes a competitor of the workman himself... The whole system of capitalist production is based on the fact that the workman sells his labour-power as a commodity. Division of labour specialises this labour power, by reducing it to skill in handling a particular tool. So soon as the handling of this tool becomes the work of a machine, then, with the use value, the exchange-value too, of the workman's labour-power vanishes; the workman becomes unsaleable, like paper money thrown out of currency by legal enactment.¹¹¹

Deskilling workers through each specialised task of a greater operation stayed as a constant while layout configurations, energy sources, and kind of products changed. Hence, it needs an assessment to better understand the reality of production spaces and design concerns that came along.

The division of labour, welfare legislations and facilities, rise of industrial economy, capitalist estrangement, efforts to ameliorate working conditions, advancement of technology, new installed energy sources, and many more development through history were steps toward the continuance of production, and if possible, for its increment. All of the listed and following improvements and alterations quantify mechanisms to exploit labour. They took advantage of the generic human potential to its limits with the awareness of possible health hazards, and they have been for the sake of production. The cost of these needs a recognition; labour has transformed to ‘labour sans phrase’ as Marx explained.

In order to be exchanged on the market, labor lost the specificity of its purposes and the relation to its performing subjects to become an homogeneous entity, a “labor sans phrase” as Marx defined it: not this or that labor but “a pure and simple activity, abstract labor; absolutely indifferent to its particular specificity, but capable of all

¹¹⁰ Marx, *Capital Volume I*, 605.

¹¹¹ Marx, *Capital Volume I*, 618-9.

specificities”, uniform in quality and only different in quantity, indifferent from the modes of expenditure and from the concreteness of its use-value.¹¹²

The abstraction of labour; homogenising the work force, preference of unskilled worker over skilled one met within the confinement of a structurally simplified, functional and homogeneous production space as typical plan lays out the base. The more labour was abstracted, the more the floor plan had to be abstracted. In the beginning of the twentieth century, through the influence of the Werkbund and collaboration of AEG with Peter Behrens, architects were included in the design process of production spaces with the assistance of engineers. Studies and efforts of engineers in close contact with the owners about maximizing their profit and production rate with the minimized waste ratios were consolidated with architects’ knowledge. Through this collaboration, the eighteenth century ideal of the great machine metaphor suited with the production space found its floor plan, lighting, heating and power source with electrification, and economic dynamics to sustain the outcome of mass production.

The machine has enabled us to repeat the same object hundred – or thousandfold, to make exact mechanical copies in countless numbers... The fundamental result of the introduction of the machine in production and thus the true difference from earlier times is the mass production of fully identical commodities in place of the earlier individual production.¹¹³

After the realization of the fact that production spaces needed to be planned, designed and operated with high efficiency ratios, there seemed to be something lacking during processes. It was the second crucial component of the Second Industrial Revolution, the assembly line. To comprehend the composition of assembly line and its outcome for production spaces, production spaces of Ford Motor Company will be examined since the assembly line was formulated within the architectural body of Ford Motor Company that the architect Albert Kahn designed.

¹¹² Marullo, “Typical Plan: The Architecture of Labor and the Space of Production,” 29.

¹¹³ Schwartz, *The Werkbund: Design Theory and Mass Culture before the First World War*, 100.

3.4. The Second Industrial Revolution | Assembly Line

Every kind of capitalist production, in so far as it is not only a labour-process, but also a process of creating surplus-value, has this in common, that it is not the workman that employs the instruments of labour, but the instruments of labour that employ the workman. But it is only in the factory system that this inversion for the first time acquires technical and palpable reality... The separation of the intellectual powers of production from the manual labour, and the conversion of those powers into the might of capital over labour, is, as we have already shown finally completed by modern industry erected on the foundation of machinery.¹¹⁴

In the early decades of the twentieth century, with industrialists realisation of the opportunities that electrification offered and the value of factory building itself led the most determinative aspect of the Second Industrial Revolution to emerge, assembly line. After mechanisation and electrification, assembly line as an outcome of years of accumulating experimental process to guarantee more efficiency in production spaces, had the most subversive effect on the notion of labour. It was an instrument to shape the layout of the production space as well as a tool for rationalisation and standardisation at utmost levels with a dismissive regard for skilled labour due to the principles led to its emergence.

‘With steam power, the mills were best built several stories high, but with electric motors which could be built any size, each machine could have its own motor drive. A single-story structure could be used with a resulting improvement in materials handling.’ Flexibility in design was further enhanced by electrical cranes, lifts, ventilation, and illumination, making possible a factory of any size, height, or shape. Collectively, these changes prepared the ground for a new production system: the assembly line.¹¹⁵

Assembly line materialised in auto industry during 1908-1913 in Detroit by concerns for speed, innovation, interchangeable parts, standardisation, and economies of

¹¹⁴ Marx, *Capital Volume I*, 605-6.

¹¹⁵ Nye, *Electrifying America: Social Meanings of a New Technology*, 221.

scale.¹¹⁶ It fulfilled the institutionalisation of the values and practices of acceleration and became the fundamental principle of production and consumption.¹¹⁷ “Nor is it incidental that this new system was first applied to manufacturing automobiles, which themselves embodied the values of speed, interchangeability, standardization, and the homogenization of space and time.”¹¹⁸ There were five practices that laid the foundation for the emergence of assembly line. First necessity was the division of labour that Adam Smith introduced in his book, *The Wealth of Nations*. Based on Smith’s introduction of the concept, Hannah Arendt defined the division of labour as the segmentation of a task into very minute parts in her book, *The Human Condition*.¹¹⁹

Segmentation of a task and mechanisation of the process enabled the standardisation and thus, production of interchangeable parts.¹²⁰ The significance of interchangeable parts was clarified predominantly in practices of weaponry and clock manufacturing that demanded high standards of precision to actualise. Thus, machineries and relevant tools attained a certain standard to allow mass production and accuracy along each other. It anticipated the requisites of mass production and supplied expanding demand for precision and standardisation especially for mobility in the twentieth century.

Tertiary aspect was single-function machineries powered by unit drive. In the twentieth century, factories were already adopted electrification and exercised its conveniences, thus, single-function machineries improved the quality of parts they produce while individually-powered. Precise and accurate standards of production in an adequately illuminated, heated, and ventilated work environment maintained with single electric motors. The end point of electrical drive permitted products to have more precision, and also, increased productivity. These accumulating developments led to a change in the configuration of the architectural floor plan of the production

¹¹⁶ David E. Nye, *America’s Assembly Line* (Cambridge, Massachusetts: The MIT Press, 2013), 2. These concerns were later evolved to be referred as principles of Fordism, after Henry Ford.

¹¹⁷ Nye, *America’s Assembly Line*, 6.

¹¹⁸ Ibid.

¹¹⁹ Arendt, *The Human Condition*, 90.

¹²⁰ Interchangeable parts were rooted in the eighteenth century French engineering knowledge, and then highly valued in the military industry.

space because division of labour supplemented with interchangeable parts and single-function machineries enabled machines to be organised according to the sequence of work rather than grouping based on machine types. Through this articulation, alignment of varied machineries according to the overall layout production instead of grouping of same types altered the possibilities of settlement inside the production space. It gave engineers the opportunity to organise the production processes and intervene in the duration from raw material to the end product. Changing working dynamics supplied with singular sources of energy and precision in parts as a result started to reflect on the floor plans and stated the need from the practice of architecture. Production spaces in transition of energy, means of production, and instruments of labour called for a spatial evolvement to design ameliorated buildings with stable structural systems and healthy work environment for the sake of production and efficiency. The last practice out of the five was the design and mechanism of materials handling and processing which was realised with continuous moving belts and gravity slides to automatically move sub-assemblies from one stage to the next without workers leaving their workstations.¹²¹ The more intricately resolved plans of work sequences, and thus, plans of factory floor, the higher rates of productivity and necessity for an assembly line observed.

The combination of these five practices – subdivision of labor, interchangeable parts, single-function machines, sequential ordering of machines, and the moving belt or line – defines the assembly line. Factory electrification was the necessary precondition before these elements could be improved individually and then welded together into a new form of production.¹²²

Under the influence of the Second Industrial Revolution, in the twentieth century during the time of monopoly formation, especially in the United States, industrial complexes excessively multiplied and embraced either Taylorism or Fordism to cultivate their mass production expectancies. In the first half of the twentieth century,

¹²¹ Nye, *America's Assembly Line*, 26.

¹²² Nye, *Electrifying America: Social Meanings of a New Technology*, 224-5.

industries embarking on either Fordism or Taylorism produced goods at an incredibly expanded scale and mobilised an ever larger and well-managed workforce.¹²³ Though both methodologies enriched the production volume and took industries forward, they differ from each other by the implementation. Fordism dawning from the necessities of assembly line and mass production as power, accuracy, economy, system, continuity, and speed, whereas Taylorism was anteriorly generated by Frederick Taylor's concept of scientific management.¹²⁴ Taylor scrutinised on ways to modify how workers move, act, and conduct their tasks in the production space.¹²⁵ The application of Taylorism dwells on the mandated aim of being efficient, the best, and productive. Standardisation of tools, work experience, and movements of workers by determining 'best way' for every aspect of production and paying accordingly to an incentive system demonstrate the high levels diminished of interference to human labour as a generic ability to produce.

With similar outcomes, Fordism as stated before is unification of the mass production principles and conclusions derived of experiments to be more efficient within the entity of production space. It penetrated into each process of production through interchangeable parts, handling of materials, single-function machineries, division of labour, and sequential ordering instead of grouping machines. Thus, Albert Kahn designed in accordance with these precepts and assimilated workers into these layouts as mobile, deskilled, and massive workforce on the assembly line. In Fordism, instead of the 'best worker' to determine the optimum duration of a task, demand on cars regulated the rhythm of production.

¹²³ Deamer, "Architectural Work: Immaterial Labour," 138-9.

¹²⁴ Frederick Winslow Taylor published *The Principles of Scientific Management* in 1911 and through his book, his ideas – Taylorism circulated widely.

¹²⁵ Nye, *America's Assembly Line*, 33.

For instance, he determined the ideal weight for a man to lift while shovelling, then he devised specialised shovels to arrange volume-weight ratio for different materials. If a worker had a task to shovel sawdust, he could carry greater volume due to the lightness of material, whereas in the case of sand, heaviness of the sand inhibit him to get the same volume of material. Beside the reformulation of tools, Taylor assessed work routines in a similar way with Ford's engineers and managers by timing the most efficient worker during tasks to set a standard for every worker.

Taylor designed ideal shovels, Ford abolished shovelling by using electric cranes, moving belts, and other devices as aids to continuous flow manufacturing. Taylor retrained a worker to do the same job more efficiently; the assembly line redefined and simplified jobs. Taylor offered workers incentives to do piecework more quickly; Ford made piece rates pointless, because the assembly line paced the work, pushing everyone to move at the same speed. Instead, workers received a high fixed wage. Taylor maximized efficiency in existing production technologies; Ford transformed the means of production. Taylor saved time; Ford sped up time.¹²⁶

Consequently, the architectural entity of production space holds the control mechanism of mass production and labour power of workers. With the acts against the strict confinement of instruments of labour, architecture of production spaces transformed, yet improved working and spatial conditions slanted towards the sake of industry in between these dialectical relationship of labour and production. With every advancement of technology or new materials and techniques in construction, new factories were built by concretisation of these precepts. As a result, industries again congregated with a new architectural model, daylight factories and to perceive changes in production spaces.

3.5. Albert Kahn and the Collaboration with Ford Motor Company |

Daylight Factories

The automobile industry provides one of the best illustrations of the important changes introduced in the early twentieth century. It is a good example because the industry, and especially the Ford Motor Company, experimented with the new ideas about organizing factories within a short period of time; Ford, for example, went from a small machine shop in 1904 to a major experiment in planning a rational factory in 1914.¹²⁷

¹²⁶ Nye, *America's Assembly Line*, 34.

¹²⁷ Biggs, *The Rational Factory*, 87.

In the first decades of the twentieth century, almost every company in the automobile industry was ascending with new developments regarding the planning of production spaces, construction techniques, and access to mobility. As described, the immense acceleration in the industry supported with architectural practice converted Ford Motor Company from a small machine shop to a rational factory that even produced its own raw materials. In 1903, after two failed attempts to start his own company, Henry Ford founded the Ford Motor Company and started to produce first Model A Ford in a small, rented building on Mack Avenue in Detroit., then moved to a larger production space on Piquette Avenue in 1904.¹²⁸ Three-story, rectangular (17 m wide - 122.5 m long), brick building on Piquette Avenue followed the standards of mill buildings in terms of facade conditions, building materials, working environment, and multi-story presence.¹²⁹

¹²⁸ Charles K. Hyde, "Assembly-Line Architecture: Albert Kahn and the Evolution of the U.S. Auto Factory, 1905-1940," *The Journal of the Society for Industrial Archaeology* 22, no.2 (1996): 10.

¹²⁹ Ibid.



Figure19. Piquette Avenue Factory, Ford Motor Company, Detroit, 1904.



Figure20. Interior organisation of Piquette Avenue Factory, workers in an electrified room and producing by pre-assembly line technologies.

Interior conditions with simple allocation of workstations in parallel rows, artificially and naturally illuminated narrow space, and not entirely mechanised production processes depending on the manual labour of workers portray the qualities of mill buildings. However, rapid acceleration of the industry and the epitome of efficiency through rationalisation maintained experiments of engineers within the factory to advance and utilise their findings within the boundaries of production space and in new entities. The outgrowth of production in 1908 with the Model T directed Henry Ford to a diverse design by Albert Kahn to apprehend the essence of new possibilities. “The resulting Highland Park plant was the start of a remarkable 35-year partnership that helped revolutionize automobile manufacturing and industrial architecture.”¹³⁰

Albert Kahn began to work for an architectural office in 1882 as an office boy when he was thirteen and continued as he matured to become an architect and own his independent practice.¹³¹ He was renowned for his use of reinforced concrete and contributions for the architectural development of industrial buildings by eliminating the deficiencies of mill buildings through automobile production spaces in the first decades of twentieth century.¹³²

From 1903 to 1905, Albert Kahn designed and oversaw construction of nine buildings for Packard, all of standard mill design and organized much like other factory complexes. In 1905, as he built the company’s tenth building, Albert and his engineer brother, Julius, began their experiment with reinforced concrete. Packard Number Ten and its architect attracted considerable attention from the industrial community.¹³³

Packard Motor Company Building Number Ten was a milestone for Albert and Julius Kahn because it implemented a new model for production spaces by the use of concrete frames. It was designed as a two-story structure constructed with reinforced

¹³⁰ Hyde, “Assembly-Line Architecture: Albert Kahn and the Evolution of the U.S. Auto Factory, 1905-1940,” 12.

¹³¹ Hyde, “Assembly-Line Architecture: Albert Kahn and the Evolution of the U.S. Auto Factory, 1905-1940,” 5.

¹³² In the first decades of the twentieth century, advancements subsequently transpired. Utilisation of reinforced concrete by the efforts of Kahn brothers (Kahn System of Reinforced Concrete patented by Julius Kahn) paved the way for structural innovations in the construction of production spaces as described.

¹³³ Biggs, *The Rational Factory*, 88.

concrete. The application of it distinguished Building Number Ten from the prior nine mill buildings that Albert Kahn designed for Packard Motor Company in recognition of wider span, reduced number of columns, sound construction, fire safety, less vibration, and ameliorated lighting and ventilation.¹³⁴ “innovative structure [that would] bridge the gap between the older tradition and the stunningly new type of factory.”¹³⁵ Therefore, transition from mill buildings and nineteenth century industrial complexes to twentieth century production spaces of daylight factories depended on the construction techniques and materials as well as planning strategies. Managers and engineers inclined toward rational planning and systematising of the flexible floor of production spaces while number of workers, machines, and materials were enhancing. Materials handling and processing along with good visibility for maintenance purposes were determining factors for the transition. “‘The design of the building,’ wrote Charles Day, ‘should allow work to go forward as though the building did not exist at all.’”¹³⁶ Strategies for steady flow of operations included distinct arguments regarding the shape and floor numbers of production spaces. For instance, traditional building shapes of L, E, and H replaced by rectangular floor plans to avert hidden corners and lack of control.¹³⁷ Although it embodied the exhaustive maintenance understanding of engineers and managers, standard rectangular base (typical plan) enabled spatial focus to be on ameliorations rather than the shape of the building.

¹³⁴ Hyde, “Assembly-Line Architecture: Albert Kahn and the Evolution of the U.S. Auto Factory, 1905-1940,” 7-9.

¹³⁵ Reyner Banham, *A Concrete Atlantis: U.S. Industrial Building and European Modern Architecture, 1900-1925* (Massachusetts: The MIT Press, 1986), 237.

¹³⁶ Biggs, *The Rational Factory*, 50.

¹³⁷ Biggs, *The Rational Factory*, 51.



Figure21. Interior view of Packard Motor Company Building Number Ten, Albert Kahn, 1905. Earlier interpretation of a daylight factory, in spite of set electrical fixtures, some gears, belts, and shafts were still in-use, workers closely aligned at workstations in front of large windows.

Moreover, change of building shapes prompted the discussion of multi-story versus single story production spaces. Since the nineteenth century construction techniques constrained single story structures, familiarity resided with multi-story buildings. In the case of growth, multi-story structures were evaluated as more advantageous in contrast to single story production spaces on the basis of supervision of processes and placement of operations. However, single story production spaces with less columns and cluttering in the work environment seemed to offer easier access, visibility, and stability to heavy workload. “Typically, one-story plants were built for the heaviest work – foundries, railroad car works, steel mills, machine shops, and forges. Producers of machine tools, firearms, clothing, shoes, and automobiles commonly used

multistory plants.”¹³⁸ These preconceived opinions due to the limitations of construction materials altered with the utilisation of reinforced concrete.

After Albert and Julius Kahn’s work for the Packard Number Ten, reinforced concrete revolutionised the architectural direction of production spaces for auto industry. Tensile strength of reinforcing bars in concrete allowed to construct internal and fewer columns without the necessity to constitute load-bearing exterior walls. Thus, relieving exterior walls from carrying loads to foundations paved the way for large window-walls to let natural light in. Furthermore, reinforced concrete enabled heavy machineries to be placed on higher floors of the multi-story buildings, eliminated vibration that caused discomfort for workers and damage to machineries, and fireproofed production spaces.¹³⁹ These improvements materialised the spread of reinforced concrete production spaces and eliminated antecedent constraints of mill buildings such as improved lighting, ventilation, stability, energy efficiency, layout, health hazards, and etc. Through articulation made possible with multi-story reinforced concrete framing, solid and void relationship between structural components of buildings such as lintels, columns, and floors attained a simplified pattern of light and shade and became open to interventions. Therefore, Packard Motor Company Building Number Ten as the first multi-story production space built by reinforced concrete frames also referred as one of the primary attempts to concretise daylight factories. Consecutively Building Number Ten was followed by the collaboration of Ford and Kahn, and the emergence of Highland Park Plant. Thus, before transitioning to the assembly line production model, assembly halls of production spaces were already opened up, enlarged, naturally illuminated, and better ventilated. The interior view of the Building Number Ten captured the working conditions, concretised structural components, large glazing surfaces, and alignment of machineries of 1905 in one frame that construction technologies and architecture of the production space were transformed before means of production. While

¹³⁸ Biggs, *The Rational Factory*, 52.

¹³⁹ Ibid.

instruments of labour continued with the latest technologies of the nineteenth century, labour struggles and architecture laid the foundation for an industrial tabula rasa, the daylight factory.



Figure22. Interior view of the assembly department of the Packard Motor Company Works, Albert Kahn, 1917. Layout of a daylight factory in the absence of workers, window-walls naturally illuminating the work environment, wide spans with reduced number of columns to open up more space, electrical lighting arranged as supplementary according to a grid, pipes were organised at the upper layer and invisible configuration of electrical wires that uncluttered and simplified the assembly hall. Structurally simplified, generic base of a nth plan of this daylight factory modelling the common variation of the typical plan.

Daylight factories gave way to the consolidation of rationalisation and standardisation of production in a mechanic way regardless of human agent it depended, however, its emergence and distancing the typology of production spaces away from mill buildings

contributed to living and working conditions of workers. Despite the hidden agenda of standardising workers into parts of machineries by Americanism/Fordism and strategies to avoid high labour turnovers, daylight factories were crucial in the development of architecture of production spaces.

Over time, capitalism did not determine the factory; rather, the attitudes, frustrations, and needs of the working class influenced advancements in policy, plant conditions, and architecture. As employers answered their employees' struggles, protests, and sit-ins by investing in better wages, fairer hours, and safer working conditions, capitalist goals were not simply met but exceeded. Financial potential lay within revolution and the architecture and work systems that answered it.¹⁴⁰

Daylight factories were the architectural embodiment of capitalist incentives and labour struggles in the beginning of the twentieth century. While workers demanded more wages, healthy and better work conditions, and eight-hours shift, daylight factories provided healthier, cleaner, bright, open, and organised production spaces. Ameliorations in the work environment distinguished daylight factories from mill buildings. Reyner Banham elaborated on the generation of daylight factories in his book, *A Concrete Atlantis: U.S. Industrial Building and European Modern Architecture, 1900-1925*.¹⁴¹ Banham divided the development of the daylight factory into three periods; preliminary (late 1890s to 1906), classic (1906 to 1913), and decadent (1914 to early 1920s).¹⁴² This separation was necessary due to subsequently transpiring advancements whether the use of reinforced concrete, adoption of the assembly line, or rapidly growing industry. On the basis of layout, facade articulation, and means of production, although Packard Motor Company Building Number Ten and Highland Park Plant of Ford Motor Company were closely built, they differed and hence, involved in different periods. In a similar manner, although Highland Park Plant and River Rouge Plant were both designed by Albert Kahn, they differed with regard to the floor plans, number of floors, and materials handling. The diversity within the

¹⁴⁰ Marullo, "Typical Plan: The Architecture of Labor and the Space of Production," 103.

¹⁴¹ Reyner Banham, "The Daylight Factory," in *A Concrete Atlantis: U.S. Industrial Building and European Modern Architecture, 1900-1925* (Massachusetts: The MIT Press, 1986), 23-109.

¹⁴² John Coolidge, "From Grain to Gropius," *The New York Times*, May 4, 1986, accessed April 28, 2021, <https://www.nytimes.com/1986/05/04/books/from-grain-to-gropius.html>.

typology of daylight factory mirrored the rapidly evolving technology and industry onto the architectural plane. On that note, Albert Kahn did not invent the daylight factory, there were several early cases in Buffalo and New York, however, he refined and popularised its design through reinforced concrete, steel framing, enlarged windows, glass roof monitors, and numerous projects for industry.¹⁴³

The German architect Peter Behrens had already used windows in a unique way in his AEG Turbine factory in Berlin, but it was not yet a daylight factory... So even though, Albert Kahn, the architect for the automobile industry, received the greatest attention for his early daylight factories, he shared interest in the new type of factory with many others. Daylight factories became practical only with the introduction of reinforced concrete.¹⁴⁴

The emergence and development of the daylight factory became possible not only with the introduction of reinforced concrete but also, the wide range of electrification in the instruments of labour to ease the process. The progress of industry and correlatively the architecture of production spaces were interdependent developments. For instance electrification and the disappearance of the mechanical power transmission systems enabled the use of electrical travelling crane, and new configuration of transportation and materials handling tools. Furthermore, the inexistence of mechanical power transmission equipment allowed natural light to enter through large glazing surfaces

¹⁴³ Albert Kahn even restructured his architectural practice as it was a factory and included subdivisions within the office due to the immense workload. To keep up with the growing demand from the industry, he divided the requirements of projects to teams that comprised of specialists varying in architecture, construction, and engineering, then, added a management structure to supervise the progress and tasks-accomplished. The way of compartmentalizing projects and embracing rationalisation to complete projects encouraged collaboration between disciplines but also, mechanised the process of design and creation. This may have caused the difference that Lindy Biggs assessed between the works of Peter Behrens and Albert Kahn. According to Biggs, Peter Behrens as an architect collaborated with leading industrial company, AEG for every product, building, and advertisement had great influence on Albert Kahn during Kahn brothers' tours of German architecture. In spite of specific reference for Behrens, Biggs deduces the impact of Behrens on Kahn brothers through their drawings, notes, structural studies, and artefacts. She also assess that the imagination and idealism of Behrens is hard to find in Kahn's theoretical and practical works. Yet Albert Kahn drew advantage from the void in the automobile industry of the United States as an architect and became well-known for rapidly-developing production space blueprints he created with reinforced concrete and steel frames. His neutral stand as an architect while generating designs to cover his clients' needs mutated spatial improvements into capitalist exploitation tools of labour.

¹⁴⁴ Biggs, *The Rational Factory*, 97.

and roof lights onto machineries without hard shadows. Therefore, prior advancements regarding technology and energy acted as agencies in the construction of production spaces, and in the case of the daylight factory, it was the accumulation of many alterations and movements. With the aim of maximum efficiency, “the ‘plan’ of the daylight factory was transformed into a ‘layout’ that reduced men and raw materials to parameters of an overall logistical dispositive and eliminated any possibility of waste, congestion, or worker insubordination.”¹⁴⁵



Figure23. Old Shop, Highland Park Plant, Ford Motor Company, 1910.

¹⁴⁵ Marullo, “Typical Plan: The Architecture of Labor and the Space of Production,” 114.

The Ford Highland Park Plant began operating on January 1, 1910.¹⁴⁶ It consisted of nine buildings, a four-story main manufacturing unit (approximately 23 meter wide and 264 meter long) of reinforced concrete framing paralleled with a single story, steel-framed machine workshop (43 m × 256 m) where the parts of the Model T were produced under a glassed saw-tooth roof. The main manufacturing building, also referred as the Old Shop (due to the addition of new buildings in 1914-8) planned according to a grid of 7.6 m × 6.6 m in the main assembly area of production and all circulation elements such as elevators and stairs along with restrooms and shafts separated from the main hall with the attachment of four utility towers. The implementation of reinforced concrete frames made possible the uninterrupted layout of production, simplified interior structural organisation with wider span and thus, less columns, and enlarged glazing surfaces on exterior walls. The change in fenestration systems increased the natural light exposure in the main hall and supported with light-coloured paint to brighten the interior spaces.

‘Light is the first essential of low labor-cost factory production.... Good light facilitated precision work, which was essential to the severe standardization needed to make interchangeable parts. Ventilation was just as important, as dust makes machines working at close tolerances malfunction.’¹⁴⁷

After first occupation of the land, Ford adjoined two four-story reinforced concrete wings to the Old Shop and enclosed the sides of the single story machine shop with a U-shaped structure.¹⁴⁸ In addition, Highland Park plant included an administration building and a powerhouse within its plot. Even in its first state before the emergence of New Shop (two six-story concrete buildings annexed in between 1914 and 1918 due to efficiency experiments including assembly line iterations and better materials handling systems), the Highland Park plant represented Henry Ford’s revolution in automobile industry and in general, architectural transition of production spaces on

¹⁴⁶ Hyde, “Assembly-Line Architecture: Albert Kahn and the Evolution of the U.S. Auto Factory, 1905-1940,” 12.

¹⁴⁷ Nye, *Electrifying America: Social Meanings of a New Technology*, 222-4.

¹⁴⁸ Hyde, “Assembly-Line Architecture: Albert Kahn and the Evolution of the U.S. Auto Factory, 1905-1940,” 12.

the grounds of construction advancements, rationalisation, and recognition of labour power in the reality of turnovers and strikes.

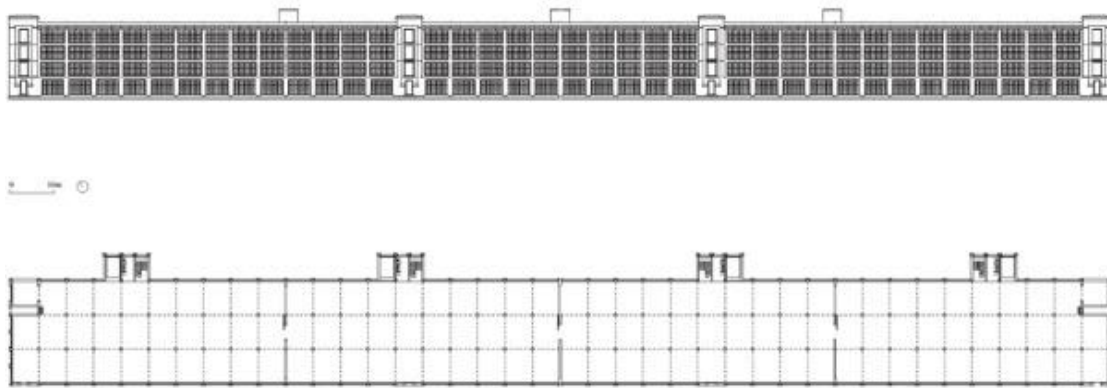


Figure24. Elevation and Plan of Old Shop, Highland Park Plant, Redrawn by Francesco Marullo. Elevation depicts the distinct change that window-walls generated on the facade and generic floor plan of the building points out the base as typical plan, structurally simplified, separated functions (circulation-production), and open. Narrowness of the building still existent despite available electrical lighting and increased natural light.

The Highland Park Plant was built to meet with the demand of Model T, “the average car for the average man.”¹⁴⁹ At first, the Ford Motor Company chose to produce solely the Model T due to the experiments of assembly line to have more efficient production and keep up with the incremental demand in the Old Shop. And also, one product and single layout design in a similar manner with the case of Adam Smith’s pin makers allowed to perfect the production process where assembly line and streaming of parts resolved.¹⁵⁰ Then in 1914, Henry Ford involved two six-story concrete buildings (18 m × 259 m) in perpendicular placement behind the Old Shop and a third six-story building segment two years later, he referred them as the ‘New Shop.’¹⁵¹ In the New Shop, Albert Kahn arranged the six story structures as a series of parallel buildings and assembled every component under six story glass-roofed craneways with more than two hundred cantilevered balconies to provide vertical distribution of materials.¹⁵² After experiments, in the New Shop, improved models of materials handling were operated as railroad tracks continued into the building and carried processed materials and products under cranes. Electrical cranes lifted parts or materials to upper levels and unloaded at the cantilevered balconies above the tracks. Thus, a vertical assembling system also arose through sounder construction techniques and inclusion of assembly line without concerning with vibration or weight of machineries. Starting with raw materials turning into parts in the upper floors, as they go down to the sub-assembly lines on lower floors, they are processed, and lastly reach to the main assembly line on the ground floor. After the overall process completed, Model Ts could be driven out of the building to the parking lot.¹⁵³

¹⁴⁹ Marullo, “Typical Plan: The Architecture of Labor and the Space of Production,” 114.

¹⁵⁰ Nye, *America’s Assembly Line*, 27.

¹⁵¹ Hyde, “Assembly-Line Architecture: Albert Kahn and the Evolution of the U.S. Auto Factory, 1905-1940,” 12.

¹⁵² Marullo, “Typical Plan: The Architecture of Labor and the Space of Production,” 126.

¹⁵³ Hyde, “Assembly-Line Architecture: Albert Kahn and the Evolution of the U.S. Auto Factory, 1905-1940,” 25.



Figure26. Inner Configuration of the New Shop with electrical cranes, balconies in various levels, and railroad tracks at the bottom to carry products to the shipment area after production completed.

By gradually introducing the moving assembly line and related manufacturing innovations at the Highland Park plant in 1913-14, Ford revolutionized automobile production... In 1914, the Highland Park plant employed 13,000 workers and 15,000 machines... The new factory architecture Kahn and Ford created at Highland Park supported these innovative production methods. The wide floor spaces uninterrupted by walls, extremely strong and vibration-resistant floors, and well-lit work areas with excellent ventilation all contributed to Ford's mass-production system.¹⁵⁴

¹⁵⁴ Hyde, "Assembly-Line Architecture: Albert Kahn and the Evolution of the U.S. Auto Factory, 1905-1940," 14.

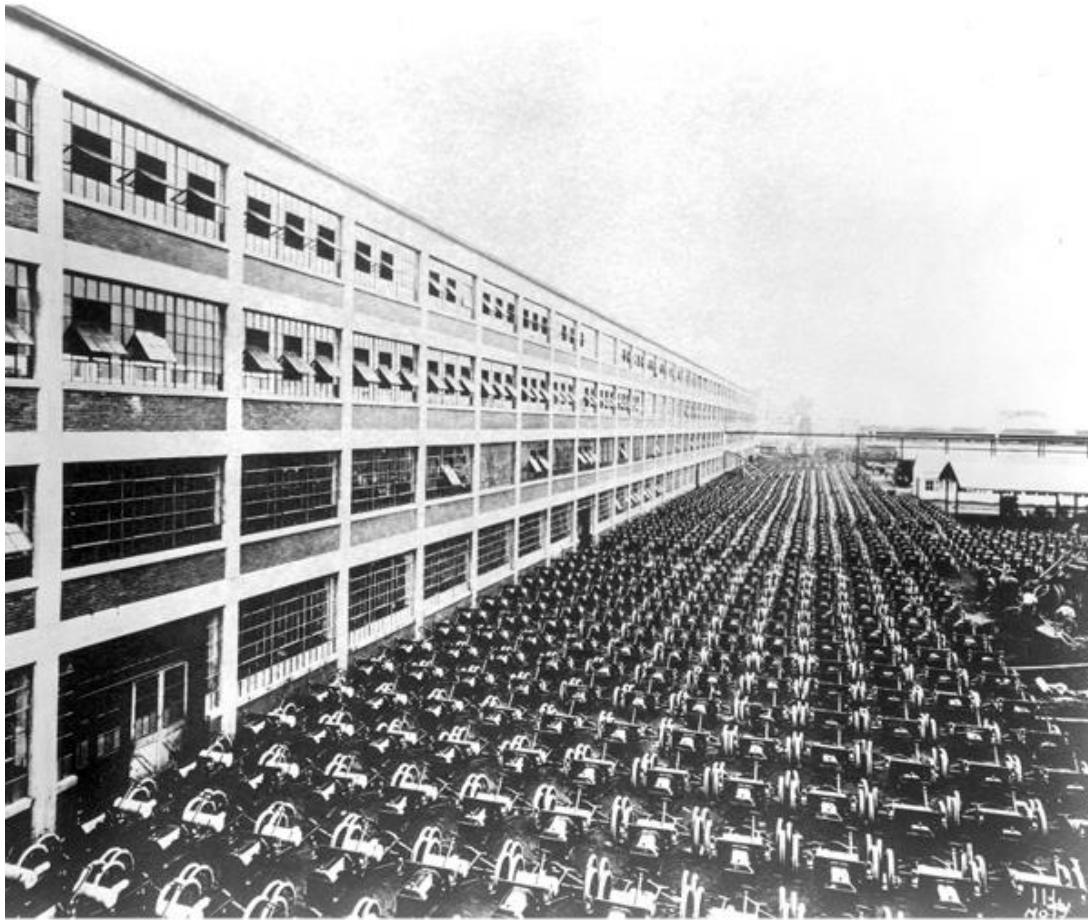


Figure27. The Highland Park Plant, The Ford Motor Company, daily production amount of Model Ts parked outside.

The Highland Park Plant, from the Old Shop to the means of production in the New Shop altered the architecture of production space and instruments of labour while abruptly increasing production volume. “In 1909, when older methods were still in use, assembling a single Model T took more than 12 hours; by 1914 it took only 93 minutes. The same number of workers could assemble 775 percent more automobiles in 1914 than in 1909.”¹⁵⁵ In light of the statistics of production, feasibility of the

¹⁵⁵ Nye, *America's Assembly Line*, 28.

assembly line evidenced its generation in terms of sustaining the volume of capitalist production and accelerating its momentum. The great difference of production volume in five years reversed the cost of the Model T, and the initiative of Henry Ford to lower the price to enlarge the market resulted in more demand and rise in production. The reduction of the price of Model T and growth of production allowed Henry Ford to raise wages to avoid labour turnovers, and thus, a chance for workers to buy one on their own. The idea of workers to become consumers and purchase what they produce on the assembly line resembles the perspective of the Werkbund, hence, same ideals of expanding market and increasing the demand captured the character of mass production.

TABLE 2. I
Data on Model T automobiles, 1910–1921

	Nominal price	Real price (1910 dollars)	Number of cars produced
1910	\$950	\$950	19,051
1911	\$780	\$787.90	34,070
1912	\$690	\$669.40	76,150
1913	\$600	\$585.90	181,951
1914	\$550	\$526.80	264,972
1915	\$490	\$448.60	283,161
1916	\$440	\$359.30	534,108
1917	\$360	\$236.70	785,433
1918	\$450	\$263.10	664,076
1919	\$525	\$269	498,342
1920	\$507	\$227.90	941,042
1921	\$397	\$214	971,610

Figure28. Production growth and correlatively declining prices of Model T in between 1910-1921.

Through rationalisation, Henry Ford continued to progress means of production in his daylight factories, and after Highland Park Plant – Old Shop followed by the New Shop – River Rouge Plant allocated higher expectancies of production within a new typology. Rather than the multi-story production space, Henry Ford favoured the single story, long, steel-framed, and glass-enclosed structures in the River Rouge Plant. It concluded the discussion regarding number of floors in a production space to have more efficiency, at least for Ford since advancements in technology allowed production to flow horizontally around the long entity of the space without exceeding the efficiency rate of vertical circulation of materials. New model of structures in the River Rouge extended the spatial limits of production spaces and introduced a different version of daylight factory into the practice. And also, the River Rouge Plant converted the great machine ideal of the eighteenth century into reality.

In the Rouge, Ford succeeded in translating one hundred years of discourse about the rational factory into physical design. The River Rouge plant was indeed a great machine embodying the principles of efficiency, order, and control; it could produce automobiles much as Oliver Evans's mill had ground flour: the raw materials entered at one end, and a finished product left at the other. All this was done with the help of sophisticated special-purpose machines, an elaborate system of materials handling, a well-controlled work force, and a building designed for production.¹⁵⁶

To assess the change between Highland Park and River Rouge Plant, renowned B Building in the River Rouge needs an examination.

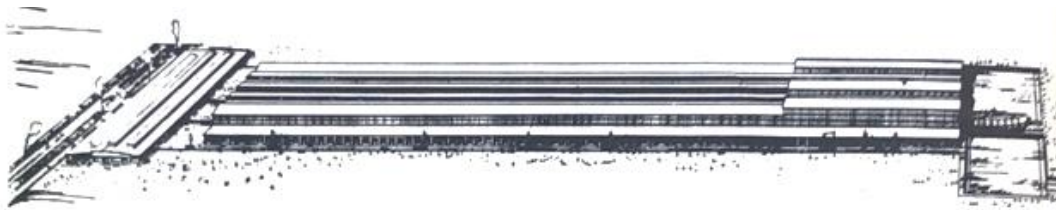


Figure29. The B Building, River Rouge Plant, Albert Kahn, 1918. Designed as a boat building, later converted into automobile production. Single story, app. 520 meter long, steel framed, glass-enclosed daylight factory model.

¹⁵⁶ Biggs, *The Rational Factory*, 161.

The configured and precise assembly line of Ford Motor Company compiled systems of management such as cost accounting, inventory control, incentive wages, and standardisation of work routines through advanced instruments of labour and accelerated materials handling.¹⁵⁷ The initial efforts actualised in the Highland Park strengthened the design parameters and layout strategies when Henry Ford decided to expand his production near River Rouge. Lindy Biggs -mentioned severally- conceptualised strivings of efficiency from the eighteenth to the twentieth century as ‘the rational factory’ and in the progress of Ford Motor Company, she asserts that the River Rouge Plant is the destination point for the actualisation of rational factory.

The plant that Ford built on Detroit’s Rouge River was a new kind of factory. It was innovative not only for its size and suburban location but also for its buildings, plant organization, and the fact that it produced and processed almost every component of the Ford car. In the early 1920s, Henry Ford believed that his business would prosper if he no longer had to rely on outside suppliers who could raise prices for steel and other essentials as the market allowed, and he embarked on a radical venture to supply himself with raw materials... At the Rouge, the entire thousand-acre plant would become a great, integrated machine.¹⁵⁸

The self-sufficient line of production realised in River Rouge plant carried Ford Motor Company further after the adaptation of assembly line. In the production process, Ford gained the acceleration and standardisation in Highland Park, however, in River Rouge, he became independent from external suppliers, market instabilities, and material shortages. It changed every input that constituted the base lines of the production space and more with regard to the planning of industrial premises. Since at that time in the second decade of the twentieth century, Ford was the leading figure in means of production and respectively, production spaces, there were no master blueprints for River Rouge plant. According to William F. Verner, the supervisor of River Rouge’s construction, Ford began by deciding on the expected capacity of production as five thousand Model T’s a day, and accordingly determined the required

¹⁵⁷ Nye, *America’s Assembly Line*, 16.

¹⁵⁸ Biggs, *The Rational Factory*, 137-8.

raw materials and facilities.¹⁵⁹ In the absence of master blueprints, the procedures of production and its rational order shaped the order of construction and proximity of buildings. For instance, Verner studied the production process of Model T and after consultations with the managers of each process, he formed the construction flow of the plant. The main material of Model T was steel, hence, Verner started with the transportation network to carry raw materials such as railroads and canals. After specifying the circulation of materials within the plant, steel mill was built. It led to the foundry for engine blocks, rolling mills, and the facilities in need to make sheet steel and stamp it into parts. Consecutively, construction of the motor department followed the foundry, and then, machine shops were added.¹⁶⁰ In a systematic order of production, the complex was configured. In compatible with the order, another concern regarding the layout was the possible growth based on the statistics in between 1910-1921. Thus, engineers left room for growth for every building and separated the lots of the buildings without causing delays in material transportation. “The enormous size of the Rouge site reflects the extent and speed of the company’s growth and the engineers’ expectation of virtually unlimited growth.”¹⁶¹

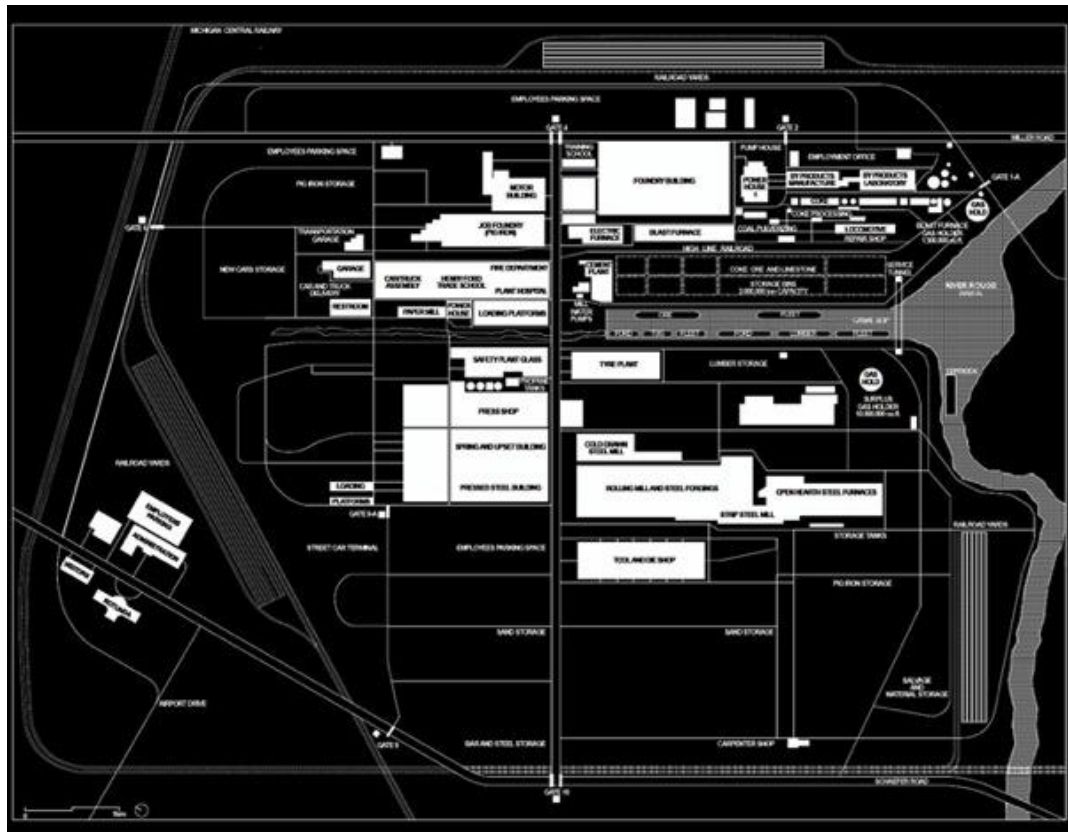
¹⁵⁹ Nye, *Electrifying America: Social Meanings of a New Technology*, 225-30.

¹⁶⁰ Nye, *Electrifying America: Social Meanings of a New Technology*, 228-32.

¹⁶¹ Biggs, *The Rational Factory*, 152.



Figure30. An aerial view of the River Rouge Plant, Ford Motor Company, Albert Kahn, 1940s.



The rationalisation phases induced the model of single story, steel-framed, longer workshops due to the modularity, easy to customise possibility, and rapid assemblage for daylight factories. One of the first trialled case of this model of daylight factory is the B Building (it was also the first building of the River Rouge, completed in 1919).¹⁶² It constructed for the production of Eagle Boats for the American Army, and despite its extensive length (app. 520 meter long and 92 meter wide), construction process was completed in less than four months by the steel framework.¹⁶³ Beside the advance of time, steel framing enabled B building to be modular. It created a diversion in the architecture of production spaces because in the process of change, power distribution system and lighting concerns were the determining factors. The more machineries progressed; the more production spaces got mechanised. The design parameters eliminated issues of power transmission with the unit drive and dimensions of machineries regulated the layout of production spaces. Then, construction materials and techniques offered more possibilities instead of acting as restrictive components. In a brief statement, production spaces were changing yet B building physicalised hitherto transformation in terms of construction, means of production, and scale.

¹⁶² Biggs, *The Rational Factory*, 143.

¹⁶³ Marullo, "Typical Plan: The Architecture of Labor and the Space of Production," 129-30.

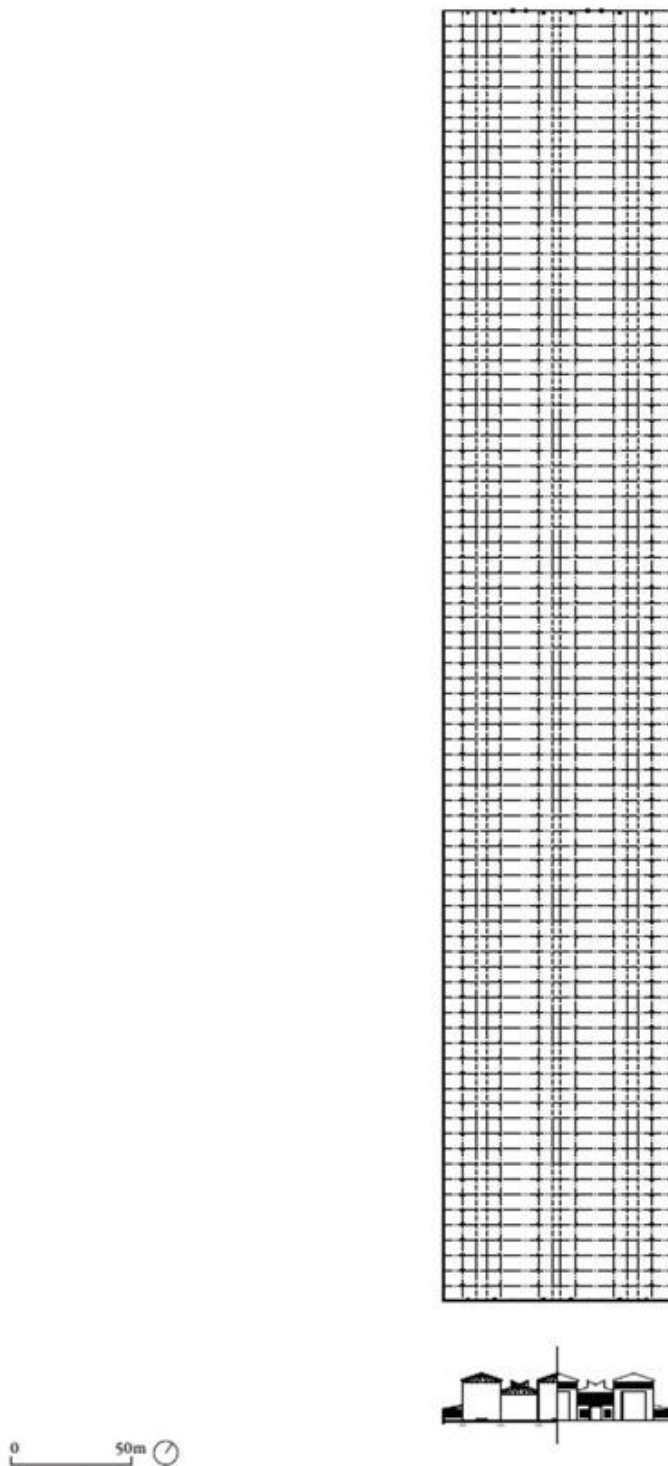


Figure32. Plan of the B Building, Albert Kahn, 1917. Below the plan, there is a reference for the front elevation and cross section. In the two aisles of the building, rail tracks were configured to transport the heavy materials of the boats while, in the rest, hulls were assembled. Annex buildings at the sides were comparatively low, wooden-framed, half the width, and reserved for service functions.

Construction of the B building signalled Ford's total break from the traditional mill building. Though in planning the New Shop at Highland Park, Ford engineers had abandoned traditional layout patterns and introduced revolutionary materials handling devices, in the end those buildings retained a similarity to the classic dimensions and appearance of the mill building. The B building retained the basic, rectangular shape of the textile mill, but its dimensions make any such comparison superficial. Its size dwarfed all factories built before it.¹⁶⁴

Through this distinction that modularity of steel framing provided, B building constituted the elementary structure which can be modified, reassembled, and enlarged under new circumstances. Since engineers configured the layout of production based on the rationalisation of the process and high efficiency aims, Albert Kahn, as the architect, was engaged solely for the outer shell of the B building. It may seem a rational decision based on the experience of engineers through advancements of production processes, however, it was a further kind of division of labour and degrading model of standardising skill against the architect and the relation of architecture discipline with industry.

By the time Kahn Associates helped build the Rouge plant, their philosophy regarding industrial architecture was fully developed: production engineers should lay out the work of the factory, and the architect 'should be able to plan a factory around the scheme of production.'¹⁶⁵

On the other hand, the modularity of the B building enabled the transformation to car production after boats. It represented the openness of the production space for further possibilities without any limitation on the material, size, and methods. Standardisation of the production process and vastness of the building maintained the accommodation of variety of materials. Although the architect demoted to the construction of an outer shell for inner operations, the indeterminacy of means of production and continuous evolvments strengthened the typology of simplified rectangular block. It was designed to correspond to changes while accommodating both its agents, machineries

¹⁶⁴ Biggs, *The Rational Factory*, 143-5.

¹⁶⁵ Biggs, *The Rational Factory*, 143.

and human labour.¹⁶⁶ In a way, it foreshadowed the production spaces in machine landscapes in terms of vastness, adaptability, and primary strategy of rational and based on needs development. Furthermore, another similarity is the dominance of machine perception over the human scale through the vastness of the space. Although not every daylight factory of the twentieth century concretised same qualities as the B building, it holds an influential and informative space for the architecture of production spaces.



Figure33. Aerial view of the B building, River Rouge Plant, Ford Motor Company, 1938.

¹⁶⁶ The simplicity and indeterminacy of the production space are reasons to consider the floor plan of daylight factories of Albert Kahn as variations of typical plan with respect to Francesco Marullo's PhD thesis, "Typical Plan: The Architecture of Labor and the Space of Production." Marullo assesses the typical plan more than a floor plan, a device to contain, mediate, and measure any kind of activity across the floor. It did not have an already articulated organisation as a layout, on the contrary, the typical plan was generated in each instance specific to the conditions, limits, and concerns. "... 'index' of the generic human potential." Thus, Marullo relates typical plan with labour, class struggles and revolts more than an architectural drawing in his doctoral thesis. He treats issues of labour and class struggles referring to Karl Marx's definitions, and structures the typical plan as a product of social conflicts rather than a neutral technical process. He considers the alienation of workers inside a production space surrendered with continuously developing machineries and advancing technology for the sake of efficiency and production to generate the necessity for the typical plan. Although Francesco Marullo's doctoral dissertation has been highly guiding and influential for this thesis, it lies heavily on architectures of production spaces that alter through industrial revolutions (while generating their plans from typical plans of their own).

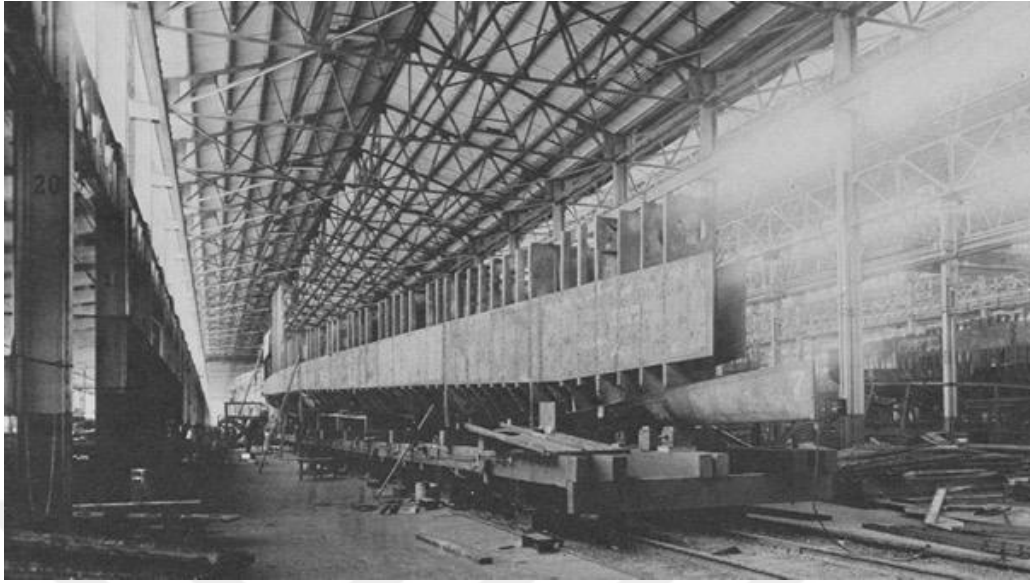


Figure34. Interior of the B building, Albert Kahn.

The entanglement with rationalisation and moves for the sake of production characterised the industrial journey of Ford Motor Company from the Piquette Avenue to the River Rouge and in many more international attempts to globalise. However, despite the reached productivity and efficiency, River Rouge plant also discovered the detriment of the rational factory, the lack of flexibility.¹⁶⁷ The absence of adaptability to changes in the market, demand, model, and thus, reconfiguration of assembly lines in a continuous pattern demonstrated the limits of the total rationalisation. Nevertheless, the processes of production required flexibility in product and building design in terms of materials, techniques, and continuous demands. The flexibility

¹⁶⁷ Biggs, *The Rational Factory*, 159-60.

As a counter-argument for Lindy Biggs' 'rational factory,' David E. Nye suggested 'flexible factory' as mentioned before. However, Nye's assessment was towards the flexibility that electrification made possible for the production space. It included the flexible layout, yet the main aim was to refer to the flexibility that emerged with the disappearance of cluttered and mechanised power distribution systems as well as artificial lighting equipment. In addition, the lack of flexibility awareness led some machine landscapes to employ human workers to respond to the market changes better like in the case of Rapoo Technology in the Pearl River Delta region.

depended on the skilled labour. Years of deskilling workers to maximise their adaptation to the mechanised means of production instead of cultivating and strengthening the labour force through advancements resulted in a total rationalisation of tangible components of the production space. Consequently, Ford Motor Company reached its peak of rational factory in the River Rouge plant while exhibited the growth of automobile industry through the differentiation of production spaces.

The Piquette Avenue plant represented the company's first expansion. Its builders clearly copied the nineteenth-century mill building style, which worked because the company's production process at the time differed little from nineteenth-century production. Highland Park's Old and New shops were transitional buildings, embodying characteristics of both nineteenth- and twentieth- century factories... The River Rouge plant undoubtedly introduced the modern rational factory to the world; the modern factory combined rational factory planning with modern production and construction technology.¹⁶⁸

¹⁶⁸ Biggs, *The Rational Factory*, 162.

3.6. Ford Motor Company in Istanbul¹⁶⁹



Figure35. Ford Motor Company Exports Inc., an assembly plant, Tophane Pier, Istanbul, 1929-1944.

In 1920s, Ford Motor Company had ambitions to increase their share in the international automobile industry and to establish global superiority over other companies such as General Motors, Chrysler, Fiat, Renault, and Citroen. However, transportation and shipment of goods was precarious because carrying cars, trucks, and tractors as intact as they left the River Rouge plant posed difficulties. Therefore,

¹⁶⁹ For this section of the study, two journal articles were laid the foundation for Ford Motor Company Exports Inc. located inside the warehouses of Tophane Pier. Both articles are written in Turkish. Aslı Odman, "Serbest Mıntıka'dan Amerikan Pazarı'na Tophane Rıhtımı: Ford Motor Company Exports Inc., İstanbul Otomotiv Montaj Fabrikası, 1925-1944," *Tarih ve Toplum Yeni Yaklaşımlar*, no.12 (Spring 2011): 71-93. Alper Yulu and Kaan Kapan, "An Investigation of Industrial Geography: Assembly Plant of Ford at Istanbul," *The Journal of International Social Research* 11, no.59 (October 2018): 384-91.

Ford Motor Company started to settle in assembly plants in many countries based on their geographic conditions, proximity to the countries with the highest density of consumers, and lack of nationalisation politics and international embargoes. Assembly plants established in strategic geographic locations expedited the travel time of goods, and shipment of parts of automobiles cost less than to transport the whole car. Thus, assemblage of parts which were produced in River Rouge plant by local labour power formulated the global sprawl of Ford Motor Company through 'territories'.

Emergent Republic of Turkey attracted Ford Motor Company with its geographical location and proximity to the foreign markets of Greece, Romania, Russia, Iran and Afghanistan since 1925 as a new territory.¹⁷⁰ In 1929, after the enactment of 'Serbest Mintika Kanunu' and identifying some parts of Tophane Pier as free zone, Ford Motor Company Exports Inc. got settled in the warehouses located at the pier and started to realise the assembly of automobile parts.¹⁷¹ Since Republic of Turkey arrived late to the prior industrial developments, Ford's assembly plant was the first automobile manufacturing company in Turkey, thence, its presence contributed to the prosperity of the new republic and introduced local labour with the improved means of production. The enumeration of industrial facilities in 1927 documented that there were 155 establishments that employed a hundred and more workers in total of 65 245 industrial corporations. According to the industrial enumerations of 1927, Ford Motor Company with its approximately four hundred workers (in 1930) was one of the leading industrial entities.¹⁷²

¹⁷⁰ Special Cable to the New York Times, "Hear Ford Plans Factory in Turkey," *The New York Times*, July 31, 1925, <https://www.nytimes.com/1925/07/31/archives/hear-ford-plans-factory-in-turkey.html>.

¹⁷¹ Odman, "Serbest Mintika'dan Amerikan Pazarı'na Tophane Rıhtımı: Ford Motor Company Exports Inc., İstanbul Otomotiv Montaj Fabrikası, 1925-1944," 76-81.

¹⁷² Yulu and Kapan, "An Investigation of Industrial Geography: Assembly Plant of Ford at Istanbul," 385.



Figure36. First Model T's assembled at Ford Motor Company Exports Inc., Tophane Pier, 1929.



Figure37. Interior view of the production space under the Administration of Seyr-i Sefain in 1920s, before Istanbul Chamber of Commerce, and Ford Motor Company Exports Inc. Mechanical gears, shafts, and belts were supported through steel columns and opened the production space.

The allocated warehouses were single story, plastered stone buildings with a total floor area of 13 433 square meters.¹⁷³ They were supported with steel columns, enclosed by wooden gable roofs which were strengthened by wooden beams and differed in heights (3.5 to 10 meters), and constructed on a stone floor. They represented the typology of mill buildings excluding the number of floors, but it might be sourced from regulations or design parameters due to its location near the sea front. While transitioning from a warehouse to an assembly plant, it spatially did not change, however, through the means of production Ford Motor Company brought the technology and knowledge of twentieth century into the production space. Ford configured the organisation of the assembly line through six buildings by dividing and making necessary connections. As Aslı Odman describes, one of the building was assigned as the main assembly hall where assembly line and ovens for dying and polishing were placed and powered through electrical drive. The other two (adjacent) buildings were attributed as storage for parts and tools of assemblage whereas one building was reserved as a garage for manufactured cars. And the last two buildings which were closest to the pier and crane were organised for the storage of spare parts.¹⁷⁴

¹⁷³ Odman, “Serbest Mıntıka’dan Amerikan Pazarı’na Tophane Rıhtımı: Ford Motor Company Exports Inc., İstanbul Otomotiv Montaj Fabrikası, 1925-1944,” 85.

¹⁷⁴ Ibid.

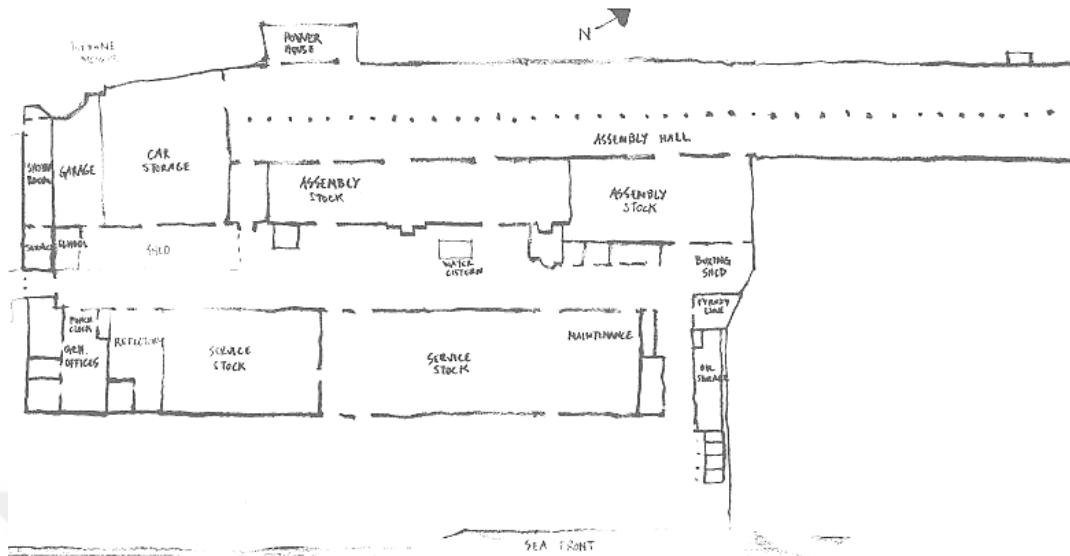


Figure38. Schematic layout of Ford Motor Company Exports, Inc., Istanbul. Sketched by Ash Odman.¹⁷⁵

Although projections regarding the production volume did not realise after 1930s due to the economic depression in the United States and initial political conflicts of World War II, Ford Motor Company Exports Inc. converted warehouses of Tophane into an efficiently operating assembly plant in its earlier stages of development. It introduced the advanced techniques of production that they experimented and validated in Highland Park and River Rouge Plant to newly developing industries of Republic of Turkey and contributed know-how of workers employed in the assembly plant. However, the ‘territory’ that Ford Motor Company preferred in the free zone of Istanbul caused the delocalisation of the warehouses in Tophane Pier and did not contribute as much as projected in the initial agreements.

¹⁷⁵ According to the schematic layout drawn by Odman, allocation of Ford Motor Company in the existing structures enabled to recognise its affinity to the mill typology. The scale, building materials, being limited, and the layout reflect the qualities of mill buildings.

Consequently, any contribution of architecture in the realm of industry can be examined as crucial and necessary steps either in a form collaboration with the ideals of good or efficient design since the Industrial Revolution. Architecture as theory and practice has positive impact on the conditions of production spaces with regard to lighting, ventilation, circulation, sanitation, and structure. The gaze of an architect simplifies and regulates the intricate state of production spaces with the technological and construction advancements. For instance, daylight factories elevated the state of production spaces in terms of working conditions, openness, and foremost, brightness. Through progressing construction techniques and utilisation of new materials, it altered the dark and congested interior environment of mill buildings into well-lit and open daylight factories. However, under the hegemony of industry and immoral strategies concretised in production, architects' contribution remain incapable to transform the balance between the base and superstructure. Neither Behrens nor Kahn transcend the exploitive strategies against the drive of production, labour power through their architypes although they contributed to the architectural transformation of production spaces from mill buildings to the daylight factories. Nevertheless, the presence of architecture as a discourse in industry matter to comprehend with the changes in industry, energy, and labour movements through a spatial perspective. Therefore, following the historical overview of industry and the architecture of production, storage, and distribution enables to perceive machine landscapes of Industry 4.0 within the discourse of architecture.

CHAPTER 4

MACHINE LANDSCAPES

4.1. Industry 3.0 and 4.0

In the later twentieth century, after naturalising the utilisation of electricity and being accustomed to the rhythm of the assembly line in production spaces, industry transformed again with the invention of computer, Internet and automated machineries. Through Internet, electronics and online communication technologies started to progress and accelerated the emergence of globalisation.¹⁷⁶ In the Industry 3.0, machineries in production spaces substituted with semi-automated machines that required the assistance of workers to operate, yet largely being automated on their own during production processes. Industry 3.0, also referred as the Third Industrial Revolution in relation to the shift in industry, expanded the range of accessibility of knowledge through globalisation due to new inventions regarding information technologies and electronics.

In rapidly evolving industrial environment, after Industry 3.0, ascending pace of advancements prepared the necessary medium for actualisation and materialisation of Industry 4.0, the Fourth Industrial Revolution, that sourced with the implementation of cyber physical systems.¹⁷⁷

Industry 4.0 describes the organisation of production processes based on technology and devices autonomously communicating with each other along the value chain: a model of the ‘smart’ factory of the future where computer-driven systems monitor

¹⁷⁶ Notes from “Transformation in Manufacturing Industry Toward Industry 4.0” lecture by Assoc. Prof. Dr. Sedef Meral, METU, October 2, 2019.

¹⁷⁷ Ibid.

physical processes, create a virtual copy of the physical world and make decentralised decisions based on self-organisation mechanisms. The concept takes account of the increased digitalisation of manufacturing industries where physical objects are seamlessly integrated into the information network, allowing for decentralised production and real-time adaptation in the future.¹⁷⁸

The Industry 4.0 distinguishes itself from the previous industrial revolutions by targeted full-autonomy of machineries, Internet of Things (IoT), and to change singular entities of production, transportation, energy and agriculture into vast lateral networks.¹⁷⁹ The main focus of the Industry 4.0 concentrates on the degree of automation in many peculiar territories ranging from fulfilment centres, cryptocurrency mines, data centres, and to unmanned logistical spaces (ports, warehouses, etc.). As the degree of automation increases in these territories, they become more desolated from humans. Therefore, they are referred as machine landscapes, and by yielding to the technological momentum of automation and its inevitable impacts on the built environment, industrial advancements should be treated as architectural opportunities to reduce mechanic and logistical problems of Industry 4.0 into spatial parameters of design.

¹⁷⁸ Jan Smit, Stephan Kreutzer, Carolin Moeller and Malin Carlberg, "Industry 4.0" (Study, European Parliament Directorate General For Internal Policies, Policy Department A: Economic and Scientific Policy, 2016), 7.
[https://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU\(2016\)570007_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf). Accessed on December 3, 2019.

¹⁷⁹ "The Third Industrial Revolution: A Radical New Sharing Economy," Vice Documentary Films, Youtube, documentary, 1:44:58, <https://www.youtube.com/watch?v=QX3M8Ka9vUA>, accessed on March 1, 2021. The narrator in the documentary is Jeremy Rifkin, an economist and author of *The Third Industrial Revolution* (2011) and *The Zero Marginal Cost Society* (2014).

4.2. Automated Labour and Machine Landscapes

Acts of building and designing to fulfil the fundamental infrastructure of Industry 4.0 with the anticipated levels of automation changed the dependency on labour while excluding humans from the trajectory spaces of industrial activities, machine landscapes.

The server farms, telecommunications networks, distribution warehouses, unmanned ports and industrialised agriculture that define the very nature of who we are today are at the same time places we can never visit. Instead they are occupied by processors and hard drives, logistics bots and mobile shelving units, autonomous cranes and container ships, robot vacuum cleaners and connected toasters, driverless tractors and taxis.¹⁸⁰

Architecture of production, storage, and distribution converted into data centres, fulfilment centres, cryptocurrency mines, server farms, and among many more spaces of vast lateral networks in the planned absence of humans. Although advancements toward machine landscapes have been reached in the twenty-first century and with the infrastructure of Industry 4.0, ideals of efficiency, automation, and mechanisation constituted the foundation of industry since the eighteenth century. From the initiation of steam engines, labour to actualise processes of production, storage, and distribution experienced the aforementioned division and alienated itself from the generic human capacity of creating by the division of labour. Furthermore, it can be stated that in the absence of human agent in spaces of production, storage, and distribution, then labour struggles would also be eliminated in these spheres and outputs of operations would be referred as work. Mechanised processes of machineries could not be put on par with human labour power. As division of labour blunted the free will, enthusiasm, and connections of human workers to their labour, full-automation annihilated labour power over the standardised and programmed work. In the case of machine landscapes, the objective was to exclude humans from the sphere of production,

¹⁸⁰ Liam Young, "Architecture Without People: Neo-Machine" in Machine Landscapes: Architectures of the Post-Anthropocene, *Architectural Design*, (January/February 2019): 10.

storage, and distribution while maintaining all processes with the assistance of machineries. However, majority of machine landscapes still require human workers and their labour for some operations due to being unable to reach the anticipated level of automation.

‘Automatism,’ writes Mr Eugene Staley, ‘will mean that human labour in advanced technological societies will be used less and less for the repetitive functions involved in feeding workpieces through machines and assembling them into finished products. Labour will be more and more ‘upgraded’ into the kinds of functions performed by the engineer, the designer, the production planner, the skilled maintenance and repair man, the organizer or manager.’¹⁸¹

As Eugene Staley discloses his expectations from the automation process, he states that machines will actualise the divided and repetitive tasks in daylight factories once human workers were employed to do and labour will be upgraded into functions performed by engineers, designers, and skilled individuals. Although replacing human workers from the highly segregated and repetitive tasks of production, storage, and distribution with automated machineries seems like a constructive amelioration, years of tradition to favour deskilled workers for the tasks on the assembly line over skilled and informed workers generated the deficiency of trained individuals. “...at this new stage in technical progress and thanks to automatism, industry will require more and more skilled and highly trained men – managers to think through and plan, highly experienced technicians and workers to design the new tools, to produce them, to maintain and direct them.”¹⁸² Therefore, optimism regarding automation and need of human labour to design, construct, plan, and manage the new ways of operations in machine landscapes is restricted by the accustomed dialectics of means and relations of production since the Industrial Revolution.

¹⁸¹ Georges Friedmann, *The Anatomy of Work: Labor, Leisure and The Implications of Automation*, trans. Wyatt Rawson (New York: The Free Press, 1961), 101.

¹⁸² Friedmann, *The Anatomy of Work: Labor, Leisure and The Implications of Automation*, 116-7.

Moreover, the elimination of human agent in these new spaces changed architectural design parameters. The rationalisation and standardisation of production spaces to design the layout of operations, placement of assembly line to meet with the demands of mass production, and ameliorated conditions for workers through the plan, type of windows, sanitary and ventilation systems, in brief components of daylight factories, lost the key figure of its design parameters, workers. This replacement of parameters enhanced technology and industry, however, alienated production spaces from human scale and needs such as windows and electricity for lighting.

Ancient craftsmen once measured using parts of the human body: the cubit is based on the length of a forearm; the inch, the length of a thumb. Le Corbusier designed his buildings based around the Modulor, a scale he derived from the proportions of the human body. We once understood our world through systems that positioned ourselves, human scale, vision and patterns of occupation at the centre of the structures that we design. In the age of the network, however, the body is no longer the dominant measure of space; instead it is the machines that occupy the spaces that now define the parameters of the architecture that contains them – an architecture whose form and materiality is configured to anticipate the logics of machine perception and comfort rather than our own.¹⁸³

The adaptation of machine perception and exclusion of the human agent inside the production space to ease the automated processes initiated a transition from human domination to post-human conditions, as Benjamin Bratton expresses in his article, *Further Trace Effects of Post-Anthropocene*, cyber physical systems, artificial intelligence and internet of things prepare grounds for an architecture to accommodate a computational world that is connected with infrastructural and online networks instead of individuals. Bratton indicates that these developments convey to the dawn of the Post-Anthropocene due to the elimination of human agent in the operational mechanisms of production.¹⁸⁴ Technological advancements and efforts to progress the

¹⁸³ Young, “Architecture Without People: Neo-Machine” in *Machine Landscapes: Architectures of the Post-Anthropocene*, 11.

¹⁸⁴ Benjamin H. Bratton, “Further Trace Effects of the Post-Anthropocene,” in *Machine Landscapes: Architectures of the Post-Anthropocene*, *Architectural Design*, (January/February 2019): 14-21.

industry in numerous disciplines provoke theoretical research to anticipate the transformation of existing surrounding environments into human exclusion zones and prepare for societal and economic shifts that emergence of new territories reformatise in prospect.¹⁸⁵ Though complete transition to fully-automated machineries have not been succeeded and human input considered necessary to design, elevate, operate, repair, and settle machineries and their vast landscapes, the aimed direction of the industry comprises of the post-human status quo.

4.3. The Data Centre | Data Haven in the Principality of Sealand

The most compelling precedent of machine landscapes in which high automation and disappearance of human bodies regarded as necessities is the data centre. It is an architectural artifact designed and constructed mostly by humans, yet it is for the accommodation of data and machineries. Data centres are considered as primary post-human institutions that incorporate technological rationale and architecture in one entity. Thus, data centres “are more than just computational infrastructures, they are becoming the defining cultural constructions of our age.”¹⁸⁶ Despite denoting data

Benjamin H. Bratton defines the post-human conditions to lead humanity into the Post-Anthropocene period on the basis of dependence on machineries, objective aim of automation and new means of production, and expansion of cyber physical systems, however, Anthropocene is a geological epoch that was acknowledged by many relevant disciplines to follow the end of the Holocene. Thus, Post-Anthropocene notion may refer to the post-human status quo of machine landscapes in an architectural, social, and productional manner with the awareness that it does not indicate a confirmed geological transition.

¹⁸⁵ One of these research have conducted under the name of “Automated Landscapes” in Het Nieuwe Instituut in 2017 as a collaborative research regarding the impacts of automation for the built environment and exhibited as part of Work, Body, Leisure at the Biennale Architettura 2018 in Venice. This collaborative research initiative signifies the repercussions of automation on the configuration, design, and occupation of existing and emerging territories as well as notion of labour after the exclusion of human agency. It studied several territories including dairy farms, greenhouses, data centres, factories, and container terminals.

¹⁸⁶ Young, “Architecture Without People: Neo-Machine” in Machine Landscapes: Architectures of the Post-Anthropocene, 9.

centres as cultural constructions of the Anthropocene, the corporate and national secrecy regarding them challenge the physical and intellectual involvement of individuals and attribute a precarious autonomy that query the existence of accumulating culture. In the manner of autonomous structure and eliminated inclusion of human labour for production that a data centre holds, nonoperating data hosting company called HavenCo's choice of land in the North Sea demonstrates initiative for latter developments.¹⁸⁷

Lackey and his colleagues are setting up Sealand as the world's first truly offshore, almost-anything-goes electronic data haven - a place that occupies a tantalizing gray zone between what's legal and what's ... possible.¹⁸⁸

HavenCo, a data hosting company that established by Sean Hastings and Ryan Lackey, aimed to exclude itself from governmental restrictions on privacy, censorship, music sharing, and copyright by moving their company to Sealand.¹⁸⁹ The Principality of Sealand is a sovereign territory in international waters of the North Sea, seven nautical miles from the east coast of the United Kingdom and declared as principality in 1967 by Roy Bates, a former Major in British army.¹⁹⁰ With the *E Mare Libertas* (From the Sea, Freedom) motto of the principality, it is the smallest country in the World because it used to be an anti-aircraft defence platform built from concrete and steel against the risk of German invaders in World War II. "Sealand is stranger than fiction. A pair of concrete legs supporting a 120-foot by 50-foot platform, 60 feet above the North Sea..."¹⁹¹ Roy Bates attempted to squat a long-deserted platform two times to run an independent (pirate) radio station, broadcasting for twenty-four-hour long and play

¹⁸⁷ On Principality of Sealand and HavenCo, Hamed Khosravi's "Sealand and the Architecture of the Sea: From Counter-Space to Counter-Culture" is referred.

¹⁸⁸ Simson Garfinkel, "Welcome to Sealand. Now Bugger Off," *Wired*, January 7, 2000. <https://www.wired.com/2000/07/haven-2/>.

¹⁸⁹ John Markoff, "Rebel Outpost on the Fringes of Cyberspace," *The New York Times*, June 4, 2000, <https://www.nytimes.com/2000/06/04/world/rebel-outpost-on-the-fringes-of-cyberspace.html>.

¹⁹⁰ "About Sealand," Sealand, accessed on March 23, 2021, <https://sealandgov.org/about/>.

¹⁹¹ James Grimmelmann, "Sealand, HavenCo, and the Rule of Law," *University of Illinois Law Review* 2 (2012): 406.

120 foot = 36.6 meter, 50 foot = 15.2 meter, and 60 feet = 18.3 meters.

any song without restrictions. The first one was Knock John Tower in which Bates and his crew forced to move out for illegal broadcasting due to its location within the UK's 3-mile territorial waters, however, the second attempt to Fort Roughs Tower was a success and led him to become the Prince of Sealand.¹⁹² The new principality embraced the ancient legal doctrine of *jus gentium* (rules of law common to all people regardless of nation) and assessed their position in international waters as *terra nullius* (Nobody's Land).¹⁹³ These ideologies to build a sovereign state and give a choice of freedom from national rules and constraints attracted HavenCo to partner with Roy Bates to accommodate their data centre in one of the concrete cylindrical towers.

Mr. Bates used the abandoned concrete fortress, east of London, as a platform for what was called pirate radio, operating without license from the British government. He says he is struck by the parallels between pirate radio and the idea of a pirate Internet. 'We've had dozens and dozens of proposals and we've turned them all down,' he said. 'This is the first one that seemed to be really suited to what we are.'¹⁹⁴

In the description of Hamed Khosravi, in his article regarding Sealand, he elaborates the settlement in detail. Accordingly, there is a single-storey structure above the main deck that contains water and fuel tanks, washrooms and toilets of crew members and staff, a kitchen, office spaces, a lounge, a gathering and transmitter room, and they are all naturally lit and ventilated. The rest of the accommodation resides in the two hollow concrete legs that support the load of the main deck. There are seven floors in each of the cylinders, and constitute of rooms of crew members, a royal chamber, a conference and prayer room, a jail, and room for water pumps and safety valves. After 2000, with the engagement of HavenCo and Sealand, they became one identity in a like-minded environment and the south leg transformed into a multistorey data centre. Computers, servers, transaction processors, data-storage devices as networking gears were placed inside the concrete cylinder and banks of air conditioners to provide the optimal

¹⁹² Hamed Khosravi, "Sealand and the Architecture of the Sea: From Counter-Space to Counter-Culture," *Architecture and Culture*, (July 2019): 3-6, <https://doi.org/10.1080/20507828.2019.1608102>.

¹⁹³ "The Birth of Sealand," Sealand, accessed on March 23, 2021, <https://sealandgov.org/about/>.

¹⁹⁴ Markoff, "Rebel Outpost on the Fringes of Cyberspace."

temperature for servers were included as well as generators.¹⁹⁵ Even the royal chamber of Roy and his wife Joan turned into an uninterruptible power supply (UPS) and computer server room that monitored and controlled databanks stored in lower floors.¹⁹⁶ Although HavenCo and Sealand naturalised each other's existence, HavenCo's precautions of safety and secrecy may averted the prior ideals of the principality. As initial plans of Lackey and Hastings explained in detail in Simon Garfinkel's news article called *Welcome to Sealand. Now Bugger Off*, onboard staff of HavenCo regularly come and go by helicopters and speedboats while heavily armed security personnel and maintenance staff of network operations stay at all times. In case of malfunctioning in servers, six employees of the maintenance staff were required to replace failed hard disks and install new equipment. Another precaution included machine rooms to be filled with an unbreathable pure nitrogen atmosphere rather than the normal oxygen mix to keep out sneaks, inhibit rust, and reduce the risk of fire.¹⁹⁷ Therefore, the Principality of Sealand was planned to be a data haven more than a sovereign state, however, its facilities and service never matched with the image it created among the public and in two years, authorisation of HavenCo was transferred to the principality and as a result, this data haven was nationalised.¹⁹⁸

Although HavenCo went offline in 2008, the unity between Sealand's ethos and HavenCo's requisites to function exemplify the restructuring of production spaces. The abstraction of spatial conditions to meet with functional realities and machine perception introduce architectural theory and practice with machine landscapes and expose differences between production spaces of every century since the Industrial Revolution.

Shrouded in the ambiguous spatial and juridical conditions of Sealand, the collective form of contingent labor could escape the gaze of the corporate state markets, taking on the free territory of the sea, cyberspace and intellectual capital. Sealand resembles a form of sanctuary for almost any innovative collective action. Its brutal military

¹⁹⁵ Garfinkel, "Welcome to Sealand. Now Bugger Off."

¹⁹⁶ Khosravi, "Sealand and the Architecture of the Sea: From Counter-Space to Counter-Culture," 7-9.

¹⁹⁷ Garfinkel, "Welcome to Sealand. Now Bugger Off."

¹⁹⁸ Grimmelmann, "Sealand, HavenCo, and the Rule of Law," 454-7.

architecture has been not a space of confrontation, but rather a space of fulfilment where life, production and distribution are merged and fluxes of goods, capital and information are mobilized.¹⁹⁹

Sealand as once the Fort Roughs Tower, then a sovereign territory, and a visioned data haven elaborates the existence of terra nullius in all its identities and realised the possibility of a machine landscape on sea. It strengthens the spatial functionality and efficiency instead of former necessities of production spaces such as well-articulated circulation, layout, and natural light in the work environment. The change of spatial perspective and priorities unveil the machine perception of these new territories rather than accessibility and human scale. They still accommodate humans to operate, control, and maintain but the centre of attention is machineries.

¹⁹⁹ Khosravi, "Sealand and the Architecture of the Sea: From Counter-Space to Counter-Culture," 12.



Figure39. Photograph of the Principality of Sealand, taken in 1986 by John Wray, showing two concrete legs supporting the main deck with a single storey building and helipad on the roof the building.

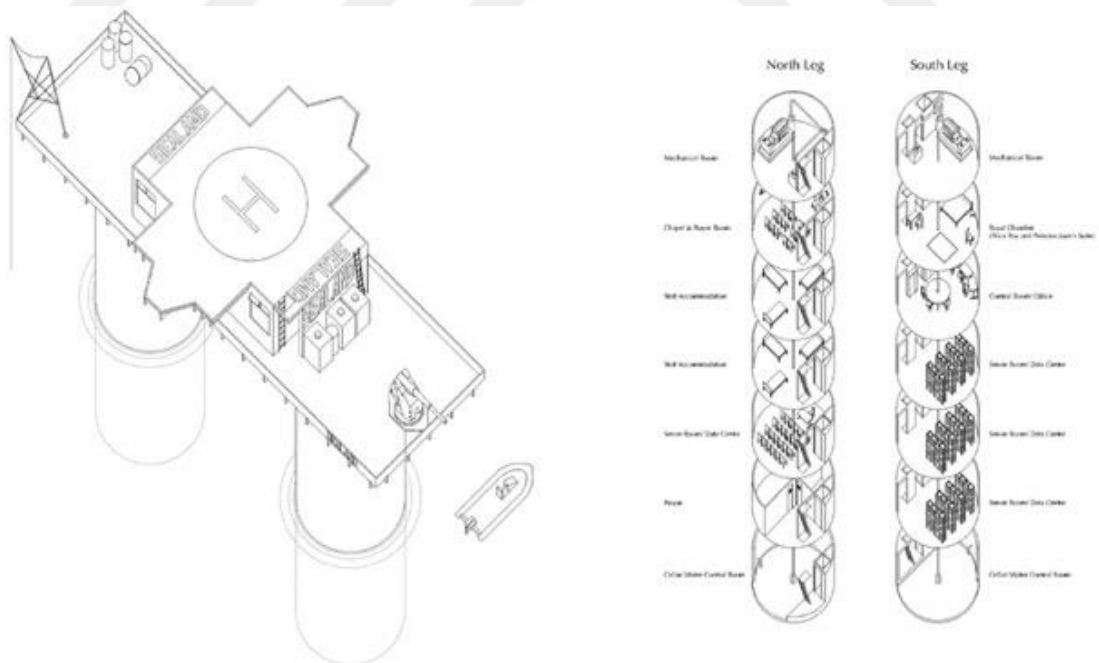


Figure40. Hamed Khosravi's drawing of Sealand's Axonometric Reconstruction, demonstrating functions inside the floors of hollow cylindrical towers (legs).

4.4. The Fulfilment Centre | Amazon Fulfilment Centres

“Like electrification, fulfilment is on its way to becoming a new utility and a new expectation of contemporary life. And like electrification, it is changing us in the process.”²⁰⁰ Fulfilment centres represent the concretised form of production and consumption rush of individuals rooted from mass production strategies of the twentieth century. Fulfilment centres are vast machine landscapes comprised of production, storage, and distribution of goods and capital, in other words, all stages of sustaining the habits of consumption and demands of the market are covered in one architectural meta. They are indicative for the continuation of industry and the development of altering architectural language for production spaces merging with the necessities of automation. Thus, new design parameters to overcome operational and logistical issues emerged from the spatial greatness empower the architectural transition from daylight factories to fulfilment centres as part of machine landscapes. To comprehend, Amazon Fulfilment Centre and articulation of its layout with the inclusion of Kiva Systems (cornerstone for Amazon Robotics) have been examined to supply insights about the semi-automated work environment. Despite Amazon is highly referred company, its centres convey pioneering information to explore architecture of machine landscapes.

Amazon reclaimed as a technology company which simplifies online transactions for consumers more than a retail store from the perspective of its founder, Jeff Bezos who purchased Kiva Systems in 2012 to automate circulation of goods inside the production space and introduced Amazon Robotics to enhance company’s relation to technology rather than retail.²⁰¹ The vastness of its centres invigorates the need for automation to increase efficiency and welfare of declining number of workers. “When we drag an item into our Amazon digital basket, on the other side of the screen a

²⁰⁰ LeCavalier, “Human Exclusion Zones: Logistics and New Machine Landscapes,” 55.

²⁰¹ “Amazon.com,” Britannica, accessed on March 25, 2021, <https://www.britannica.com/topic/Amazoncom>.

‘picker’ in a bright-orange safety vest is rushing through these endless stacks, locating objects and dropping them into packing boxes.”²⁰² In a daily shift between the stacks of goods that are organised with an engineered algorithm based on sales frequencies and purchase patterns of consumers, each ‘picker’ may cover a distance of 25 kilometres by the personal navigation tablets to locate necessary products to pack in an optimised and machinic manner.²⁰³ Thus, Amazon’s fulfilment centres, with the hopes of increasing efficiency, engineer the circulation of goods and workers inside the work environment and integrate robotic drive units (product of Kiva Systems) when ‘human pickers’ become less sufficient. The engineering of production spaces rather than configuring through architecture has been the most preferred method since the eighteenth century with the ideal of one great machine. During four progressing industrial periods, the ultimate aim of engineers with owners did not change, however, methods to achieve a model of factory operating as a singular entity with all its contents differed on the basis of technological advancements. In the Industry 4.0, with the same aim in mind, Amazon explored the potential of a production space coalesced with a distribution centre, the fulfilment centre, through the influence of algorithms and automation. Industrial complexes that had the capacity to grow and sustain the incremental production volume in the nineteenth century transformed into daylight factories with the utilisation of the assembly line to meet the demands of capitalist incentives and workload of mass production in the twentieth century. Then, in the twenty first century, production spaces became machine landscapes that can be planned with algorithms, artificial intelligence, and robotics. However, there is still need for humans to resolve and assess problems of production process in a flexible manner which automated machineries lack to offer. Thence, Amazon’s fulfilment centres united their human workforce with the robotic drive units and update the

²⁰² Liam Young and Ben Roberts, “A Place for Everything – Ben Roberts: Amazon Unpacked,” in *Machine Landscapes: Architectures of the Post-Anthropocene*, *Architectural Design*, (January/February 2019), 47.

²⁰³ Ibid.

operational mechanism of this collaboration on a regular basis with the works of Amazon Robotics.



Figure41. Photograph of Amazon Fulfilment Centre in the UK, lack of human scale and filled with shelves of goods.

Some of Amazon's fulfilment centres are now almost fully autonomous, the shuffling feet of pickers replaced by the smooth glide of mechanised robots... The warehouse captured in Roberts's photography is a library for machines, a library that is not designed for us, an icon of the Post-Anthropocene, an early example of a new architectural typology that does not defer to our own patterns of orientation. This is a space organised by efficiency algorithms and inhabited by the human components of Amazon's global logistics robot.²⁰⁴

Kiva Systems developed robotic drive units (RDUs) that in Amazon's fulfilment centres approximately 30 000 units operate in unison and as hosts to lift inventory shelving units to transport to the requested picking station or to a picker by a threaded cam.²⁰⁵ "...the initial concerns of automation were primarily those of position, location and movement."²⁰⁶ As Jesse LeCavalier reveals in his article, *Human Exclusion Zones: Logistics and New Machine Landscapes*, through RDUs, position, location and movement of shelving units convert from static to dynamic structures. For each request, every RDUs on the floor calculate the amount of time to deliver the required product to the awaiting station and one with the quickest route realizes the transfer, then returns into the closest available spot on the floor. Thus, in each request, organisation of the floor changes and reconfigures itself with the movement of RDUs, which portrays the transition from the static engineered layout of the floor plan to the dynamic flow of designed units and enable multiple iterations for the same floor. In addition to various reconfigurations, in highly automated fulfilment centres, inventory is managed and processed by RDUs without any need for lighting.

As goods arrive from suppliers they are 'stowed' in the inventory pods, which are then moved into the storage area. Since the RDUs get their directions from a grid of 2D barcodes on the ground, and since the local wireless network governs their location, the bots only need a small light to scan the codes on the floor. As a result, the human exclusion zone is dark... Periodically, an inventory pod on its way to a new location silently interrupts the long cross-aisles.²⁰⁷

²⁰⁴ Young and Roberts, "A Place for Everything – Ben Roberts: Amazon Unpacked," 47.

²⁰⁵ LeCavalier, "Human Exclusion Zones: Logistics and New Machine Landscapes," 52-4.

²⁰⁶ LeCavalier, "Human Exclusion Zones: Logistics and New Machine Landscapes," 52.

²⁰⁷ LeCavalier, "Human Exclusion Zones: Logistics and New Machine Landscapes," 54.

Fulfilment centres of Amazon without any segregation depending on the level of automation or the location of the site, display changes in production spaces in terms of lighting, layout, kind of machineries, and adopted technologies for architecture, construction, and industry. As human scale and orientation started to fade from machine landscapes, design parameters of the floor plan alter. The need for natural lighting and ventilation supported with artificial lighting and HVAC systems declines since automated machineries and robotic systems' requirements are not the same with humans. Therefore, fulfilment centres enable the development of new architectural parameters for machine landscapes and strengthen the collaboration between human and robotic work force through trials of ameliorated conditions.

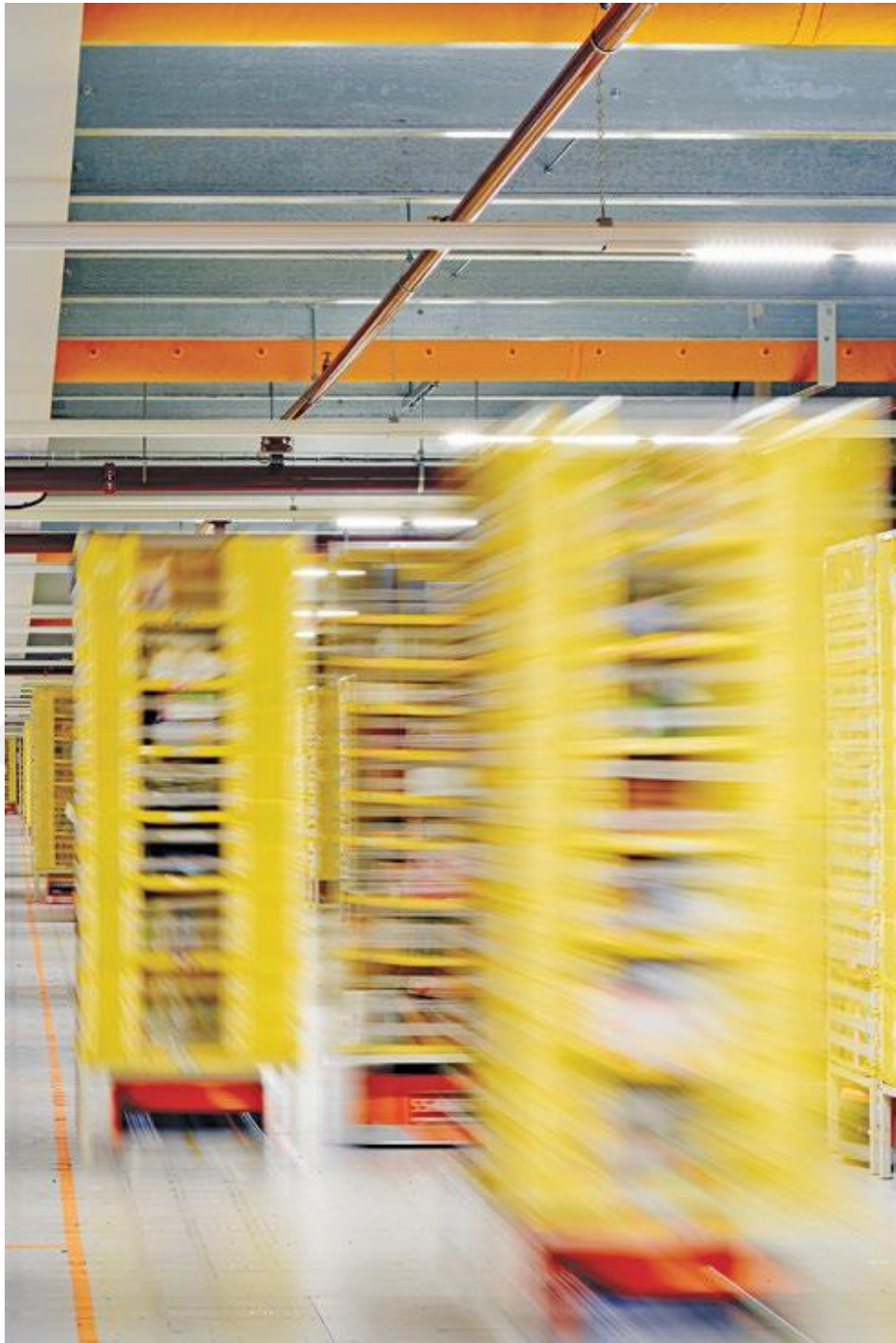


Figure42. Multiple RDUs in motion, occupying the particular floor of the fulfilment centre free from human interference.

4.5. Production and Maintenance of Cryptocurrency |

An Overview of a Bitcoin Mine

In the reality of Industry 4.0 and the twenty first century with artificial intelligence, cyber physical systems, and Internet of Things, the economic equivalent of the developing industry has evolved into a new technology, that is cryptography and cryptocurrency. There were some former attempts to actualise transactions through online systems and benefiting from cryptography, however, the renowned case that led cryptocurrency to be a part of the technological industry of the twenty first century is the company called Bitcoin which has been introduced by Satoshi Nakamoto through the medium of cypherpunks in 2009.²⁰⁸ Since cryptography and cryptocurrency are unknown territories from the perspective of architectural discourse, it is more convenient to assess the typology of a Bitcoin mine through the built environment instead of the technological industry occurring within the content. However, it is necessary to quote "... Bitcoin is a currency that ultimately derives its worth from energy. It requires electricity to run the calculations that generate new coins..."²⁰⁹ in order to comprehend the basic production system of Bitcoin to evaluate further of the architectural qualities of its mines.²¹⁰

²⁰⁸ Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller and Steven Goldfeder, *Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction* (New Jersey: Princeton University Press, 2016), XVII-XVIII.

Sean Hastings and Ryan Lackey, founders of HavenCo, were also members of Cypherpunk.

²⁰⁹ Liam Young, "Tending Goats and Microprocessors - Xingzhe Liu: Uncovering Sichuan's Remote Bitcoin Mines," in *Machine Landscapes: Architectures of the Post-Anthropocene*, *Architectural Design*, (January/February 2019), 77.

²¹⁰ On May 13, 2021, according to the news on CNBC, Elon Musk stated that Tesla will no longer accept bitcoin as a payment due to its incremental use of non-renewable energy sources. As mentioned, Bitcoin mining is a process depending on electrical energy, thus, generation of electricity from fossil fuels led Musk to support more sustainable options of cryptocurrency. In China where bitcoin mining was concentrated highly, economies heavily rely on coal as an energy source, however, in Sichuan province of China, mountain streams are dense and get denser in monsoon seasons. Thus, bitcoin miners preferred to be located in remote mountain villages of Sichuan to produce electricity through hydropower stations and reduce the cost of electricity by utilising the excess energy from the streams.

The densest population of bitcoin miners and company owners inhabit in remote mountain villages in Sichuan province of China where the fundamental need for electricity supplied with hydropower through the utilisation of mountain streams for the lowest cost. “Data shows that miners using hydropower in Sichuan are paying between 0.065-0.075 yuan or \$0.01 per kilowatt-hour.”²¹¹ In comparison with other regions, Sichuan is considered as the area to have the lowest cost for electricity due to the high capacity of hydropower production.

Hydro-electric plants set up along mountain streams often produce more energy than they are able to sell to China’s state grid, and some plant owners have found they can either sell the surplus to Bitcoin mines—for which electricity accounts for up to 60-70 percent of expenses—or set up their own mines.²¹²

The cost of electrical energy shape the choice of settlement locations for the sake of 24 hours a day production of mines.

Liu Xingzhe, a photojournalist, travelled to Sichuan’s Ngawa (Aba) Tibetan and Qiang Autonomous Prefecture where he photographed a contradictory territory for another machine landscape, a Bitcoin mine. In consideration of the privacy of the subjects and legal standing of Bitcoin mines with Chinese government, Liu conserve the full names of workers, company, and village, but through photographs, it is possible to observe living and working conditions of individuals, placement and operation of machineries, as well as spatial resolutions.

First and foremost, this machine landscape next to a mountain stream is more than 30 kilometres away from the nearest public transportation, and employees responsible for the maintenance of machineries live in dorm rooms and once a week hitchhike to access the public transportation area.²¹³ Therefore, it includes a dormitory and living

²¹¹ Jamie Redman, “Sichuan Officials Continue to Foster the Relationship Between Bitcoin Mining and Hydropower,” *Bitcoin.com*, August 18, 2020, <https://news.bitcoin.com/sichuan-officials-continue-to-foster-the-relationship-between-bitcoin-mining-and-hydropower/>.

²¹² Liu Xingzhe, “Inside the World of Chinese Bitcoin ‘Mining’,” *China File*, June 21, 2017, <https://www.chinafile.com/multimedia/photo-gallery/inside-world-of-chinese-bitcoin-mining>.

²¹³ Young, “Tending Goats and Microprocessors - Xingzhe Liu: Uncovering Sichuan’s Remote Bitcoin Mines,” 77.

areas for humans in contrast to aforementioned machine landscapes. Although it is a remote settlement that is crammed with microprocessors (mining machines) and lack of social facilities to attend, human workers prefer to stay and control machines to save up money without anywhere to spend their salary.²¹⁴ There are seven employees working in shifts to control the status of machines through physical or online observation on their phones and computers and intervene by restarting machines if necessary. During their shift if all machines run without any complication, then workers spend their time on their phones and computers for leisure in a similar manner with when they are on breaks.²¹⁵ Therefore, in spite of newness of the industry, from the working conditions of humans inside the production space of Bitcoin mines, it is possible to deduce that the automation of microprocessors lead to the eradication of skilled labour.

Moreover, this establishment with its unfinished facades and stocked walls of cooling fans resembles an abandoned building at first sight, yet it realizes production of cryptocurrency 24 hours a day. There are 550 microprocessors that are aligned in rows on shelves inside.²¹⁶ Despite its visual far from usual machine landscapes, in which human scale and orientation resigned in favour of machine apprehension, this structure prioritises necessary working conditions for its microprocessors without altering the generic layout of the building. For instance, stocked walls of cooling fans provide optimal temperature for microprocessors to run continuously and keeping human scale eases the reach of human workers to machines and shortens the duration of control and maintenance. Thus, even in the absence of machine perception, this Bitcoin mine is considered as a machine landscape through its product, operational mechanism, and design priorities for the sake of machines.

²¹⁴ Xingzhe, "Inside the World of Chinese Bitcoin 'Mining'," <https://www.chinafile.com/multimedia/photo-gallery/inside-world-of-chinese-bitcoin-mining>.

²¹⁵ Young, "Tending Goats and Microprocessors - Xingzhe Liu: Uncovering Sichuan's Remote Bitcoin Mines," 76-7.

²¹⁶ Ibid.



Figure43. Photograph of the outer view of the Bitcoin mine building, taken by Liu Xingzhe in 2016.

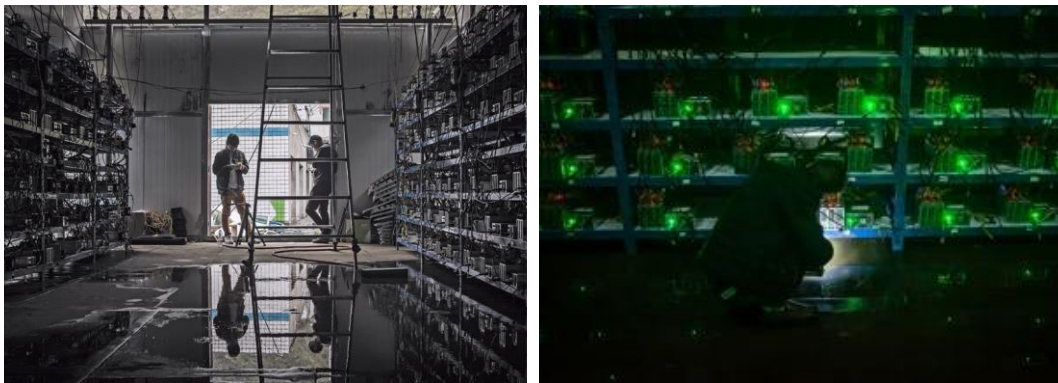


Figure44. Photographs of interior environment during day and night shift, taken by Liu Xingzhe in 2016. In the day shift, it seems there is not any malfunction concerning production since two workers are waiting at the side of the natural light, whereas, in the night shift, a worker operates on one of the microprocessors to resolve a problem to continue the running mechanism.

From the outer appearance of the mine building, after the first impression of cooling fans, the primitivity of the architecture catches the eye. In response to spatial resolutions, there is a risk of assuming in the absence of any architectural drawing such as floor plans and sections. On the other hand, from photographic documentation of the production space, it can be seen that the act of construction ended with rough finishes and by the completion of requisites for machineries such as stacks, cooling fans, configured electrical system, and organisation of wires. The only articulated and regulated areas inside the production space are stacks and machines aligned with their electrical wires. For the rest of the building, the primitivity of the outer shell reflects itself on the interior spaces. In dorm rooms, there are solely beds to rest and there are no indications for common areas for workers to spend their leisure time. The mine is constructed with the parameters of production rather than human workers and community they may gather, counter to the strategies after the Second Industrial Revolution as exemplified with Ford Motor Company and its settlements. The contrasting difference with machine landscapes sources from the change of architectural design parameters to adopt the conditions of machineries and automation as referred before. Machines operate depending on their algorithms, power source, and optimised setting with respect to temperature. They do not require light to run, instead many machine landscapes turned dark where machines are working instead of humans. To that end, artificial lighting is not utilised in machine rooms where natural light entered through the slits of cooling fans and during night, green and red lights on microprocessors indicate the condition of the machine for workers to control and fix. In brief, this Bitcoin mine concretises solely the necessities for the production of Bitcoin through the electrical energy. It exhibits a distinct case of machine landscapes and contrasting environment in the leading technological industry, that is cryptocurrency. With the concerns of energy expenses and legal status of Bitcoin mines, the choice of settling near mountain streams and utilising hydropower contributes to the rare character of this machine landscape. In most industries, non-renewable energy sources promoted instead of renewable sources such as sun, wind and water. Thus, leaning towards hydropower and its surplus of energy during wet

season highlight the significance of utilisation of renewable energy sources as a rational and inventive change in both environmental and industrial means.

4.6. Pearl River Delta | Transformation of Production Spaces with Automation

In China, Sichuan is not the only region to accommodate leading technological and industrial advancements, but Pearl River Delta Region is also considered as pioneering and referred as “a hotbed of technological transformation.”²¹⁷ Diversifying from Hacker Robot Laboratories in Huizhou to battery factories for electric car companies, e-commerce villages, production spaces for machines to actualise data farming and harvesting, and many more machine landscapes generate and develop in the Pearl River Delta region with the technological initiatives and easy access to outputs of various manufacturing processes.²¹⁸ The most unequivocal aspect of this region arises with the interaction and co-existence of humans and robots in manufacturing establishments. In other words, production spaces territorialised around the Pearl River Delta internalise the necessity and flexibility humans can offer with their labour and redefined structure to consolidate their relationship with robots and automation. It contributes to spatial concerns of production spaces and reformalising architectural discourse in relation to industry and technology. “Machine landscapes are not necessarily all perfectly sterile spaces; they still reflect the complexity of human culture and the production process in their architecture.”²¹⁹

²¹⁷ Merve Bedir and Jason Hilgefort, “Fringes of Technology and Spaces of Entanglement in the Pearl River Delta,” in *Machine Landscapes: Architectures of the Post-Anthropocene*, *Architectural Design*, (January/February 2019), 80.

²¹⁸ Bedir and Hilgefort, “Fringes of Technology and Spaces of Entanglement in the Pearl River Delta,” 81-3.

²¹⁹ Bedir and Hilgefort, “Fringes of Technology and Spaces of Entanglement in the Pearl River Delta,” 81.

There are different strategies employed to lay foundation for the gradual transition of automation in the work environment, and a research team from Het Nieuwe Instituut explored in detail in their article, *Assemblages of Humans and Machines in the Pearl River Delta*. From their analysis, there are at least three cases that differ by the degree of human-robot interaction: almost fully automated (Build Your Dreams, battery company), gradually transitioning (Rapoo Technology, electronics manufacturer), and artificial intelligence for the management position (Enterprise Resource Planning system implemented in Ash Cloud, electronics accessories).²²⁰ While inclusion of robotics and artificial intelligence change based on the department, it affected the layout of the production spaces. As illustrated in Amazon's fulfilment centres, almost fully automated workspaces referred as human exclusion zones and operated in dark with the guidance of 2D barcodes on the ground, Build Your Dreams (BYD) battery company preferred a thorough transformation for their factory in a similar manner. Without an interference on the outer shell of the production space, authorities of the company redesigned the interior to support the revised rules of safety, maintenance, health, and security in relation to the robotic environment. The interior layout of the building is separated with glass partitions which are labelled with indications of workers eye-sight to make them visible, and while glass walls compartmentalize the production processes, they also inhibit any interaction between human and machine while they are operating. "Engineers and even managers do not cross into the workers' production zone. Instead, software and computer systems follow the entire process and, through QR codes, track the status and location of the newly assembled batteries along the production line."²²¹ Thus, organisation of the layout with glass walls and control of the process through online systems eliminate the human agent inside the production space and paved the way for closer placement of machines and assembly lines for maximised productivity in the absence of circulation routes. The thorough

²²⁰ Merve Bedir, Marten Kuijpers and Marina Otero Verzier, "Assemblages of Humans and Machines in the Pearl River Delta," *The Site Magazine*, <https://www.thesitemagazine.com/read/automated-landscapes>.

²²¹ Ibid.

transformation of the interior mechanism cooperates the regulation of new rules, training to get acquainted with the level of automation and machineries and introduces new concerns to be resolved that cultivate involved disciplines, however, it alienates humans from particular operations and interactions with robotics. The fully automated work environment may increase the volume of production and rationalise the running of the production space, yet the sharp-edged physical separation walls acting as borders downgrade the involvement of human workers with the emergent production techniques. Therefore, gradual transition and utilising artificial intelligence for the control and management may reinforce the interaction of humans with robots to advance their connection with the evolving industry. To that end, Rapoo Technology, electronics manufacturer chose to integrate automation into the production space by gradual transition.

... so-called soft manufacturing system based on a collaborative production model between humans and robots. Robots perform the relatively simple, repetitive tasks that include a higher volume of production of standardized components with a longer product run, as well as the dangerous and heavy tasks, while human workers carry out the functions that require more flexibility and that are, therefore, difficult to automate. This model, the company claims, brings resilience to the production line, allowing it to respond to future changes in product design and mass production.²²²

Although the strategy of the company started to incorporate robots in the production stages, it did not reflect in the production space as spatially. It employed robots in the easy to automate repetitive tasks that workers actualised on the assembly line in daylight factories by synchronising to the mechanic rhythm of production and appointed human workers to the control and maintenance. Therefore, it preserved the flexible capacity of humans to respond to the market change and continuance of robot-human involvement increased the adaptation of humans to the new means of production. On the contrary case, Ash Cloud, manufacturer of electronics accessories, kept humans on assembly lines for the repetitive tasks due to the variety of products,

²²² Bedir, Kuijpers and Verzier, “Assemblages of Humans and Machines in the Pearl River Delta.”

whereas utilised the Enterprise Resource Planning (ERP) system to manage operations and workers.

The ERP, accessed in real-time by an IOS application on mobile devices, brings together size of supply and demand, product stocks, use of resources, working hours and holidays of employees, waste produced, as well as currency and stock exchange figures. Every process is monitored, every product and assembly part is coded, and every worker is individually managed, allowing the factory to be controlled internally and remotely.²²³

In this opposite automation, human workers are believed to be further automated through the ERP as a result of robotic sprawl and dependency on the app. Human workers learn their tasks by watching the video embedded in the app that is displayed on the screens on the assembly line, report to the app for any request and connect to their superiors with the app.²²⁴ The ERP system challenges the conventional methods of communicating, training and learning, and working through the digitalisation of operations and societal dynamics in the production space. It excludes the intermediary roles that converted to obsolete and limits human workers relation by a screen and an interface in a mechanic yet inhuman manner. Thus, apart from the increase in screens, personal electronics, tablets, automated management system, and the app, spatial organisation of the production space did not redesign. Multiple assembly lines with human workers stayed still while humans became more adapted to the progress of production displayed on screens and personal devices in a hypnotic way. The analysis of three diverse cases in the Pearl River Delta region provides informative knowledge for the development of production spaces in Industry 4.0 and exhibits array of machine landscapes to learn from both theoretical and practical perspectives.

Overall, all machine landscapes differing as data centres, fulfilment centres, bitcoin mines, and manufacturing facilities experimenting through the integration of robotics with human workers portray versatile entity of the architecture of production, storage, and distribution in Industry 4.0 without having a certain typology as mill buildings

²²³ Bedir, Kuijpers and Verzier, "Assemblages of Humans and Machines in the Pearl River Delta."

²²⁴ Ibid.

and daylight factories constituted. Yet, their presence and transition in the industrial sphere endure the relation of architecture with the dynamics of production, storage, and distribution, and foremost, allow the opportunity to examine and anticipate toward the future of enhanced machine landscapes.



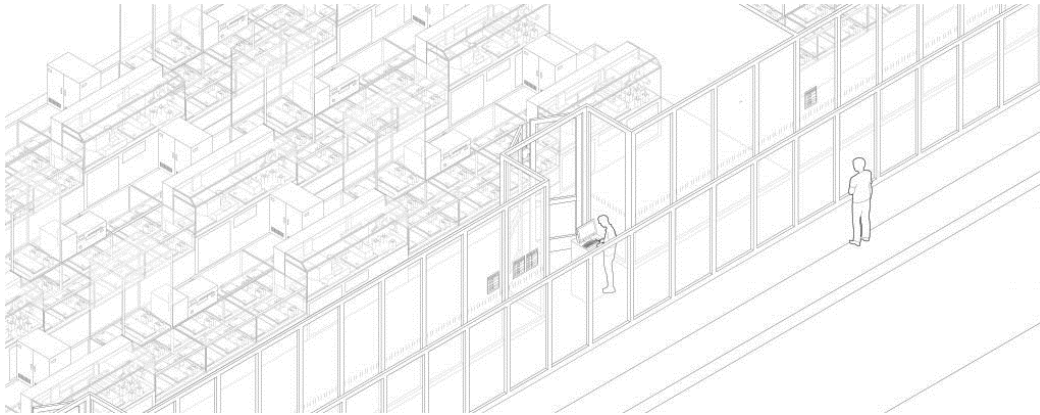


Figure45. Build Your Dreams (BYD) battery factory, glass partitions that separate machineries and alienate human workers as well as redesigning the configuration of the floor layout.²²⁵

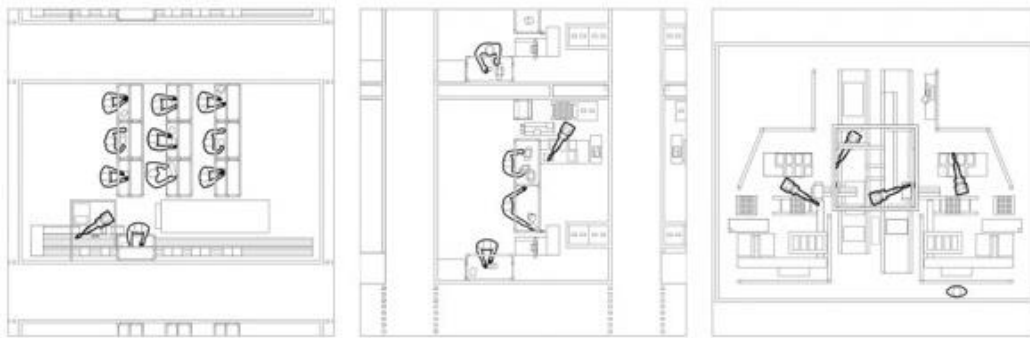


Figure46. Rapoo Technology, different work isles portray the gradual transition from manual labour to fully automated stations with robotics.



Figure47. Ash Cloud production space integrated with the Enterprise Resource Planning (ERP) system on the assembly line to narrate the progress and task for workers.

²²⁵ Illustrations were produced as visual analyses for the article “Assemblages of Humans and Machines in the Pearl River Delta” by Het Nieuwe Instituut in 2018.

CHAPTER 5

CONCLUSION

The architecture of production as reflected through industrial periods is immensely significant for the accommodation and reformulation of energy, labour, and technology since the Industrial Revolution. With the invention of steam engine, small scale and regional production of goods scaled up to delocalised and redundant model in which steam power gradually replaced the water wheel, wind mills, and horsepower. Change in the volume of production and energy sources led to the emergence of mill buildings in the eighteenth century and initiated a search for the most efficient and mechanised model of structure for production. Mill buildings varied along the pursuit of engineers and owners to design the great machine that is the factory, and at the same time, conveyed the limitations of production, power transmission, and lighting of the century. They were multi-story, narrow, masonry and/or wood constructions of production spaces as resolutions against the limitations. Mill buildings were mechanised with an intricate system of gears, shafts, and belts to distribute power to each machinery from the main source. In the process of advancing technology with the invention of the incandescent electrical light bulb, industry started to electrify its operations and settings. Industrial complexes moderately changed by the capabilities of electricity as a lighting, heating, and power source, and thus, means of production got closer to the great metaphor of machinery. In the beginning of the twentieth century, foundation laid by the electrification and utilisation of new construction materials and techniques introduced industry with the daylight factories in one of which Ford Motor Company engineered the most efficient way of production, the assembly line. Therefore, electrification, assembly line, and mass production defined the Second Industrial Revolution as the steam engine defined the first. The transition

from multi-story and masonry mills to single story, reinforced concrete and steel daylight factories framed how industrial changes physicalised in the architectural discourse. In a similar manner, in the twenty-first century, daylight factories converted into machine landscapes by the industrial requirements and technological advancements that arose with the Industry 3.0 and mainly, 4.0. Machine landscapes are the closest image to the ideal of the eighteenth century due to the envisioned absence of humans and automated processes of production, storage, and distribution. Once the typology concerning the architecture of production constituting all stages from the storage of raw materials and their processing to the distribution of produced goods dispersed, machine landscapes differed from mill buildings and daylight factories in terms of overall operations. Machine landscapes diversified the architecture of production while preserving the former typologies and generating new cases of segregated yet automated entities. In some of the cases without any alteration regarding the existing structure of the factory, robotic and online systems are superimposed on the interior organisation as production spaces in Pearl River Delta region revealed. On the other hand, emanation of fulfilment centres, data centres, and cryptocurrency mines and their involvement as machine landscapes in architectural discourse demonstrate the segregated configuration of production, storage, and distribution in contrast to the prior typologies. Fulfilment centres mainly function as storage and distribution facilities whereas data centres serve as spaces of storage. Thence, this thesis includes various machine landscapes without singling out based on functions, rather emphasises the inclusivity of production spaces. Moreover, machine landscapes are new and unknown territories in the architectural discourse and their diversity allows to comprehend the transformation of architecture of production.

Every element constituting the presence of production space such as building materials, fenestration types, lighting and ventilation systems, circulation, configuration of power distribution and machineries, and kind of products shape its architecture to adapt to the expectations of industry. As it progresses from mechanisation to mass production, and to vast lateral networks through Internet of Things, architecture of production spaces evolved both in theory and practice.

However, even machine landscapes are not fully-automated territories of Industry 4.0 due to the dependency on humans to design, generate, produce, maintain, enhance, and etc. They require the assistance of human workers and their labour power to develop further.

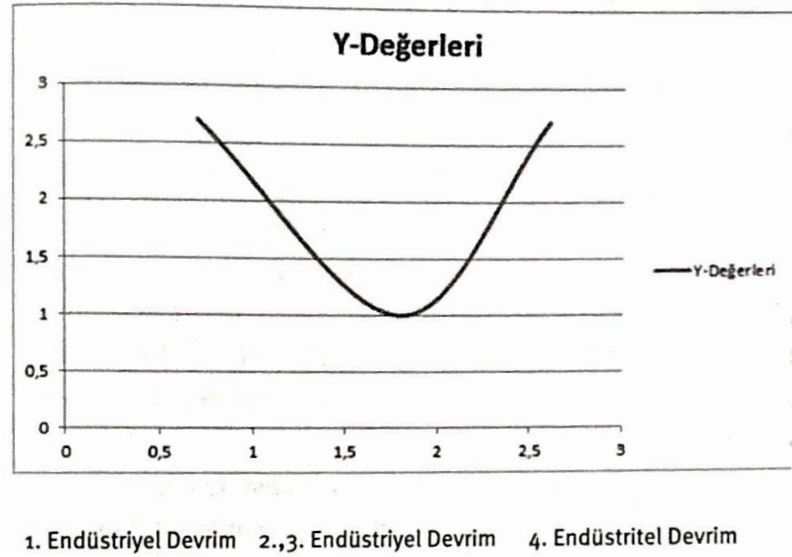


Figure48. Graph of the relationship between technology and creativity/emancipation through industrial periods (x: technology and y: creativity, emancipation) by Rasit Gokceli, 2020.

According to the graph prepared by Rasit Gokceli, creativity and will to produce identified with the y-values that reached its peaks during the Industrial Revolution (first) and Industry 4.0 as he defines as the Fourth Industrial Revolution, whereas in the Second and Third Industrial Revolution, it thoroughly reduced. The radical difference in between y-values, as technology (x-values) advances, sources from the standardisation and rationalisation during the production precepts of Fordism, Taylorism, and Post-Fordist strategies. As it is mentioned before, major setback of machine landscapes is the negation of trained labour which drew back because of these methodologies during the prior industrial periods. Hence, in comparison with the

developments of technology, reduced emancipation levels are estimated to increase with the replacement of human workers and robots. Repetitive and divided tasks realised by workers on the assembly line in daylight factories were transferred over to the programmable robotics in machine landscapes. By employing machines in easy to automate and constant operations and including human workers to maintain, control, design, and improve the existing processes help new industries to anticipate and balance the future demands with the flexibility and experience that human workers provide. Therefore, creativity and/or emancipation in spaces of production need to increase to sustain the accelerating ratio with technology.

“Statis is death,” as Colonel Delair noted around 1870 as the general rule of this world.²²⁶ Although he asserted this note in a context of war and peacetime and concerned with the art of defence and layout of fortresses, as the general rule, it applies to the industrial developments under capitalist incentives. As industry advances itself in terms technology, energy sources, volume of production, and consumes the labour power of individuals, it moves forward as confirming this general rule. Paul Virilio affirms this progress and emphasises on the speed of change that sources from pioneering military strategies, organisation, and requirements in his book, *Speed and Politics*.²²⁷ “Factory work must not escape the dictatorship of movement. It reproduces the enclosure on the spot, in an obligatory and absurd kinetic cycle, the slow death of the reject.”²²⁸ The narration of Virilio elaborating on the factory work and the obligatory kinetic cycle generalises three typologies of mills, daylight factories, and machine landscapes as one entity in spite of their differences. It degrades all three typologies to the same plane of production space, even to the enclosure to accommodate industrial activities. Therefore, comparison of these typologies attains a

²²⁶ Paul Virilio, *Speed and Politics*, trans. Mark Polizzotti (New York: Semiotext(e) Foreign Agents Series, 1986), 13.

²²⁷ As it is mentioned in “Mills and Preliminary Factories” and “Daylight Factories,” military needs regarding weaponry, standardisation of smaller parts of weapons, settlement strategies, punctuality, discipline, and automation lead industry to adopt certain aspects to reach maximised efficiency and minimised wastes. Therefore, Paul Virilio’s book called *Speed and Politics* clarifies the relations in between industry, revolutions, military developments, and urban movements.

²²⁸ Virilio, *Speed and Politics*, 80.

solid ground on the basis of architecture independently of industrial periods, means, kind, and volume of production.

The task of a history of modern architecture is to present contemporary events within the framework of their immediate precursors; it must, therefore, go far enough into past history to make a complete understanding of the present possible and to set contemporary events in adequate historical perspective.²²⁹

In accordance with Benevolo, after finding a common ground within architectural discourse, this study traces back to the Industrial Revolution and limits its framework solely to spaces of production and advancements to sustain the flow of industry. Leonardo Benevolo with internalised understanding of the task of history provides an extensive network of relationships and connections out of new building technologies, materials, construction techniques, tools of mechanisation, urban planning strategies, architectural formations, and etc. since the middle of eighteenth century to fully comprehend the generation process of modern architecture in his book, *History of Modern Architecture* (vol.1). In contrast to the vastness of connections ensured in the book, this thesis misses urban developments, world fairs and exhibitions, utilisation of new materials in variety of settings before the industrial sphere, and many more incidents promoting the spread of modern movement due to the narrowed scope. However, this study puts emphasis on the transformation of production spaces and closely related developments while drawing the limits around its subject rather than broadening the framework. Thus, it seems to fall short in some senses with regard to the overall historical developments although completed within its boundaries.

The historical narration and integrity in architectural publications such as Benevolo's *History of Modern Architecture*, David Harvey's *The Condition of Postmodernity*, and Reyner Banham's *Theory and Design in the First Machine Age* offer comprehensive analyses referring to the historical evolution of architectural theory and practice. Banham defines the duration since the Industrial Revolution as an Industrial Age and

²²⁹ Leonardo Benevolo, *History of Modern Architecture*, Vol.1: The Tradition of Modern Architecture (Cambridge, Massachusetts: MIT Press, 1971), ix.

refers to the period in middle of the twentieth century as Machine Age and suggests that with the domestic electronics and synthetic chemistry, initiated Second Machine Age can reevaluate the First.²³⁰ It is a crucial reassessment to interpret the transformation of science and technology realised during the first half of the twentieth century into the architectural realm and explore forthcoming technical revolutions that was expected to be easily accessible for each individual.

...unlike those developments of the past, which left the objects of daily life, the hierarchy of the family and the structure of sociable intercourse almost untouched, the technical revolutions of our own time strike us with infinitely greater force because the small things of life have been visibly and audibly revolutionised as well.²³¹

Therefore, reviews of Banham regarding projects, theories, and innovations with respect to its geographical, social, economic, historical, and theoretical foundations enhance the understanding of conditions surrounding the first half of the twentieth century and act as precedents for the rise of Industry 3.0, and even 4.0. While Banham increases the number of cases and countries to generate an overall coverage of the period, David Harvey specifies his work on postmodernity, conditions that prepared its emergence and after effects of its arrival into the discourse. The inquiry to incorporate postmodernism starts from modernism and their relation to support the transition. Thus, the effort of perceiving an issue to the fullest extent and initiating from its prior conditions resonates to this thesis and its methodology to start from the Industrial Revolution. Furthermore, descriptive analyses of modern and related disciplines while discussing their reflection as premises strengthen the theoretical framework of this study in terms of other disciplines such as industry, energy, labour, and technology. Even though these literatures coincide in some time frames, they relate different layers of architectural discourse and its relation to other transformative elements. Yet, they empower the understanding and cohesion between energy,

²³⁰ Reyner Banham, *Theory and Design in the First Machine Age* (New York: Praeger Publishers, 1967), 10.

²³¹ Banham, *Theory and Design in the First Machine Age*, 9.

technology, and labour with architecture in contexts of broad historical surveys in relation to other disciplines that cultivate and shape architectural practice and theory.

Under the conditions of the lasting epoch, Anthropocene and indispensable renewals regarding industry and consumption habits of individuals due to the pandemic, machine landscapes and latter industrial facilities foreshadows the possibilities and necessary actions to take regarding industry. First and foremost, an attentive transition to regulated and environmentally audited digital world should be intended to own a low-carbon and green economy. In order to reach this aim, reliance on fossil fuels as energy source and primary element in production of chemical materials need to be reduced ranging from data and fulfilment centres to the textile industry.

Furthermore, in response to the new conditions surfaced due to the pandemic, there arises a new spatial concern regarding new ways of working. “Offices became empty. 88% of the global population started working remotely. This working condition can be considered a crystallisation of a process which has reflected on wider trans of labour.”²³² The high percentage of remote working through online infrastructures led to the conscious examination of the tangible end of sprawled Internet use. “The data centers’ electricity consumption accounts for 1% of the global energy demand, more than the national energy consumption of many countries.”²³³ Therefore, as production volume in certain industries declined according to the market and demand, some digitally-based sectors gained momentum. However, the nonappearance of Internet

²³² Datapolis (@datapolis_cp), “No-Stop Office / Stop Office, Movie by Allard Meijer and Hanna Rudner,” Instagram video, November 5, 2020, <https://www.instagram.com/p/CHOAaJYJ23y/>.

As part of a research programme in TU Delft called Datapolis, Hanna Rudner and Allard Meijer conducted a research proposal for the transformation of working and living conditions of individuals. They referred to the intense ways of online working without any spatial awareness and segregation in private sphere of individuals as No-Stop Office and introduced Stop Office as a counter measure. This study presents a comprehensive analyses about the spatial loss of work environment and reducing architecture into the two-dimensional frame of computers under the emergent irrelevant reality of geographical location and leisure time through the widespread Internet use. Stop Office can redefine the spatial limitations between labour, work, and leisure since majority of global population transferring to online working and staying at home. The redefinition and acquired environmental consciousness may develop into an improved model of production spaces and change in consumption habits.

²³³ Obringer, et al., “The Overlooked Environmental Footprint of Increasing Internet Use,” 1.

use as a physical product call for an awareness regarding its impact on land, water, and carbon footprints.

Policymakers can enact regulations, requiring full transparency on the footprint of digital products and the proactive measures taken by service providers to curb or reduce their environmental impacts. This would ultimately allow for consumers to make decisions on what products and companies they choose, creating market competition to ‘go green’.²³⁴

To conclude, industry as a means of production, employment of labour, and one of the fundamental sources of elevation for technology altered many disciplines since the Industrial Revolution. It allows to own a perspective with regard to the intrusion of human infrastructures to environmental systems through the understanding of Anthropocene. And also, spatial examination of spaces of production through industrial periods enable to associate architecture with histories of energy, labour, production, and technology. Therefore, as it aimed in this thesis, architecture materialises practices of production and strengthens the dialectics of labour and energy. As both practice and theory, its contribution is highly relevant and influential for the growth of industry, and it is the crucial component to embody intertwined relations of production in one entity. Consequently, current industrial facilities as machine landscapes of Industry 4.0 and conditions of Anthropocene including the pandemic and climate change necessitate the inclusion of architecture to comprehend to the changing dynamics of energy, labour, technology, and production.

²³⁴ Obringer, et al., “The Overlooked Environmental Footprint of Increasing Internet Use,” 3.

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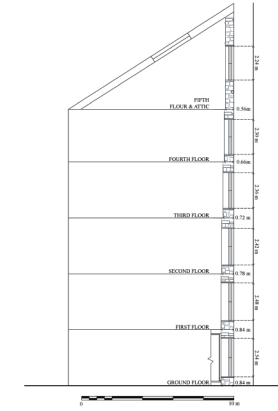
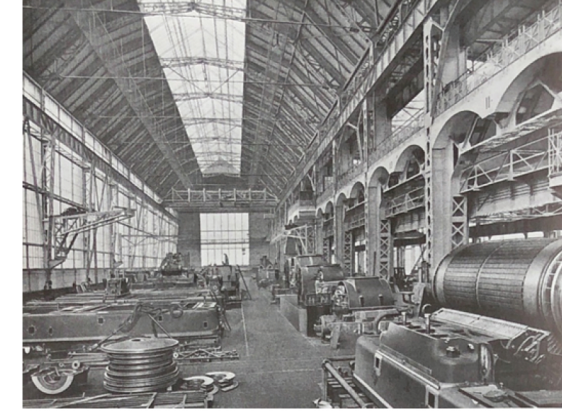
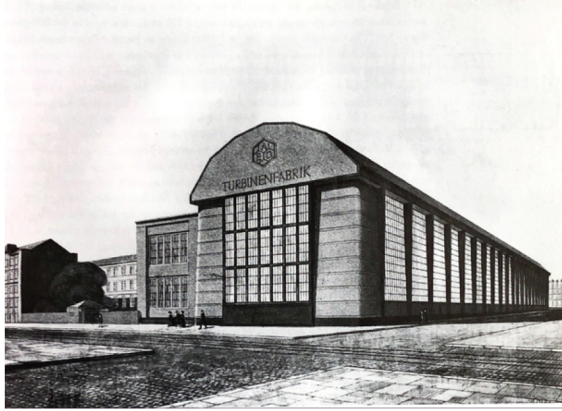
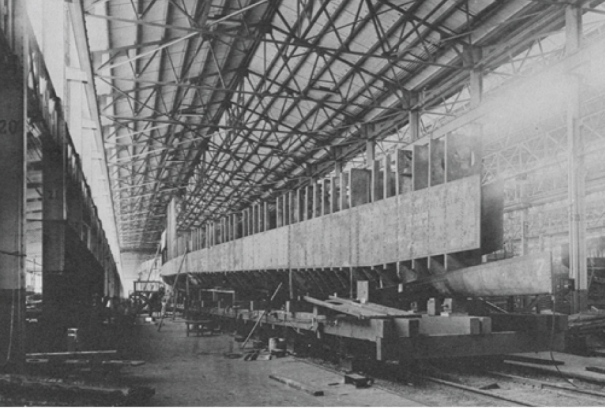
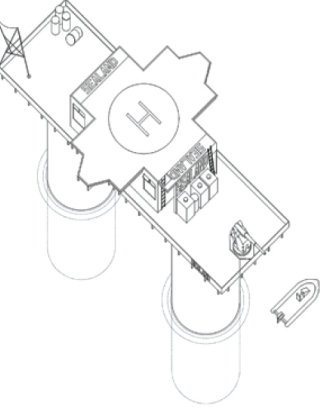
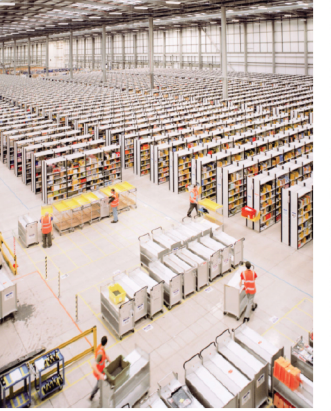
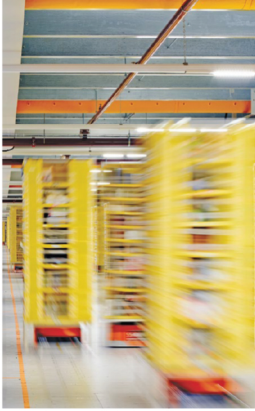
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APPENDIX A | Table1. Comparative Analysis of Cases

	 	 	 	 	 	 	  	  
	DURFEE MILLS In the industrial complex, five mill buildings were built in different years starting from 1866, additionally a store building, boiler and engine houses, and a separate office building were present.	AEG TURBINE FACTORY	OLD SHOP, HIGHLAND PARK PLANT, FORD MOTOR COMPANY Highland Park Plant consisted of nine buildings. Old Shop was a four-story main manufacturing unit structured by reinforced concrete framing.	B BUILDING, RIVER ROUGE PLANT, FORD MOTOR COMPANY Adjacent six buildings in the photograph constituted the B Building with two annex buildings at sides and two aisles with railroad tracks to circulate materials and products.	FORD MOTOR COMPANY EXPORTS INC. One of the territories of Ford Motor Company, functioned as an assembly plant, buildings were initially served as ateliers of Administration of Seyr-i Sefain in 1920s, and as warehouses for Istanbul Chamber of Commerce.	HAVENCO DATA CENTRE An anti-aircraft defence platform known as Fort Roughs Tower in international waters, declared as a principality in 1967, accommodated HavenCo in 2000-2008.	AMAZON FULFILMENT CENTRE Fulfilment centres represent the concretised form of production and consumption rush of individuals rooted from mass production strategies of the twentieth century.	A BITCOIN MINE CRYPTOCURRENCY
Year & Location	planning and design started in 1866, built No.1 and No.2 in 1871 Fall River, Massachusetts / US	designed in 1908-1909, built in 1910 - Peter Behrens & Karl Bernhard (engineer) Moabit Industrial Site, Berlin / Germany	1909-1910, started to operate on January 1, 1910 - Albert Kahn Detroit / US	1917 - Albert Kahn Dearborn, Detroit / US	Tophane Pier and warehouses were constructed in 1895, Ford Motor Company settled in 1929 Tophane Pier, Istanbul / Turkey	built in 1942, restored in 1967 to accommodate the new principality, then in 2000 with HavenCo. the Principality of Sealand (affirmed in 1967 by Roy Bates) / North Sea	2011 Rugeley, Staffordshire / UK	2015 (start of production, there is no information regarding the building) in a remote mountain village in Sichuan province / China
Area / Dimensions	Mill Building No.1 & No.2 12 582 sq. m, Mill No.3 3 611 sq. m, No.4 3 838 sq. m, No.5 5 000 sq. m	Main assembly hall 207.38 m long, 39 m wide, and approximately 28.5 m high	approximately 23 meter wide and 264 meter long, 24 288 sq m.	approximately 92 meter wide and 520 meter long	13 433 sq. m	Main deck approximately 37 meter long and 15.2 meter wide rectangular plane, 18.3 meter high from the North Sea by the hollow cylinders that has seven floors in each	228 600 sq. m	unknown
Number of Floors [multi-story/single]	multi-story No.1, 2 and 3 5 stories - No.4 and 5 2 stories	single story at the main assembly hall without interruption, two-story production spaces based on operations next to the main hall	multi-story four stories	single story	single story buildings with different heights ranging between 3.5 and 10 meter	single story structure on top of the main deck, multistory in cylinders (seven floors)	single story, high-ceiled	multi-story
Construction Materials	masonry walls, wooden floors and structural supports metal beams in boiler rooms	iron and glass structure, reinforced concrete used as foundation for the structural system to be constructed upon	mainly constructed by reinforced concrete framing, planned according to a grid of 7.6 m × 6.6 m, four utility towers separated circulation and sanitation facilities from the main assembly hall	mainly steel framework and glass (4 months of production) modular, high-ceiled, and reinforced concrete was used for some supporting structure	plastered masonry buildings, wooden flooring and beams, steel columns (since buildings were built in 1890s, construction techniques and materials did not reflect the advancements)	reinforced concrete and steel	concrete tilt panels, steel structuring and sheets	reinforced concrete structure
Type of Fenestration	double-hung windows with wooden frames size of windows change according to stories (section)	large glazing units integrated into the iron structuring addition of skylight along the roof	large glazing surfaces, window-walls through steel structuring and reinforced concrete framing	large glazing surfaces applicable with the height of the building to maximise natural light in the production space	regular and fixed windows (smaller according to Old Shop, AEG Turbine Factory, and B Building)	large windows in comparison with the size of the building above the main deck, no windows on the cylinders	no fenestration units, frosted plexiglass panels provide illuminance in the interior and artificial systems are responsible for ventilation	no fenestration units in the production space, light and air enters through slits of cooling fans, regular and fixed units in other parts of the building
Architectural Typology	industrial complex, mill building (later development since it had space to develop new buildings in a case of expansion)	neither a mill building nor a daylight factory, however it physicalised the transition process of production spaces and architectural experimentation through efforts of Peter Behrens	early development of daylight factory before the inclusion of assembly line	daylight factory, 'rational' factory	typologically mill building with the exception of number of floors	machine landscape without a clear typology established, machine landscapes are assessed according to existing spatial conditions and ways of meeting functional needs with architecture	machine landscape	machine landscape
Power Source, Transmission	steam engine (sourced from fossil fuels) mechanical distribution system of gears, shafts, and belts	group drive and unit drive of electrical energy mechanical distribution apparatus disappeared by electricity and its offered invisibility	electrical energy inclination towards unit drive due to experimentation processes to become more efficient	electrical energy unit drive, single-function machineries	electrical energy group drive and unit drive	electrical energy unit drive	electrical energy unit drive	electrical energy sourced from hydropower stations producing energy from mountain streams unit drive
Means of Production	inclusion of machineries in some operations sprawl of mechanisation	as technology advances, dependency on machineries increased more organised workspace according to operations and advances	dominance of rationalisation and standardisation in production processes and instruments of labour trials to generate the components of the assembly line	division of labour, single-function machineries, interchangeable parts, moving line, sequential ordering of machineries assembly line (railroad tracks enabled the transportation of products)	assembly line (to sustain the efficiency rate and standards of assembly, Ford Motor Company articulated the same techniques and technologies into the typology of mill building)	semi-automated / automated machineries in floors of the data centre	semi-automated / automated machineries, robotic driverless units (RDUs), shelves of goods, multiple moving lines	automated bitcoin mining machines (stocked in shelves)
Need of Labour	despite mechanisation, labour was highly necessary to production	skilled labour started to fade, deskilling initiated through division of labour	increased division of labour, preferring workers with no experience over skilled workers	highest segmentation of labour into the smallest tasks by efforts of rationalisation machines intervened to labour (machines/mechanisation + deskilled labour)	mechanisation + deskilled labour	automated + contribution of labour as control and management	automated / robotic + manual labour	automated/robotic + human labour for control, maintenance, and repair of machinery constant shifts of seven employees and remote location of the mine necessitated dorm rooms
Lighting	mostly natural light, oil lamps as supplementary	increased natural light through large windows and skylight, electrical lighting as artificial source	incremental exposure of natural light with the enlarged windows and electrical lighting	natural light + electrical lighting	natural light (less illuminated due to architectural qualities) + electrical lighting	naturally-lit above the main deck, electrical lighting inside the cylinders	artificial lighting + no lighting in fully-automated sections	natural light in the production space during day, and at night, no artificial lighting