Radical Technological Change, the Rise and Fall of the Pneumatic Grain Elevator in the Port of Rotterdam in the 20th Century

Figure 1: Johan Hendrik van Mastenbroek - Lichters in de Maashaven, Rotterdam. 1930

Name: Jordi Rijsdijk

Student No: 483809

Supervisor: Richard Velthuizen

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Introduction:

This thesis looks at the impact of the pneumatic grain elevator in the port of Rotterdam. The pneumatic grain elevator is a machine that can load and unload grain through the use of compressed air to discharge its contents through tubes into a ship's hold.

The first grain elevator in the port of Rotterdam was put into use in 1905, however this led to a widespread strike in which labourers refused to work with these new machines. The machines were temporarily put out of order until 1907. However, this sparked further revolt, and another strike soon followed. Eventually an agreement was reached, and the elevators were put into widespread use starting in 1908, with the foundation of the Graan Elevator Maatschappij (GEM).

The scope of the project encompasses the largest part of 20th century, from the introduction of the grain elevator in the city's port in the early years of the 20th century, to its decline in the latter half of the century. This thesis aims to explore multiple both the introduction and the eventual decommissioning of the pneumatic grain elevator. In doing so, it will aim to provide a substantial overview of how radical technological change can have a long-term impact on ports, with the Rotterdam port and its pneumatic grain elevators serving as a case-study.

The 20th century in the Rotterdam port can be considered a tumultuous one. Rapid technological change created a highly dynamic and vibrant transit-port at the mouth of the Rhine. Starting in the late 19th century, increasing currents of mechanisation took place within the port of Rotterdam, shaking up the contemporary fabric of the port significantly. Not all of these innovations were accepted readily by both labourers and businesspeople alike. During this period of intense transformation, significant strikes occurred that aimed to delay or completely quell mechanisation efforts in the port of Rotterdam.[1]

At the root of this all were ostensibly new technologies and applications that were able to significantly increase the rate at which transhipment of bulk goods such as coal, petroleum, ores, and perhaps most importantly, grain, could be conducted.

The overall mechanisation efforts within the Rotterdam port are interesting, however there is one specific innovation that would have a long-lasting impact, which is the widespread use of the pneumatic grain elevator.

In this thesis both the introduction and decommissioning of the pneumatic grain elevator will be looked at in the greater context of radical technological change. Briefly summarised, radical technological change constitutes the widespread application of new technologies in a relatively short period of time, thereby rendering previous technological applications obsolete, hence the term radical, as opposed to more incremental applications which happen over a longer time period.

This thesis has a particular socio-cultural relevance to the broader public history of Rotterdam. The Rotterdam Maritime Museum prominently displays a pneumatic grain elevator in the Leuvehaven. This elevator, originally used in Antwerp, serves as a museum object which can be seen and visited in the public sphere. This thesis then might lead to those of the interested public to look at this museum piece with a more concrete understanding of its implications on the Rotterdam port.

[1] Hugo van Driel and Ferry de Goey, *Rotterdam: Cargo Handling Technology, 1870-2000* (Zutphen: De Walburg Press, 2001). p. 11-15.

Main Research Question and Sub-Questions:

This thesis aims to answer a main research question. Namely: *Why can the introduction and eventual decommissioning of the pneumatic grain elevator in the port of Rotterdam be considered examples of radical technological changes?* This main research-question is a twofold one, with both the introduction and eventual decommissioning of the pneumatic grain elevator serving as case studies. The first is relatively well researched, the latter less so. It is my opinion that this gap in the historiography should be amended by adding perspectives on the decommissioning of the pneumatic grain elevator in the port of Rotterdam.

In order to facilitate research, three sub-questions have been compiled. The first sub-question relates to the concept of radical technological change: *How can the concept of radical technological change be described and how can it be applied in the port of Rotterdam?*

This section aims to answer the question of how radical technological change can be interpreted when looking at multiple case studies in the port of Rotterdam. This section leans heavily on works on technological change as well as those works that focus on the workings of the port of Rotterdam.

The second sub-question will explore the introduction of the pneumatic grain elevator in the port of Rotterdam: *Did the introduction of the pneumatic grain elevator in the port of Rotterdam constitute radical technological change?* This sub-question will be answered through existing literature on radical technological change as well as literature on the introduction of the pneumatic grain elevator, both contemporary works written on the introduction of these machines as well as academic works that offer a more theoretical approach on the subject.

The third sub-question is related to newer technologies that came to supplant the use of the pneumatic grain elevator. This sub-question goes as follows: *Did the decommissioning of the pneumatic grain elevator in the port of Rotterdam constitute radical technological change?* Due to the relative lack of secondary literature this sub-question will be answered through the use of primary sources that deal with the appropriate time period in the Rotterdam port. This particular section will constitute the most important addition to the existing historiography, by looking at a less-studied aspect of pneumatic grain elevators in the Rotterdam port.

Lastly, having answered these secondary research questions it becomes possible to answer the main research question. This main research question will be answered in its own dedicated section which furthermore offers a conclusion to the research project as a whole.

Main theoretical concepts:

To increase the readability of this work, a brief section on the most important theoretical concepts has been compiled. It covers concepts related to the pneumatic grain elevator and cargo shipment in the Rotterdam port as a whole. Furthermore, it covers important concepts on (radical) technological change.

- **Evolutionary View of Technological Improvement:** Set out by J. Farrell, and applied by Joel Mokyr, the evolutionary view of technological improvements has three distinct forms. First, mutations: these create totally new knowledge, an example of this is the steam engine, which needed three separate macro-inventions to reach its most useful form. Second, recombinations: these apply knowledge from one area to another in order to create an entirely new device or method. Third, hybrids: these combine different inventions that are already in use in a novel way.[2]
- **Direct and Indirect Methods of Transhipment:** The direct method of transhipment refers to goods being transferred directly from seagoing ships into other methods of transport to serve the hinterland. Oftentimes these methods of transport would be trains or river-going barges/lighters. Indirect transfer on the other hand refers to sea-going vessels' goods being transported to land-based facilities such as silos or tanks whereupon these goods will be loaded on the appropriate vessels from further shipment to the hinterland. The post-WWII trajectory of the port of Rotterdam increasingly favoured the indirect method of transport over the direct form.[3]
- **Micro- and Macro-Inventions:** Broadly speaking, micro-inventions improve, adapt, and/or streamline existing techniques. Oftentimes they are able to lower cost and energy requirements. Micro-inventions often present incremental changes to existing technologies and are thus able to refine them. Macro-inventions on the other hand are more radical in nature. These often arise more or less out without precedent and can truly be called radical technological improvements. Furthermore, they often arise out of serendipity rather than following a set path. Micro- and Macro-inventions have some degree of interaction with one another, especially when viewed as complimentary, without micro-inventions some macro-inventions would not have been as effective. This phenomenon is also called technological drift.[4]
- **Radical Technological Change:** Radical technological change is distinct from more incremental paths of technological applications. Radical technological change arises when new technological applications become widely used in a relatively short period of time, thereby making the previous forms of technological application obsolete, hence the term radical change.[5]

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[2] Joel Mokyr, "Evolution and Technological Change: A New Metaphor for Economic History?," in *Technological Change: Methods and Themes in the History of Technology* (Amsterdam: Harwood Academic, 1996), p. 63-69.
[3] Hugo van Driel and Johan Schot, "Het Ontstaan van Een Gemechaniseerde Massagoedhaven in Rotterdam," in *Techniek in Nederland in de Twintigste Eeuw. Deel 5. Transport, Communicatie.* (Eindhoven: Stichting Historie der Techniek, 2002), p. 75-76.
[4] Mokyr, The Lever of Riches, p. 13-14.
[5] Mokyr, *The Lever of Riches*, p. 12

- **Regime Change:** A regime can be defined as a set of rules that are adhered to in the use of technology, i.e., the environment into which new technologies can enter. Regime change constitutes a change in a set regime through the application of newer technologies.[6]

[6] Hugo van Driel and Johan Schot, "Radical Innovation as a Multilevel Process: Introducing Floating Grain Elevators in the Port of Rotterdam," *Technology and Culture* 46, no. 1 (2005): p. 55-56.

Literature report:

A substantial body of literature used in this thesis is dedicated to both mechanisation efforts in the Port of Rotterdam as well as the concept of radical technological growth. This section aims to give the reader an overview of existing literature that has been written on relevant concepts within this thesis. Furthermore, this literature report has been sorted thematically so that the reader can easily distinguish between several important concepts.

The first section of this report is concerned with the role of mechanisation in the Rotterdam port, especially the case of the pneumatic grain elevator. The second section of this report is dedicated to writings on technological innovation and (radical) technological change and how these can be interpreted.

Section I:

Technological Improvements and mechanisation in the Rotterdam Port before 1940:

There is ample amount of literature dedicated to the introduction and influence technological advancements and mechanisation efforts in the Rotterdam Port. Hugo van Driel and Ferry de Goey have written a comprehensive overview of mechanisation efforts in the Rotterdam Port, starting in 1880. According to Van Driel and Schot, the Rotterdam port can be considered an important junction node where large sea-going vessels unload their goods for transfer to modes of transport that would serve the Ruhr-area, the hinterland of the port of Rotterdam. The most notable forms of transport in this case being Rhine-based barges as well as trains. This transfer could either be direct or indirect. Direct transfer refers to goods being transferred directly from the sea-going vessels into modes of transport suitable to serve the hinterland. Indirect transport refers to transfer from sea-going vessel onto facilities on land. In the 1880s, cargo handling in the Rotterdam Port was entirely dependent on manual labour. Dockworkers would move goods such as ores and coal from cargo holds into crates by means of spades and hooks. Grain was manually moved into loose sacks as well as woven baskets.[7]

Another work by Van Driel and De Goey traces the mechanisation efforts in the Rotterdam Port. Starting at the end of the 19th century, the port of Rotterdam became gradually more mechanised, especially in cargo-handling. Mechanisation that had set in at the end of the 19th century caused a huge increase of both liquid and dry bulk goods being processed through the port, the most important of these being petroleum, ores, coal, and grain.[8]

Originally petroleum consignments were loaded in barrels and crates and transported by hand from ship to barge, and efficiency bottlenecks were widespread. Petroleum storage and transloading underwent significant changes starting in 1888 when the Rotterdam-based company Pakhuismeesteren installed two tanks at the Sluisjesdijk in Rotterdam-Charlois. This year also marks the first arrival of a tanker ship. The introduction of the tanker ship caused a

[7] Hugo van Driel and Johan Schot, "Het Ontstaan van Een Gemechaniseerde Massagoedhaven in Rotterdam," in *Techniek in Nederland in de Twintigste Eeuw. Deel 5. Transport, Communicatie.* (Eindhoven: Stichting Historie der Techniek, 2002), p. 75-76.

[8] Hugo van Driel and Ferry de Goey, *Rotterdam: Cargo Handling Technology, 1870-2000* (Zutphen: De Walburg Press, 2001). p. 11-15.

significant transfer of petroleum shipments from rail-based transport towards inland shipping by barge, which by 1894 had reached 96% of the total volume shipped to Germany.[9]

Coal and ore handling also became increasingly mechanised. From 1886 to the early years of the 20th century, innovations such as the coal tip and the electric ore cranes were used and increased the overall presence of mechanisation in the handling of ores and coal rapidly.

In 1886, the first coal tip was installed in the Binnenhaven in Rotterdam-Feijenoord. By 1896 the need for more coal tips became evident, however the Binnenhaven proved too small to house more tips, and the municipality decided to install two more tips on the Katendrechtse Hoofd. The coal tip effort proved successful, and by 1898, these coal tips handled nearly 350 thousand tonnes of coal and cokes in the Rotterdam port.[10]

After 1898 however, the volume of coal and cokes that was handled through coal tips decreased. Lump coal constituted an increasing share of the coal that came through the Rotterdam port, and its fragile consistency led to it breaking when dropped from great heights through the use of coal tips. Because of this it was decided to use electric ore cranes which could easily load wagons located on the quays. These electric cranes virtually eliminated manual labour from the process of coal handling.[11]

The (Pneumatic) Grain Elevator in the Rotterdam Port:

Almost simultaneous to the introduction of more mechanised methods of bulk goods such as ores, coal, and petroleum another interesting technology emerged, namely the introduction of the pneumatic grain elevator.

Its origins lay in a more primitive version, first introduced in Buffalo, New York, back in 1842. These elevators were so-called bucket elevators, and not completely mechanised yet, meaning that the process did not completely eliminate manual labour altogether.[12]

Van Driel and Schot point out that there was an early attempt to introduce bucket elevators in Rotterdam. In 1882 the Rotterdamsche Ballast Maatschappij aimed to introduce a bucket elevator for use in the Rotterdam port. There was heavy resistance by both labourers as well as local transporters who were involved in hinterland shipping. The eventual fate of this elevator is unknown, although speculations of arson were rife. Van Driel and Schot argue that this constituted a failed attempt at mechanisation.[13]

A more successful attempt, according to Van Driel and Schot, was conducted by the Holland America Line in 1896. Having adopted the American model of grain transportation as bulk, the HAL installed a bucket elevator to load and unload its grain cargo. The HAL’s attempts at mechanisation related to their ordering of a new ship called the Rotterdam, which had a gross tonnage of 8000, eclipsing the 4500 tonne ships they had in service at this time. The old, labour-intensive method of grain loading would prove too slow to handle the newer, larger ships, and would cause the HAL to miss its time-schedules. This provided incentive for the HAL to adopt bucket elevators. The introduction of the bucket elevator by the HAL proved relatively successful.

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[9] Hugo van Driel and Ferry de Goey, *Rotterdam: Cargo Handling Technology, 1870-2000* (Zutphen: De Walburg Press, 2001). p. 16-18.
[10] Van Driel and de Goey, *Rotterdam: Cargo Handling Technology*, p. 20-22.
[11] Van Driel and de Goey*, Rotterdam: Cargo Handling Technology,* p. 23, 28.
[12] William J. Brown, *American Colossus: The Grain Elevator, 1843 to 1943* (Brooklyn: Colossal Books, 2015). 55-63.
[13] Van Driel and Schot, *Het Ontstaan van Een Gemechaniseerde Massagoedhaven in Rotterdam*, p. 89.

Mechanisation in this case did not cause a shrink in the number of labourers that were working in grain transhipment, this contributed to the lack of resistance to the introduction of the bucket elevator. Cost-saving for the HAL was also successful, mostly due to the relatively cheap purchase of the bucket elevator (7.500 guilders), compared to wages saved, and its ability to increase grain outputs, and thus profits.[14]

Despite a brief moment of convergent technologies, William Brown argues that by 1908 the development of grain elevators in Europe and the United States showed a clear divergence. The American elevators would remain mostly semi-mechanised, whereas European, especially German, elevators would become fully mechanised, as is evident in the development of the pneumatic grain elevator.[15]

An interesting work on the introduction of the pneumatic grain elevator in the Rotterdam Port is a 1933 book by Ch. A. Cocheret, who used the archival sources of the Graan Elevator Maatschappij (GEM) and its earlier incarnations while writing his work. Cocheret presents a business history that stretches from the early days of the grain elevator up and until 1933.[16] Looking at Cocheret, a clear chronological outline of the introduction of the pneumatic grain elevator emerges that is supported by other literature on the subject.

The years 1901-1905 show early attempts to bring the pneumatic grain elevator into use in the Rotterdam port. A 1901 visit by the Verein Deutsche Handelsmüller, a German organisation of mill owners who imported grain, sparked local interest in acquiring pneumatic grain elevators. An agreement was made between several leading companies in the Rotterdam Port to establish a company that could instigate the introduction of pneumatic grain elevators, and on the 14th of March 1904 the Maatschappij tot Exploitatie van Drijvende Elevators was founded. An earlier order for two elevators through A. Luther A.G. was met in 1905, and on the 21st of July 1905 two pneumatic elevators were put into use in the Maashaven, the main grain *entrepot* of Rotterdam. The introduction of these behemoths sparked revolt, not in the least because its integrated automatic weighing system malfunctioned. Workers went on strike and Maatschappij tot Exploitatie van Drijvende Elevators, the main operator of these elevators, was forced to revert to the previous method of labour, loading by hand.[17]

The years 1906-1908, according to Van Lente, present us with a period of prolonged struggle in grain transhipment in the port of Rotterdam. Cocheret details many of the conflicts between labour unions and the Maatschappij tot Exploitatie van Drijvende Elevators and its allies, culminating in the strike of 1907 in which marines had to be brought in to restore order.[18]

The so-called 'elevator issue' virtually became a nationwide political issue during this period, as Van Lente shows, not only liberal and religious politicians, but socialist intellectuals

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[14] *Ibid*.
[15] Brown, *American Colossus*, p. 171-172.
[16] Charles Albert Cocheret, *Het Elevator-Bedrijf in de Rotterdamsche Haven 1908-1933* (Rotterdam: Nijgh & Van Ditmar, 1933). p. 9.
[17] Cocheret, *Het Elevator-Bedrijf in de Rotterdamsche Haven 1908-1933*, p. 11, 21, 26. and Dick van Lente, "Machines and the Order of the Harbour: The Debate About the Introduction of Grain Unloaders in Rotterdam, 1905-1907," *International Review of Social History* 43, no. 1 (1998): p. 80.
[18] Cocheret, *Het Elevator-Bedrijf in de Rotterdamsche Haven 1908-1933*, p. 53-110. and Hugo van Driel and Johan Schot, "Radical Innovation as a Multilevel Process: Introducing Floating Grain Elevators in the Port of Rotterdam," *Technology and Culture* 46, no. 1 (2005): p. 52.

began to argue that revolt against these modern technologies was futile and irrational, and that workers could profit from mechanisation and increase their leverage through negotiation.[19]

Another article by Van Lente shows that this was part of a broader movement of reaction to technology within the Netherlands as well as Europe as a whole. Broadly speaking, liberal as well as socialist movements throughout Europe were enthusiastic towards technological change. There were examples of religious groups, such as Orthodox Calvinists campaigning against radical technological changes. The Anti-Revolutionaire Partij, or ARP was among the most conservative in this regard. Later on, the party revised its opinions and argued that technological change constituted the dominion of man over nature. Strikes in the Rotterdam port were thus not supported by the ARP.[20]

Another interesting perspective on the tumultuous introduction of the pneumatic grain elevator comes in the form of A. Voogd's short work *De graanelevators en de Gisting in het Havenbedrijf te Rotterdam*, which was published when the strike of 1907 was not yet at an end and can thus be considered an eyewitness account. Voogd, an editor for the Rotterdam-based newspaper *Scheepvaart* was thus heavily involved in the day-to-day workings of the Rotterdam Port. Voogd sketches a short history of the introduction of the pneumatic grain elevator, leading up to the strike of 1907. He argued that the main reasons for the introduction of pneumatic elevators were related to cost-saving. The long-term public benefits through faster transhipment and the ability to handle increasing volumes of grain in the Rotterdam port are considered to be the most important contributions of the pneumatic grain elevator, according to Voogd. Furthermore, he argues that the labourers who are striking against the use of pneumatic elevators are going against their own interests, seeing as these enabled the workers to have shorter working-days.[21] Eventually, an agreement was reached in favour of the Elevator Company. Cocheret argues that the violent nature of the strikes set-up by both the stevedores and the better-paid and unionised weighers of grain squandered all hopes of incremental introduction of pneumatic grain elevators, thus more or less forcing them to accept the introduction of these machines.[22] After the strike, in 1908, the Graan Elevator Maatschappij would be founded, this company would apply pneumatic grain elevators in the Rotterdam Port for many years to come.

The pneumatic grain elevators that were put into use during this period had a capacity of 150 tonnes per hour. A manual labour crew of 126 would need around seven or eight days to unload 6000 tonnes from a ship, when using two pneumatic elevators, each with a crew of 14, the job would take only two days. This constituted a huge reduction in labour input, amounting to 94 percent.[23] In the following years, the mechanization of grain unloading in the Rotterdam port under the GEM happened rapidly. By 1913, over 96 percent of grain was unloaded through the use of pneumatic floating grain elevators. With numbers such as these, Van Driel and Schot

[19] Van Lente, ''Machines and the Order of the Harbour'', p. 93-109.
[20] Dick van Lente, "Ideology and Technology: Reactions to Modern Technology in the Netherlands 1850-1920," *European History Quarterly* 22, no. 3 (1992): p. 386-396.
[21] A. Voogd, *De Graanelevators En de Gisting in Het Havenbedrijf Te Rotterdam* (Rotterdam: Meindert Boogaert, 1907). p. 29-32.
[22] Cocheret, *Het Elevator-Bedrijf in de Rotterdamsche Haven 1908-1933*, p. 101.
[23] Van Driel and Schot*, Radical Innovation,* p. 63.

argue that the pneumatic grain elevator quickly showed economic promise and it made sense to continue using it in Rotterdam.[24]

Other works emphasize the comparative advantages of broader mechanisation efforts in the Rotterdam port. The 2004 work *Comparative Port History of Rotterdam and Antwerp (1880-2000): Competition, Cargo, and Costs* offers up an interesting overview of mechanisation currents present in Antwerp as well as Rotterdam. Antwerp can be seen as useful in this case seeing as it presents a comparable port to Rotterdam that shows a different trajectory of growth and approach to cargo-handling technologies which might enable a comparative analysis to be made.

In their chapter on comparative studies between of Rotterdam and Antwerp, De Goey, Loyen, and Van Driel argue that between 1900 and 1920, the port of Rotterdam gained a significant comparative advantage over the port of Antwerp in the processing of bulk goods. Antwerp lagged behind in the adoption of mechanised transhipment methods such as the floating grain elevator and shore-based grab cranes. Furthermore, cargo handling in Rotterdam was mostly done by private companies who owned or were able to buy appropriate equipment. In Antwerp on the other hand, cargo handling was dominated by municipal authorities and private ownership of cargo loading equipment was limited. Rotterdam on the whole then, presented a more flexible and vibrant cargo handling environment, at least compared to Antwerp.[25]

The case of grain-handling technologies is the most important for the topic at hand. Whereas in 1910 the majority of grain (81%) in the Rotterdam port was being handled by twenty-four elevators, Antwerp only reached this threshold in the 1920s, mostly due to the immense stagnation suffered during the First World War in which Belgium was invaded by Germany. Furthermore, the average yearly growth of the Rotterdam port in this period amounted to 8 percent, whereas Antwerp only grew by 6% on average. The period 1901-1913 also highlights the large market share Rotterdam had in the shipment of foodstuffs such as grain. When comparing the two ports Rotterdam shipped about 70 percent of total foodstuffs transhipped to both ports, whereas Antwerp only controlled 30 percent.[26]

Technological Changes and Further Innovations Within the GEM:

As opposed to the introduction of the pneumatic grain elevator in the Rotterdam port, there is not such a large amount of literature dedicated to the eventual decommissioning of grain elevators. More however, has been written about further technological changes in the Rotterdam port after the initial introduction of the pneumatic grain elevator.

Although volumes of goods had risen again after the First World War ended there were still concerns in the port of Rotterdam. The pre-war realisation of mechanisation in transhipment proved successful, especially the use of the pneumatic grain elevators, and during the interbellum these technologies were refined and optimised. However, by 1926 the municipal

[24] Van Driel and Schot*, Radical Innovation,* p. 52-62.
[25] Ferry de Goey, Reginald Loyen, and Hugo van Driel, "Historiography: Comparative Port History of Rotterdam and Antwerp," in *Comparative Port History of Rotterdam and Antwerp (1880-2000): Competition, Cargo, and Costs* (Amsterdam: Aksant Acedemic Publishers, 2004), p. 37-39.
[26] Reginald Loyen and Paul van de Laar, "Cargo-Handling Technology and Competition during the Interwar Years," in *Comparative Port History of Rotterdam and Antwerp (1880-2000): Competition, Cargo, and Costs* (Amsterdam: Aksant Acedemic Publishers, 2004), p. 80-83.

authorities installed a commission to look at further options regarding the maritime infrastructure as well as the reduction of port dues to further increase goods flows. The most noteworthy improvement during this period was the broad application of level luffing cranes designed to handle break-bulk goods. Level luffing cranes were cranes that could lift vertically which was both quicker and offered increased manoeuvrability to navigate packed ports areas. The productivity gain in the handling of break-bulk goods amounted to about 68% in the period 1929-1936. In a comprehensive chapter on technological changes in the Rotterdam port Bruhèze, Rip, Schot and Lintsen opine that the introduction and widespread application of the level luffing cranes did constitute a radical technological change but did not lead to a radical regime change in the port as a whole.[27]

Further improvements in mechanisation happened after 1945, and by the 1960s the Rotterdam port had experienced another important regime change. The character of the port shifted from direct transhipment to a more indirect variant. The introduction of the container caused a major revolution in break-bulk shipment. An interesting note is that, according to Bruhèze et al., the introduction of the container in the Rotterdam port in 1966 was met with remarkably little resistance by port labourers.[28]

This period furthermore marks the further diversification of the business practices of the GEM and the grain industry in the Port of Rotterdam as a whole. As was the case with introduction of the container, scale effects were also important in the grain industry during this period. As ships became increasingly larger, the GEM was confronted with increased congestion and was unable to effectively load and unload them using only the pneumatic grain elevators in the Maashaven. The GEM decided to open an entirely new terminal in the Botlek in 1965, not in the least because they had been confronted by increased competition from the Amsterdam-based company Tradax (a subsidiary of the American grain company Cargill), which settled in Amsterdam in 1959 and applied the indirect method of transhipment. The facility in the Botlek could also be reached by larger ships that were not able to reach the shallow waters and narrow corridors of the Maashaven.[29]

The efforts by the GEM in the Botlek are argued by Bruhèze et al. to have been hugely successful. The new installation in the Botlek shore-based pneumatic unloaders were used to unload the sea-going ships, the contents of these ships were transported by conveyor belt and correspondingly loaded onto lighters through the use of floating elevators. Silos for storage, however, were only used in a limited manner.[30]

Further increases in scale occurred in 1977, when the GEM put another shore-based installation in use, this time in Europoort. Bruhèze et al. argues that this new, diversified manner of business constituted a regime change in the grain industry within the Port of Rotterdam.[31]

The GEM itself ceased to exist in 1993 as an independent company when it merged with shipping companies Frans Swarttouw B.V. and Interstevedoring B.V. to form European Bulk Services, or EBS. Total transhipment of dry-bulk cargo facilitated by EBS in 1993 amounted to 26

[27] Hugo van Driel and Johan Schot., “Indirecte Overslag En de Komst van de Container,” in *Techniek in Nederland in de Twintigste Eeuw. Deel 5. Transport, Communicatie.* (Eindhoven: Stichting Historie der Techniek, 2002), p. 97-98.
[28] Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 101, 108-110.
[29] Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 101-104.
[30] *Ibid*.
[31] *Ibid*.

million tonnes. EBS furthermore operated four distinct terminals, GEM's Europoort-terminal, Interstevedoring's Botlek-terminal, and Swarttouw's St. Laurenshaven and Vulcaanhaven terminals. The location of these ports indicates the movement from Rotterdam's ports away from the city proper, with some located as many as 25 kilometres away from the city centre. The nature of the EBS is also interesting, it is comprised of a diverse range of activities, ranging from coal and ores to grain. It thus came to pass that there was no longer a company present within the Rotterdam port that was solely dedicated to the transhipment of grain.[32]

Works on the period around downfall of the pneumatic grain elevator seem to be largely dedicated to the introduction of the container, as well as being more business-oriented, such as works on European Bulk Services. A rigorous perspective on technological change beyond the introduction of the container then, seems to be lacking. In order to address this gap in knowledge a broad range of theories can be applied, which will be looked at in the following section.

[32] Jan van der Burg, *Rotterdam Mainport Dry Bulk Cargo*, 1994. p. 5-9.

Section II:

Inventions and (Radical) Technological Improvements:

In order to gauge the effects of technological innovations as a whole, a definition of what constitutes 'radical' innovations needs to be considered. Radical innovations can be considered opposite to incremental innovations that happen over a larger stretch of time.

This statement can be explored further when looking at several examples. In his book *The Lever of Riches*, Joel Mokyr makes a distinction between micro- and macro-inventions throughout history. In this he challenges the belief that some historians maintain that inventions only occur through a so-called 'technological drift', as it is called by Eric L. Jones. This theory argues that inventions are but a result of small, incremental changes in technology over time and that credit should not necessarily be given to inventors that apply these technological changes in their inventions.[33]

Mokyr acknowledges the existence of these smaller, incremental changes and terms them micro-inventions. These micro-inventions improve, adapt, and streamline existing techniques. Furthermore, they have the ability to lower costs and energy/material requirements, as well as improve durability. Micro-inventions are also more likely to be explained using conventional economic models such as rent seeking and production efficiency.[34]

His main focus however is on macro-inventions. These can rightly be called radical technological improvements as Mokyr argues that these emerge mostly without precedent and *ad nihilo*, that is to say out of nothing. Mokyr argues that these are technological advancements in their most 'true' form as they more or less appear without a set pattern and are able to shape the history of technology more radically than micro-inventions are able to. This does however pose problems, as macro-inventions are less likely to be explained by conventional economic models, rather they often arise due to sheer luck or serendipity.[35]

Regarding the interactions between micro- and macro-inventions Mokyr argues that they should not be seen as substitutes, rather they can be considered complimentary to one another. One cannot exist without the other, and without subsequent micro-inventions, some macro-inventions would most have likely ended up as historical curiosities.[36]

Donald A. Norman and Roberto Verganti have both done independent quantitative research on radical technological innovation and offer up an interesting conclusion. They argue that most radical technological innovations throughout history from the steam engine to Facebook occur with little to no research to both societal as well as personal needs. Instead, they argue that these innovations came about because their inventors simply thought them interesting to try.[37]

Wilfred Schoenmakers and Geert Duysters have furthermore done quantitative research on radical technological innovations. They offer four distinct hypotheses that they have found to be statistically significant, namely:

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[33] Mokyr, *The Lever of Riches*, p. 12.
[34] Mokyr, The Lever of Riches, p. 13.
[35] *Ibid*.
[36] Mokyr, The Lever of Riches, p. 13-14.
[37] Donald Norman and Roberto Verganti, "Incremental and Radical Innovation: Design Research vs. Technology and Meaning Change," *Design Issues* 30 (2014): p. 78-79.

- Radical inventions are equally based on existing knowledge, as non-radical inventions.
- Radical inventions are to a higher extent based on emergent technologies, as compared to non-radical inventions.
- Radical inventions are to a higher degree based on a combination of mature and emergent technologies than non-radical inventions.
- Radical inventions are based on a relatively large number of knowledge domains, compared to non-radical inventions.[38]

These hypotheses align with Mokyr's theories about radical technological change and macro- and micro-inventions and can complement each other when looking at distinct cases of radical technological change.

Radical innovations then can be considered to bring about an entirely new direction in technological development in a relatively short period of time. In this, references to evolutionary biology are ample. Especially poignant are three concepts that can be applied to technological change. Following from evolutionary concepts as set out by Christopher J. Farrell, radical technological change can arise from three basic types of inventions.[39]

- First, mutations: these create totally new knowledge, an example of this is the steam engine, which needed three separate macro-inventions to reach its most useful form.
- Second, recombinations: these apply knowledge from one area to another in order to create an entirely new device or method.
- Third, hybrids: these combine different inventions that are already in use in a novel way.

According to Mokyr, the use of these evolutionary models enables us to look at long-term historical dynamics involving technological change more clearly and understand its implications better.[40]

This quasi-evolutionary view is further explained by Mokyr in *The Lever of Riches*. He argues that technological innovation is not at all unlike evolutionary characteristics of species and that changes in these can by right be called 'evolutionary'. This also underpins technological innovation's position as an epistemological concept, something which does not 'exist' outside of the brain. This is so because technology is information acquired through learning and not through genes. The main difference, according to Mokyr, is that this evolutionary view of technological innovation involves intentionality on the part of the inventor, whereas biological evolution has no semblance of intentionality on the species-level. In this, creative destruction is also apparent, creatures that fail to adapt are left behind or go extinct, just as older technologies are supplanted by newer ones.[41]

[38] Wilfred Schoenmakers and Geert Duysters, "The Technological Origins of Radical Inventions," *Research Policy* 39, no. 8 (2010): 1051-1053.
[39] Joel Mokyr, "Evolution and Technological Change: A New Metaphor for Economic History?," in *Technological Change: Methods and Themes in the History of Technology* (Amsterdam: Harwood Academic, 1996), p. 63-69.
[40] Mokyr, *Evolution and Technological Change*, p. 69-73, 81.
[41] Mokyr, *The Lever of Riches*, p. 275-283.

Position in the historiographical debate:

The academic discourse regarding (radical) technological advancements is diverse, and very interesting to the topic at hand. This thesis focusses on applying the ideas of radical technological advancements on the port of Rotterdam with both the introduction as well as the decline of the pneumatic grain elevator.

Most of the works regarding the introduction of the pneumatic grain elevator and its influence are rather dated and predominantly written in Dutch. Both Van Lente and Van Driel and Schot have written interesting papers in English, but these are predominantly focussed on the reactions of labourers and businesses, rather than looking at the effects of radical technological advancements themselves.

The academic literature on the decommissioning of the pneumatic grain elevator is scant. I have aimed to add to this discussion by looking at whether or not the decommissioning of the pneumatic grain elevator can be considered a radical technological change. This will be further elaborated upon in the next section.

Innovative Aspects of Thesis:

There is a large amount of literature dedicated to the introduction of the pneumatic grain elevator in the Port of Rotterdam. The formative years of the GEM have also been documented quite clearly, oftentimes by persons close to the organisation or with access to the company archives. Later efforts in the Rotterdam grain industry, including those by the GEM in the Botlek, and later in Europoort are also well-documented. Following this then, a point of discussion still remains, namely the eventual decommissioning of the pneumatic grain elevator.

As of 2021, the only floating pneumatic elevator remaining is the Stadsgraanzuiger No. 19, which operated in the port of Antwerp. Nowadays it serves as a museum object to the Rotterdam Maritime Museum and is stalled in the Leuvehaven. Pneumatic floating grain elevators are no longer in use throughout the grain industry, having been superseded by high-tonnage cranes.

Post-war growth in the Rotterdam port was staggering, and in the 1960s the port was the largest worldwide. However, this post-war period has seen a remarkable decline in *relative* grain transhipments. In 1946 12.4 percent of all goods handled in the port were grains, in 1970 this amount only constituted 2.4 percent of the total. This does not necessarily tell us anything about a decline in absolute growth, however it can be argued that grain was not one of the primary forms of cargo in the Rotterdam port during this period.[42]

Furthermore, these statistics do not tell us anything about regime change and radical technological changes within the port during this time period. In the construction of this thesis, it is my goal to give a rigorous overview of the technologies that came to the fore in replacing the pneumatic grain elevators in the Rotterdam port and ask the question whether this constituted a radical technological change.

In short then, through the writing of this thesis I have set out to address multiple problems within the existing historiography. These are as follows:

- Firstly, I aim to offer a further, more academically sound historical narrative of the introduction of the pneumatic grain elevator in the port of Rotterdam. The workings of these elevators have been described by several authors, both in contemporary and at later points in time. Interesting research papers have been published by Van Driel and Schot, as well as by Van Lente. However, these papers are situated more within an academic discourse related to either labour strikes, or to a narrower definition of technological change. The workings and impact of these machines is also addressed in several works that deal with the port of Rotterdam as a whole, oftentimes in relatively narrow detail.
- Secondly, I aim to offer a comprehensive historical overview of technologies that were applied in grain handling and eventually surpassed the use of pneumatic elevators. Information in secondary sources on these technologies are relatively scarce, especially since the bulk of post-1960 histories are oftentimes dedicated to the so-called container revolution, instead of further advancements in bulk-shipping.

[42] Paul van de Laar, Stad van Formaat. Geschiedenis van Rotterdam in de Negentiende En Twintigste Eeuw (Zwolle: Waanders Uitgevers, 2000). p. 512-513.

- Lastly, through a conclusion of my research I aim to add to a broader academic discussion of how radical technological changes and their application can have an influence on the workings of ports in general.

Nature of Sources:

The Stadsarchief Rotterdam houses a large and interesting collection of the city's port. The archives of the most prominent grain company that possessed pneumatic elevators, the Graan Elevator Maatschappij, are situated in this archive. This archival collection covers the years from 1908-1970. It contains the yearly company reports of the GEM, correspondence between its employees and clients, as well as minutes of company board meetings. Furthermore, it contains the employee-registers from the period 1910-1930. These sources provide an inside view of the company and the Rotterdam grain transhipment as a whole, which proved very useful. A downside of this archival collection is that the documents are not digitised, so they had to be researched on-location. The Stadsarchief also hosts the collection of De Does, the employee magazine of the GEM, which proved invaluable for the later period of the elevators, as archival documents regarding that period are not public.

The archive also offers a substantial photographic database, of which many are digitised and available online. This collection contains interesting photographs of the pneumatic grain elevator at work in the Rotterdam port. Some of these photographs provide a view of the amount of productivity that was present in Rotterdam's inner ports during the use of the pneumatic grain elevator.

Another useful resource is Delpher, which offers digitised Dutch newspapers. Several local newspapers, such as the Rotterdam shipping newspaper Scheepvaart are included in the collection. These particular papers can be very useful in creating a broad overview of the introduction of pneumatic grain elevators as they often feature accurate dates for the commissioning of new pneumatic elevators. A potential downside is that not all material is all that relevant to the pneumatic grain elevator and its use in Rotterdam, seeing as the newspaper covered all port-related news. It might thus present a large challenge to look search the large number of resources to find relevant material. This is also the case with several other sources included in the literature report.

Lastly, the Rotterdam Maritime Museum has a broad collection of shipping-related documents, including material on grain transhipment. The collection includes many images as well as primary documents on grain transhipment in Rotterdam and beyond. During the completion of this thesis, I have conducted an internship in the Maritime Museum. During this internship I have looked at the day-to-day workings of the pneumatic grain elevator no. 19, when it was present in Antwerp. The results of this internship were eventually not incorporated in the main part of this thesis; however, it is interesting to note that the pattern of decline as it presented itself in Rotterdam was also visible in Antwerp.

Methods:

This research has adopted both a qualitative as well as a quantitative approach in answering the main research question.

The qualitative approach will look at how the introduction and eventual decommissioning of the pneumatic grain elevator have changed the fabric of the Rotterdam port. Monographs and academic research on the introduction of the pneumatic grain elevator are useful in charting the rise of the elevator, for the decommissioning one has to look more at primary sources.

The quantitative aspect of the research will look at the impact of the pneumatic grain elevator in the port of Rotterdam in the form of more numerical statistics such as freight rates and goods flow and analyse how technological change might have influenced these numbers. It is the idea to use these statistics in a manner that might elucidate upon certain aspects within the historical narrative, rather than using them for padding.

I have aimed to collect relevant material from local archives and get a grip on the extent of primary sources that could be useful to this thesis. The archives are all local and seeing as I am located in Rotterdam it should be less of a problem to visit these. However, due to the ongoing Covid-19 outbreak this turned out to be harder than anticipated. On-site archival research only became possible in August of 2021, which caused delays in the completion of this thesis.

Interpretation of sources is another point of interest. When conducting research in the archive, I have maintained digital notes on primary source material through the use of a program called Zotero. This allows for retaining an overview of the primary sources, as well as giving a brief summary of the contents of said sources. This note-system enables one to look briefly at a primary source and determine whether or not it is applicable to the writing at hand.

Analysis of source materials is also important. This analysis can come to pass in the form of a more critical assessment of the primary source material. Primary sources within the archives, such as yearly reports can be considered relatively unbiased as they are concerned with the more quantitative aspects of the grain trade and transhipment. It is unlikely that these numbers were falsified in any way, shape, or form.

Chapter I:
Radical Technological Change and the Port of Rotterdam

This chapter aims to give an overview of the concept of Radical Technological Change and its implications on the port of Rotterdam. It will aim to explain the criteria that can be measured to judge whether or not a certain technological innovation or technological change can be considered a radical one. It will also delve deeper into the limits of the concept itself, and its application and usefulness when constructing a historical narrative. Some stronger aspects of the concept as a whole, as well as weaker ones will be considered.

Following this theoretical discussion three case studies will be analysed. These case studies revolve around the application of technological means in the port of Rotterdam in the late 19th and early to mid-20th century. The case studies that will be analysed are as follows: the mechanisation of coal and ore transhipment in the port of Rotterdam in the late 19th and early 20th centuries, the application of indirect methods of transhipment in the mid-20th century, and the rise of the container starting in the 1960s.

These case studies all regard the application of new technological means in the port of Rotterdam, however the degree of these being radical in nature will be debated according to the criteria that will be set out. This chapter forms an introduction of various technological applications in the port of Rotterdam, in order to provide the reader with context to the main case studies of the introduction and decommissioning of the grain elevator.

At the end of this section the appropriate sub-question will be answered, namely: *How can the concept of radical technological change be described and how can it be applied in the port of Rotterdam?*

1.1 Radical Technological Change, Criteria and Assessment:

Throughout history, technology has shown us a wide array of applications, all of them with a distinct impact, or lack thereof. Whereas some technologies can be rightfully argued to have been very influential in the long run, one cannot argue that all of these are thus necessarily radical in nature. This section serves to underline the concept of radical technological change and radical technological innovation and present the criteria by which to measure the extent to which a certain technological innovation can be called radical in nature.

The foremost criteria that will be set out in this section are threefold, namely: Timespan, Impact, and Precedent. These criteria have been named by me; however, they lean upon the writings of a set group of authors, namely Joel Mokyr, Hugo van Driel, Johan Schot, Wilfried Schoenmakers, and Geert Duysters.

Timespan refers to the period in which new technologies are adopted and put into practice. For a technological innovation to be termed radical this timespan cannot be overly long. If a technology is applied over a larger stretch of time, it is most likely an incremental rather than a radical technological innovation.[43]

Impact refers to the influence the new technology has on the regime that is present. The regime in this is case can be briefly summarised as the 'way of doing things', and the rules

[43] Mokyr, *The Lever of Riches*, p. 12-14.

that are adhered to, an example of this is the manual transhipment of goods that was considered the standard in the port of Rotterdam prior to mechanisation efforts.[44]

Precedent refers to the technology's immediate precursors. It asks the question whether or not the present technology is based in any way, shape, or form on previous technologies. Radical technological innovations oftentimes present a clear divergence from earlier technological applications.[45]

Timespan:

For a technological innovation to be considered truly radical the timespan in which it is applied on a large scale cannot be too long. An exact delineation of this timespan might appear difficult, and in most cases, it is in fact dependent on the situation. As a general rule it can be argued that a technological application has the possibility to be radical when its widespread application is achieved within a maximum of two years. This however is the case when there are no external factors that hamper the widespread application of the technology. Any longer period of time could point towards a more incremental process of technological innovation and thus cannot be termed truly radical in nature.

There are however some exceptions to be made to this rule. Due to (unforeseen) circumstances it might sometimes be impossible to apply a certain technology within the allotted timespan for a technological application to be termed radical. Technologies can be forgotten or only applied in a single country or port; they might thus be radically applied within the allotted two years in one case and lie outside of this criterium in another. Furthermore, attempts at applying the technology can be thwarted, for example by strikes or financial troubles, oftentimes lengthening the timespan of the introduction severely.[46]

The question remains whether or not to term these delayed introductions of technology as radical technological changes proper. The judgement regarding this should consider these external inhabiting factors and should thus treat these cases separately in order to reach a proper conclusion.

Impact:

Next, the concept of impact is essential in arguing whether or not a technological application can be considered radical in nature. Broadly speaking, this impact can refer to the effect that the application of a technology has on a variety of factors, among them shipping methods, labour regimes, as well as costs of production or shipping. When looking at technological change, impact can most effectively be gauged when looking at the concept of regime change. Regime change refers to a change in the dominant practice of doing things. In the case of a regime regarding the workings of a port this can refer to, for example, the methods of shipment and transhipment present in the port, as well as the shore-based applications that are a part of the overarching infrastructure of the port as a whole.[47]

[44] Hugo van Driel and Johan Schot, "Radical Innovation as a Multilevel Process'' p. 55-56.
[45] Mokyr, *The Lever of Riches*, p. 13-14.
[46] Wilfred Schoenmakers and Geert Duysters, "The Technological Origins of Radical Inventions," p. 1053.
[47] Hugo van Driel and Johan Schot, "Radical Innovation as a Multilevel Process'' p. 52.

Whether or not a regime is able to completely change in a short period of time can certainly be debated. It can however be argued, as van Driel and Schot have shown, that the application of certain technologies has the ability to shape a port-regime over a longer stretch of time. In order to properly apply the paradigm regarding radical technological change, cases should be analysed separately in order to gauge whether or not the regime change has taken place in the allotted time span mentioned above.

Examples of regime change in ports are ample. The most prominent example is the application of container technology in the global shipping industry. A further overview of this particular process follows bellow.

Precedent:

As Joel Mokyr has argued, radical technological innovations oftentimes arise more or less out of nothing and are thus not necessarily based on earlier technological innovations. There is however an interaction between radical, macro inventions and less radical micro inventions. Many macro inventions would not have been able to become truly radical if they were not complemented by micro inventions throughout history. Perhaps the most well-known example of this is the development of the steam engine, where the original, radical idea was still a rather rough draft which needed micro-inventions to prove viable in the long-term.[48]

This dependency on previous technologies is here termed precedent in the proposed paradigm of radical technological changes. The concept of precedent is furthermore important in gauging whether or not a technological innovation is truly radical in nature. It can be argued that this criterium is the hardest one to determine properly. Technology in itself is a highly diverse and fluid phenomenon throughout history. It can thus be argued that no single technology is wholly independent from its predecessors. This raises some problems for the concept of precedent, seeing as it implies that little to no earlier technologies are relevant in the coming into being of radical technological changes.

However, as Mokyr reminds us, the concept of a ‘first’, or be-all and end-all invention is hazardous in this context. It can be argued that, while radical technological innovations are not necessarily *based* on earlier inventions, they do derive their fair share of influence from these earlier inventions without directly borrowing or applying from them. This corresponds with the concept of existing knowledge, and the fact that radical innovations are, according to Schoenmakers and Duysters, equally based on this existing knowledge as non-radical innovations. The concept of precedence should thus not be interpreted as the total lack of inspiration from earlier innovations, but rather as a distinct application of technology in itself.[49]

Three Criteria, a Single Unifier?

Having set out these three unifying criteria it remains to be discussed if a technological application can deviate from one or more of these aspects and still be termed radical. A technological application can for example adhere to the criteria of impact and precedent but

[48] Mokyr, *The Lever of Riches*, p. 12-13.
[49] Mokyr, *The Lever of Riches*, p. 14-15 and Wilfred Schoenmakers and Geert Duysters, “The Technological Origins of Radical Inventions,” p. 1051-1053.

deviate from the allotted time span. Another combination could be a proper application with regards to timespan, but a lacking impact.

Following this, can a single criterium be singled out as being the most important in gauging whether or not a technological application can be considered radical? It is my opinion that this question is not wholly answerable for all cases, nor does it have to be. It would be wise to approach distinct cases with a single approach, however the most important criterium can vary per case. This does not discredit the criterium-based model, but rather enhances the role of one specific criterium when it is deemed the most important in arguing for or against radical technological change.

The Usefulness and Limits of the Concept:

While interesting and stimulating in itself, the concept does raise some questions regarding its usefulness in the shaping of a historical narrative. A slew of papers places the concept of radical innovation and radical technological change within the realm of businesses studies and economics, and whereas the parameters that are used in these papers are often interesting in their own right, their particular relevance to a historical narrative can be debated. The scope of the main section of this thesis is relatively narrow, both in its selection technology (the pneumatic grain elevator) as well as its location (the port of Rotterdam), nonetheless the resulting historical narrative should be compelling in its own right.

The expectation is that these three key tenets of radical technological change can be applied to the historical narrative of the two main case studies that will follow in the next chapters, namely the introduction of the pneumatic grain elevator in the port of Rotterdam, as well as the years of the decline in usage of this same machine.

1.2 Radical Technological Change in Practice

Before moving on to the case studies of the introduction and decommissioning of the pneumatic grain elevator, this section offers three other distinct case studies within the port of Rotterdam. The timespan of these case studies covers the years 1886-1970. The first case study is the increasing mechanisation of coal and ore transhipment in Rotterdam, the second case study revolves around the concepts of direct and indirect transhipment in the port of Rotterdam, the last case study focusses on the introduction of the container as a viable method of transportation for breakbulk goods.

Coal and Ore Transhipment in the Port of Rotterdam

Like the bulk of transhipment in the port of Rotterdam in the late 19th century both coal and ore transhipment were still very much dependent on manual labour. However, by the 1880s a process of mechanisation had erupted in the port itself, not always without accompanying controversy. This section serves to underline some of the most important mechanisation efforts in coal and ore transhipment during this period and aims to apply the parameters of radical technological change as set out in the previous section to these technological applications.

Starting in the 1870s Rotterdam enjoyed an unprecedented growth in freight shipped through its port. This growth was mostly confined to transit goods such as grains and ores, as well as coal from Germany. In total, the influx of goods between 1870 and 1885 amounted to an increase from around 2 million tonnes in 1870 to around 5 million in 1885. This growth continued and in 1900 around 10 million tonnes of cargo was handled throughout the port of Rotterdam.[50]

This period furthermore marks the predominance of ore and coal as the most important bulk goods in the port of Rotterdam. Of the 10 million tonnes of total cargo handled in 1900, around 3 million tonnes consisted of ores, thus forming a sizeable share of 30% of total cargo.[51]

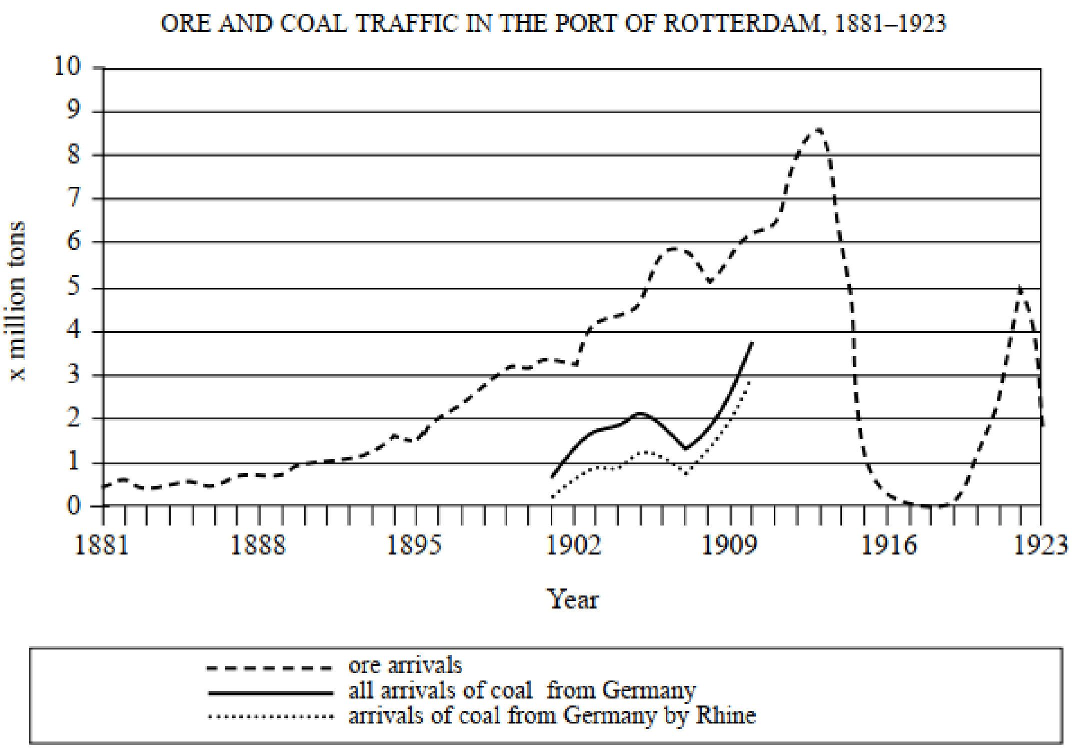

Figure 2: Ore and Coal traffic in the port of Rotterdam, 1881-1923 in Hugo van Driel, "Innovation and Integration in Mineral Bulk Handling in the Port of Rotterdam, 1886-1923," Business History 44, no. 3 (2010): p. 68.

The unprecedented growth of cargo flows during this time period provided significant challenges for both the municipality as well as private companies. One of the first companies involved in mechanisation as well as broader efforts to improve maritime infrastructure in the Feijenoord area was the Rotterdamsche Handelsvereeniging (RHV). The RHV's director, Lodewijk Pincoffs proved to be controversial, as his personal financial mismanagements jeopardised the entire company. Having been found out to have embezzled funds from the company, Pincoffs fled for the United States in 1879. This opened up the way for the municipality, which duly took over the management of the entire Feijenoord-complex in 1882.[52]

While the RHV-led Feijenoord-complex did contain some modern cargo applications such as hydraulic and steam cranes, the bulk of mechanisation took place once the municipality

[50] Van Driel and de Goey, *Rotterdam: Cargo Handling Technology*, p. 13.
[51] See figure 1.
[52] Van Driel and de Goey, *Rotterdam: Cargo Handling Technology*, p. 13.

had taken over. The year 1886 marks the first application of the hydraulic coal tip in mainland Europe at the Binnenhaven at the Feijenoord-complex. These coal tips were machines which could transport coal loads mechanically through the use of a conveyor belt-like apparatus which propelled coal forward. The structure of the Binnenhaven and the Feijenoord-complex in general however was relatively narrow and in order to accommodate increasing coal loads though the application of more coal tips the municipality decided that the construction of two more coal tips was to take place at the Katendrechtse Hoofd slightly westward. Two more coal tips as well as the first electric grab cranes were installed at the at this location in 1895-1896. Besides space for more coal tips and other mechanised applications, the Katendrechtse Hoofd boasted an artificial basin of water which was able to handle sizeable modern steam ships. Furthermore, it sported a set of railway tracks on its quays. In a period of increased coal transport by rail this proved invaluable for the success of this particular location. By 1898 the coal-tip effort had proved successful, as around 350 thousand tonnes of coal and cokes were handled by these devices throughout the entire port of Rotterdam.[53]

An important aspect of the increasingly rapid mechanisation in coal handling throughout the port of Rotterdam in the late 1880s was the role that the municipality played. Upon Pincoff's disgrace the municipality moved in and as a result also took the brunt of the risks associated with the application of machinery in the port. This is important because of the high purchase price of the coal tips at the time. The first coal tip that was installed cost the municipality over 60.000 guilders. It is unlikely that private companies would have had very much interest in purchasing such a costly machine. This is especially the case because private companies had no ownership of the quays that they conducted their business on. Instead, the municipality rented out these areas to private firms for a period of up to four years. This short-term period of rent is unlikely to have spurred private parties to invest in long-term projects such as mechanised coal tips. In the end then, one could argue that the municipality played a very important role in spurring this first wave of mechanisation towards fruition.[54]

While the coal tip effort continued steadily towards mass-adoption in Rotterdam, the aforementioned electric cranes were furthermore important. The first six electric ore cranes were placed at the newly dug basin at the Katendrechtse Hoofd in 1894, again on behalf of the municipality. The key difference from the coal tips, however, was the fact that these six electric cranes were used by a single, private party, namely the firm Wm. H Müller & Co. which had been based in the city since 1869. This particular firm was heavily involved in ore transhipment within Rotterdam, oftentimes employing their own, privately held transport ships in doing so. Furthermore, Müller & Co. had a virtual monopoly on the use of railways at the Feijenoord-complex, as well as the right to use the Dutch National Railroad Company's (Staatsspoorwegen) equipment, both locomotives and wagons. Another fact emphasising the dominant market position of Müller & Co. in the ore trade was the fact that the company themselves owned many of the ore-mines where their goods were mined and prepared for transportation.[55]

Müller & Co.'s superior position then might have spurred them to take unto themselves the chance to further improve the handling of ores, in this case through the application of

[53] Van Driel and de Goey, *Rotterdam: Cargo Handling Technology*, p. 20-22.
[54] Van Driel, Innovation and Integration in Mineral Bulk Handling in the Port of Rotterdam, 1886-1923, p. 71-72.
[55] Van Driel, Innovation and Integration in Mineral Bulk Handling in the Port of Rotterdam, 1886-1923, p 73.

electric cranes. These electric cranes were more versatile than the coal tips. They were moveable across tracks on the quay, as well as being able to continually service incoming train wagons across multiple rail tracks. Another important facet of these cranes is the fact that they could be utilised for more goods than just ores, as well as the fact that they could operate in both directions of the shipping flows, both incoming as well as outgoing.[56]

What now remains is to test the increasing mechanisation efforts in the coal and ore sector in the port of Rotterdam according to the parameters of radical innovation set out earlier in this chapter.

Following the parameters set out by the threefold model of Radical Technological Innovation and the analysis of the case study, it can be argued that the increasing mechanisation in coal transhipment can in fact be argued to have been an example of radical technological innovation.

The coal tip was adopted relatively early and became widely used in an important coal transhipment area within the port of Rotterdam (the Feijenoord-complex). By 1896, the application of the coal tip had caused the bulk of incoming coal to be handled through mechanical means. It can thus be argued that the application of the coal tip had brought about a regime change in the transhipment of coal within the port of Rotterdam, its Impact can thus be argued to have been sufficient to be called radical in nature.

Furthermore, the coal tip itself was not overly based on earlier technological applications. As mentioned before, Rotterdam was actually the first mainland European port to put the coal tip into use. It can thus be argued to have been truly radical in nature when looking at the concept of Precedence.

The last criterium that has to be considered is timespan. The timespan in which the coal tips were employed is relatively long, the first one was placed in 1886 and a second pair was only placed in 1896, after which the coal tips became more impactful on the regime on coal transhipment. Several reasons for the lack of quick construction and placement of coal tips exist, the most important of which is simply that there was not enough space at the narrow Binnenhaven to place any more than already present. When the municipality decided to place two more machines at the Katendrechtse Hoofd, a location with more space for expansion, the placement of more coal tips also became evident.

All in all, with these three factors considered, the application of the coal tips makes a solid case for being considered radical in nature. The application was relatively widespread and brought about a regime change within coal transhipment. Coupled with the fact that the technology was relatively novel, it can thus be termed a radical technological innovation.

Contrary to the coal tips, the application of electric ore cranes in the port of Rotterdam is more problematic to assess using the threefold model of radical technological innovation. As mentioned before, the six electric ore cranes placed in 1894 were only used by a single party, namely Müller & Co. Due to the nature of this company's deal with the railway companies and their control of the mines, the application of the electric ore cranes remained exclusive to only a small part of the entire ore transhipment business within the port. Because of this the impact of this technological application was hampered and remained relatively small.

[56] Van Driel, Innovation and Integration in Mineral Bulk Handling in the Port of Rotterdam, 1886-1923, p. 72-73.

On the other hand, the timespan of introduction was relatively short, with six units being put into use within the year of 1894. External factors such as the access to mines and railways might have enabled Müller & Co. to push for a quick adoption of electric ore cranes, and indeed they did just so within their own company, but not outside of it.

Regarding the precedence of the electric ore crane some brief comments can be made. First off, cranes themselves were not a new invention. However, these particular cranes were electric and powered by an electric motor which propelled the crane to the desirable direction. Furthermore, they were relatively versatile, at least compared to the rather rigid coal tips.

All in all, the case can be made that the application of electric ore cranes was not radical in nature. Whereas the timespan might allow for this innovation to be called so, the fact that a very limited amount of regime change occurred points towards a more gradual or incremental innovation rather than a purely radical one.

Direct and Indirect Transhipment in the Port of Rotterdam

Another interesting case study is the application of direct and indirect methods of transhipment in the port of Rotterdam. The first section of this part will aim to explain the concepts broadly, whereupon the narrative will focus on both applications in the port of Rotterdam and asking the question whether or not either of these methods can be called radical in nature.

The method of direct transhipment can be summarised as follows: goods are cleared from large seagoing vessels and immediately transhipped to smaller, river-going vessels such as barges. Oftentimes this happened with the aid of several technological applications, such as the pneumatic grain elevator. Upon arrival the goods are directly transhipped into the appropriate barges, hence the term direct transhipment. The method of indirect transhipment on the other hand is somewhat different in nature. Contrary to direct shipment, indirect shipment applies shore-based facilities to temporarily store incoming goods on land. After the seagoing vessel is unloaded the smaller vessels will be loaded with the temporarily stored goods and sent on its way. Seeing as the goods are temporarily held on shore and not transhipped immediately, this method bears the name indirect transhipment. As we shall see, the post-World War Two situation in the port of Rotterdam increasingly favoured the indirect option over the direct method of transhipment.[57]

During the mechanisation efforts starting in the 1880s, parties in the port of Rotterdam still mostly favoured the direct method of transhipment. Later mechanisation and improvements at the beginning of the 20th century in several different areas such as coal, ores, petroleum, and grain had enabled parties in the port of Rotterdam to establish an effective and quick regime of direct transhipment within the port. In the years after the First World War and during the Interbellum, mechanisation efforts were once again brought to the fore and were optimised even further in the aforementioned sectors of transhipment. Starting in 1927, the application of the level luffing crane in bulk transhipment caused that particular sector of transhipment to handle cargo in a more varied way. The level luffing crane after all, was able to pivot itself onto the appropriate cargo which was to be transhipped, making the process of doing so faster and more optimised. Furthermore, due to its nature as a relatively large crane,

[57] Van Driel and Schot, Het Ontstaan van Een Gemechaniseerde Massagoedhaven in Rotterdam, p. 75-76.

the level luffing crane increased the range at which cargo could be transhipped, furthering reducing bottlenecks which slowed down the process.[58]

Coupled with earlier technological applications such as the pneumatic floating grain elevator, it can be argued that a widespread, effective regime of direct transhipment had been realised in the port of Rotterdam in the period after the First World War.[59]

Besides further improvements in bulk-shipping in the period right after the First World War, there were some efforts to mechanise breakbulk transhipment as well. The broader movements of breakbulk goods within the port of Rotterdam consisted of such varied products as cotton bales, tea crates, chemicals (in barrels), and sugar sacks. The most interesting examples of mechanisation efforts in breakbulk shipping in the post-World War One years are mostly shore-based. Especially the application of equipment such as the level luffing crane as well as electrical transportation cars (which were not too dissimilar from modern-day forklift trucks) can be argued to have brought about some amount of mechanisation, and perhaps even more importantly, an increase in productivity in this sector. Despite these efforts, the regime of direct transhipment was not impacted generally, and manual labour and direct transhipment remained the norm within breakbulk shipping for the time being.[60]

It would take until the years following the Second World War before the regime of direct transhipment would decline in favour of the indirect method of transhipment. It is important to consider the factors that led to this shift from direct towards indirect transhipment. In this case-study, the Second World War, and its implications for the port of Rotterdam are perhaps one of the most important factors to consider and can be argued to have brought about a remarkable change in the way the port of Rotterdam was perceived by those in charge, as well as a change in the port regime as a whole.[61]

Prior to the Second World War, the port of Rotterdam, as we have seen, was a vibrant and effectively organised transit port in which the bulk good was the most transported type. The general character of the city was that of a *transitpolis*, a city in which the transportation of goods is held in the highest esteem and is considered one of the strongest economic factors of the city. Some amount of discussion exists on the correctness of the term, it has been opined that the term originated as an invented one in order to contrast the development of the city during the 19th and 20th centuries to the paths of development in the 17th and 18th centuries in which Rotterdam acted as a staple market and trading city. Whether or not the term is applicable lies outside of the scope of this thesis. What is clear however is that the presence of a transit port within the city itself was a great boost to employment opportunities within the city as a whole. Between 1850 and 1914 the percentual growth in persons employed in the port outpaced the growth of the population as a whole. When we look at the employment figures around the years in which an effective transhipment regime had been realised, we find that, for example in 1909, there were around 23.000 persons employed within port-related labour. This amounts to around 15% of the total employment-eligible population in the year 1909. While

[58] Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 98.
[59] Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 97.
[60] *Ibid*.
[61] *Ibid*.

not offering the majority of employment opportunities, the port of Rotterdam nevertheless offered a sizeable portion of total employment during this period.[62]

During the worldwide economic depression of the 1930 the port of Rotterdam was also hit particularly hard, however there were plans for expansion. Within the city's municipality there was widespread criticism that the port had focussed too much on bulk transhipment and should pursue efforts to attract heavy industry to the port. This would have to be realised in the form of the construction of new ports which would be made attractive for oil and petrol companies to settle. In 1934 the Eerste Petroleumhaven was finished, followed by the start of construction of the Tweede Petroleumhaven in 1939 which was delayed by the outbreak of the war.[63]

Figure 3: Aerial photo of the city centre of Rotterdam, 1945. Source: RAF aerial photographs, 1943 – 1947, no. 4228, Wageningen University.

[62] Van de Laar, *Stad van Formaat*, p. 165-166.
[63] Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 100.

During and after the Second World War the situation was wholly different. The infamous bombing of the city of Rotterdam in May of 1940 by the Germans, as well as bombings by the Allies during the war left both the city and its maritime infrastructure in disarray. During the war years, around 7 kilometres of wharfs and quays within the city limits were destroyed entirely or rendered unusable by for transhipment, this amounted to around 42% of the total. During the years after the war, these were repaired and once more made suitable to receive ships and commence business.[64]

These turbulent times themselves sparked a highly productive streak within port management. Some key players within port-related businesses, as well as the municipal council of the city saw the huge destruction caused by the bombing as a means of going forward in a different direction. A symptom of this so-called new direction was the westward expansion of several specialised ports and the gradual movement of the ports away from both the city centre of Rotterdam, as well as a further development of the southern part of the city which, as we have seen, had already enjoyed an explosive period of growth and expansion during the late 19th century.

As we have seen before the construction of the Petroleumhaven before the outbreak of the war presented an early effort for further expansion of the port. By the end of the war many more plans had been proposed and in 1947 the plan for the construction of the Botlek, southwest of the city centre, had been approved by the municipal council. During the 1950s, the Botlek was to serve as the principal petrochemical port within Rotterdam. It furthermore hosted another location of the GEM, as we will see later on. Further expansion plans were presented after the success of the Botlek, an important one of these being the council's approval for the Europoort-complex, which pivoted the scope of the port itself even further westwards. Europoort itself was to serve as an important area for refining oil and other chemicals. These expansions proved successful, and by 1962 the port of Rotterdam had become the largest in the entire world.[65]

Following this then, it can be concluded that expansion and scale increases within the port of Rotterdam in the post-war period were immensely successful and propelled the port forward as one of the most important ones worldwide. It rests now to describe the effects that the new post-war trajectory of the port had on the means of transhipment.

The post-war trajectory of port expansion in Rotterdam presents itself as much of a physical expansion as it does an expansion of sheer scale. The port of Rotterdam, following the lessons taught by the crisis of the 1930s, once again aimed to be less dependent on transhipment of bulk goods. To achieve this the new port complexes had been constructed. The scale of these complexes as well as their effectiveness is important to note seeing as it can be argued that these were essential in enabling the indirect method of transhipment. The large scale of the new port complexes enabled a significant amount of space to be devoted to storage of goods, both in the form of tanks and indoor storage facilities, and eventually containers. These port complexes then were oftentimes focussed on a single good which could thus be effectively transhipped without problem.[66]

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[64] *Ibid*.
[65] Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 100-101.
[66] *Ibid*.

Scale increases were furthermore visible in means of transportation. After the Second World War the size in tonnage of both freight ships as well as oil tankers skyrocketed. The Suez Crisis of 1957 closed the Suez Canal for passage until 1967, forcing ships to sail to Asia via the Cape of Good Hope. This route was significantly longer which forced oil companies to increase the tonnage of their tankers in order to decrease relative transport costs and retain steady profit margins. The increase in scale for oil tankers however did not present a regime change in transhipment within ports, including those of Rotterdam. The transhipment of oil and petroleum in Rotterdam had already been established by indirect means, i.e., transhipment via shore-based tanks. This was mainly due to safety concerns in handling such volatile and hazardous material.[67]

The usage of the Liberty-type ships, which were around 10.000 dry weight tonnage in the post-war period gradually made way for so-called bulk carriers which were even larger in stature, sometimes even as large as 20.000 dry weight tonnage. The increasing use of bulk carriers furthermore sparked a movement towards the indirect method of transhipment in the port of Rotterdam. The principal reason for this was that ships simply became too large to unload effectively and then tranship directly. The time needed for this direct transhipment would mean that the unloading ships would incur significant delays which would have been costly for ship operators and unloaders alike. Due to these circumstances, it was deemed that the processes of unloading ocean-going vessels and loading smaller vessels should be separated, effectively opening the way for indirect transhipment to take hold.[68]

As we have seen before, the move from direct to indirect transhipment coincided with important changes within the port business in Rotterdam. Whereas the municipality had given their approval for the construction of new, specialised ports, the companies that would lease these areas were oftentimes still dependent on the wishes of their suppliers. An example of this is the general reticence of suppliers on the other side of the Atlantic to supply goods that would be transhipped via the direct method in the port of Rotterdam. A prominent supplier of ores to the port of Rotterdam was the Hanna Mining Company from Cleveland, Ohio. In the 1950s this company had unearthed new ore deposits in the Canadian provinces of Quebec and Labrador, where the climate was harsh and could cause major problems for shipping. The weather in the period between November and April was so harsh that shipment of ores became almost impossible, the material would simply freeze to any receptacle transporting it. The company then, decided it would simply not ship during these months. The remaining time of the year that ores could be supplied thus presented parties in the port of Rotterdam with massive loads coming in, virtually forcing them to construct proper storage facilities. Coupled with this was the fact that the Hanna Mining Company was employing even larger ships, most which were around 30.000 dry weight tonnage. Hanna argued that if was virtually impossible to unload these ships through the usage of the conventional, direct practice.[69]

Following a 1956 visit to the port, Hanna executives and engineers were also less than impressed with the equipment at work in the port of Rotterdam, especially the grab cranes,

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[67] Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 101-102.
[68] *Ibid*.
[69] Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 102-103.

which they argued were ineffective due to the fact that they could not be employed alongside all incoming ships effectively. They furthermore criticised the 'shifting' method in which smaller vessels had to be placed correctly alongside seagoing vessels to evenly spread goods in their holds. This was considered too slow. The delegation pondered the situation for twenty minutes and could only spot one grab crane in effect.[70]

Hanna's comments might be unnecessarily harsh in nature or simply untrue. Contemporary records show that by 1956 level luffing cranes made up 132 of the 272 total quay cranes, by 1962 this had risen to 321 out of a total 372 cranes. Furthermore, around 80 per cent of bulk goods were discharged using the shore-based cranes. These figures would hardly indicate an inefficient regime of transhipment within the port of Rotterdam. It is more likely that Hanna wanted to move towards indirect transhipment quickly in order to lower costs and because they were not able to ship their goods during the winter months. These perceived interests then, might explain why the company's judgement of the Rotterdam port facilities was overly harsh.[71]

Next to supply-side difficulties, demand-side parties were also reticent about continuing to support the system of direct transhipment. The German smelting companies who bought ore that was shipped to the port of Rotterdam lacked the ability and perhaps the wish to properly store large amounts of ore that would come in at their facilities if direct transhipment would be continued. Instead, they argued that ores should be shipped to and stored in the port of Rotterdam, whereupon they themselves could send appropriate vessels to pick up the ores as needed.[72]

Eventually, the companies, of which Müller & Co. was the most prominent acquiesced to the demand of both the suppliers as well as the clients. An important aspect of this might have been that the Müller & Co. was the most prominent agent of Hanna on the European mainland and did not wish to anger their most important supplier and the company to which they had been dependent.[73]

These two distinct difficulties, coupled with the aforementioned changes in ship size and the different function of the ports of Rotterdam during this period are paramount in explaining why and how indirect transhipment came to be favoured over the direct method. What rests now is to analyse whether or not this change from direct to indirect transhipment can be considered a radical technological innovation.

This analysis offers some difficulties. First and foremost, it can be argued that the concepts of direct and indirect transhipment are not necessarily a technological innovation per se. However, there is some degree of interplay between the application of technological means and the transhipment regime that is applied. Both indirect and direct methods of transhipment rely heavily on the application of certain technologies, be they related to unloading or storage. Following this then, it follows that we can look at the technologies at play when the regime of transhipment in the port of Rotterdam changed from a direct one to an indirect one. All in all,

[70] *Ibid*.
[71] Van Driel and de Goey, *Rotterdam: Cargo Handling Technology*, p. 50-51.
[72] Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 102-103.
[73] Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 102.

as we will see shortly, the transformation towards direct transhipment cannot, according to the parameters of the threefold model, be seen as a radical technological innovation or change.

Regarding the timespan of the aforementioned change, it can be said that the change from direct to indirect transhipment was by no means immediate. It concerned processes of negotiation and compromise which multiple parties had to acquiesce to. Coupled with this is the fact that not every sector of transhipment would be applying indirect transhipment at the same moment. As we have seen, transhipment of ores would eventually come to adhere to the indirect method, the breakbulk good as well as grains would only follow later, in the 1960s. All in all, it can be argued that the timespan was significantly longer than the period set out in the threefold model of radical technological change and can thus be argued to have not been radical in this respect. When one looks at the application of indirect transhipment in general, one finds that, as has been noted before, there were sectors in which direct transhipment was already applied long before the post-war years. When we consider this, we find that the concept of timespan cannot be considered adherent of radical technological change in this case.

The concept of precedent presents another interesting viewpoint of this situation. As mentioned before, the loading and unloading of oil tankers had already proceeded using indirect methods of transhipment, it had been like this since at least the late 1880s. In this sense the application of indirect transhipment in other sectors such as bulk and breakbulk goods presented an already known formula. The concept of direct transhipment as it would come to be applied was nothing new. It simply presented an altered way of transhipping goods. Some key differences of course, exist, however the end goal remains the same, tranship the goods as efficiently and as rapidly as possible. The difference this time around was the fact that goods would first be stored on the shore, whereupon they would be loaded onto the appropriate vessel. This hardly represents a radical break with past manners, it can even be argued that indirect transhipment and direct transhipment are in some way or form based on each other. It lies outside the scope of this thesis to analyse older methods of transhipment and argue for one of these methods to have been the first to be applied in the port of Rotterdam. However, this distinction does help us in arguing that, when concerning the application of the indirect or direct method of transhipment, precedent was so overly strong that it can be argued that neither application presents a radical technological change when weighed with the concept of precedent as set out in the threefold model of radical technological change.

Regarding regime change there are some important pointers to be discussed. Firstly, in the earliest application of indirect transhipment in the oil and petroleum sector in the port of Rotterdam there is no radical regime change to be noted. Suppliers shipped petroleum in tankers, and this was simply the regime as it stood and came to be accepted in transhipment within the port of Rotterdam. Due to the relative novelty of the sector in general, it can be argued that the regime of indirect transhipment in petroleum was not a change in an existing regime but rather a construction of a regime in general. In this case the term regime change is not applicable.

The shift from direct to direct to indirect transhipment in bulk shipping however does present a regime change that has endured unto this day. However, this regime change cannot solely be attributed to technological innovations only. As mentioned before, the arising of an effective regime of indirect transhipment had varied reasons, perhaps chief among them the unique post-war situation in which the port of Rotterdam had to adapt itself to changes in ship size, supplier demands, as well as consumer demands. This necessitated the change in regime; however, this was not caused by technological applications per se. We can conclude that, whereas the regime did change, this was mostly not due to technological means, but rather due to the situation on the ground.

All in all, it can be argued that while the case study of change from direct to indirect transhipment in the port of Rotterdam is a very interesting one, it does not present us with a clear-cut example of radical technological change in general.

The Container Revolution in the Port of Rotterdam

Next to the increased application of indirect transhipment throughout the port of Rotterdam another development demands attention, namely the application of the shipping container as the main method of shipping breakbulk goods. This story can be interwoven with the shift from direct to indirect shipping starting in the 1950s, especially because the widescale application of the shipping containers in the port of Rotterdam marked the shift from direct to indirect transhipment in the breakbulk good.

Due to the scope of the present subject only a short overview of the development of the shipping container will suffice. Afterwards, the role of the shipping container in the port of Rotterdam will be analysed according to the parameters set out in the threefold model of radical technological change.

Whereas the shipping container became known for its worldwide service in international shipping via sea, its beginnings were less conspicuous. At first, shipping containers were fitted unto standardised train wagons and were used to ship goods via rail throughout, especially in Europe. The concept of shipping in boxes or other receptacles was also nothing new. As we have seen goods such as tea were already shipped in wooden crates in the port of Rotterdam and elsewhere. Furthermore, large wooden boxes were also utilised in rail transport in Europe earlier in the 20th century.[74]

The trajectory of development in the United States, however, was different. In the post-World War Two years 'the box', which by 1949 had come to resemble the modern shipping container, was utilised effectively in road transport by truck. This corresponds with a general switch from rail-based transport towards road-based transport by truck in the United States in the years after World War Two. One particular character of note is Malcolm McLean, who founded a trucking company called the McLean Trucking Co. in 1935 and started to apply containers on his trucks. Eventually he came up with the idea to ship these trucks on the ships, which sailed routes along the United States' east coast, whereupon they could continue their journey overland and unload the containers at their destination. McLean argued that this that this would ease the unloading process and, of course save costs by reducing petrol use. These so-called trailer ships were ineffective in large part because a lot of space was wasted on harbouring the trucks within their holds. Legal troubles were also paramount, the Interstate

[74] Marc Levinson, *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*, Second Edition (Princeton: Princeton University Press, 2016). p. 38.

Commerce Commission, or ICC, mandated that shipping and trucking businesses were to remain separate, and argued that McLean had overruled this boundary by combining the two.[75]

When the ICC ruled against McLean's efforts in shipping trucks on ships, the company decided to cease its trucking efforts and continue purely as a shipping enterprise. Having set up a new shipping company called Pan-Atlantic, McLean bought and converted a World War Two oil tanker called the Ideal X which started operations on April 26th, 1956. Its maiden voyage after the conversion, from Newark, New Jersey, to Houston, Texas, elicited widespread attention, and McLean himself flew out to Houston to watch the ship arrive safely. The first container voyage can be considered a success, having been able to load a container every seven minutes, with a total of seven hours loading for the entire ship to be filled, perhaps the most important distinction between container shipping and the previously established loose shipping were the costs. In order to ship loose cargo onto a medium-sized cargo ship the costs were around 5.83 dollars per tonne in 1956. The container effort however, provided a staggeringly different picture, McLean's containers could be loaded onto a ship for as little as 15.8 cent per tonne, an economisation of over 99 per cent. It quickly became clear that with numbers like these, container shipping might have a future.[76]

It was however clear that, in order for a worldwide container revolution to be successful, costs were not the only factor to be considered. The whole maritime infrastructure had to be adapted to accommodate containers and container ships. This included cranes, quays, ships, storage facilities and trucks. McLean was one of the first entrepreneurs to realise this, and promptly adjusted his business practice in order to suit this approach. As we shall see, the eventual worldwide phenomenon had its roots in this approach by McLean's Pan-Atlantic, which would be renamed to the more familiar Sea-land in 1960.[77]

An interesting connection then, is to be made to the eventual worldwide distribution of container shipping. In 1965, the International Standardization Organization (ISO) reached an agreement that stipulated standard, worldwide sizes and measurements for containers, meaning that there was now a worldwide system of measurements which was one of the prerequisites of successful container shipping. Standard sizes would come to be 20 and 40 feet in length, with a height and breadth of 8 feet. Having cleared this hurdle, major U.S. shipping companies, among them Sea-Land and Moore-McCormack first aimed to introduce transatlantic container shipping in 1966. Among their prospective European ports of call was Rotterdam, the director of operations for the municipal port company, Frans Posthuma was increasingly enthusiastic about the prospects of container shipping, especially those of Sea-Land, and the role Rotterdam would be able to play. Posthuma's argumentation mainly revolves around the increased competitiveness the port of Rotterdam would be able to offer on the shipping market when it would adopt containers early. As we have seen before, by 1962, the port of Rotterdam had grown to be the largest port in the world, and the prospect of adding to this stature must have been quite appealing to those in charge.[78]

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75 Levinson, *The Box*, p. 51-55, 64-65.
76 Levinson, *The Box*, p. 68.
77 Levinson, *The Box*, p. 70-71.
78 Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 108-109.

The Rotterdam-based stevedores, however, were less than enthusiastic about these plans. Their prospects were those of large investments, and thus of large debts. Significant investments would have to be made in further improving and optimising materiel and shore facilities in order for container shipping to be effective in the port of Rotterdam, and many stevedoring companies saw these challenges as insurmountable. Two prominent companies, however, did see the container as an unprecedented opportunity for further growth and competitive strength, these were Thomsen and Quick Dispatch. Both companies would play a pivotal role in the establishment of the Europe Container Terminals (ECT) in 1966. Upon its completion, the ECT was in fact one of the first of its kind on the European mainland, which serves to indicate that the port of Rotterdam was relatively swift in its adoption of container shipping. This did not however arise without quarrel. Whereas the aforementioned two companies were wholly in favour of containerisation, a key group of three other companies resisted. These three, Müller, Pakhuismeesteren and Cornelis Swarttouw set up an alliance against Thomsen and Quick Dispatch at the start of 1966. This eventually proved futile when, later that year, Posthuma practically forced the companies to come to an agreement, which they did when the ECT was definitively established in October of 1966, with an agreement signed by all companies as well as the National Railways (NS).[79]

Having successfully set up the ECT at the investment of 60 million dollars, in the early period logistics remained tenuous. In fact, it proved somewhat of an improvisational situation. At first, the maritime infrastructure was not optimised for the arrival of large container ships, furthermore, the terminal had only one crane to unload the ships. In some cases, this situation could be improved due to the fact that some Sea-Land ships had built-in cranes on deck and could thus unload their own containers. Notwithstanding, it took some years before the ECT was running at full capacity and with proper optimisation. This is partly due to the fact that the ECT itself was not generally very much involved with bringing about innovation in unloading and general transhipment. Despite this, early numbers were encouraging. In 1969, only three years after the opening of the ECT, Rotterdam was already the third-largest container port in the world on a tonnage per annum basis, only trailing New York/New Jersey, and Oakland.[80]

Despite the far-reaching consequences of container shipping on the fabric of the port, resistance was minimal in Rotterdam. This situation is entirely different when one looks at the protests and strikes against the introduction of the container in American, British, and Australian ports, or for example the introduction of earlier mechanisation efforts such as the pneumatic grain elevator in Rotterdam. A key factor of this is the difference in labour relations between these nations. Firstly, Dutch labour unions actually had a positive outlook to the introduction of containers, the same cannot be said of their American and British brethren, here the reaction was negative overall. Whereas the Dutch labour unions saw the introduction of the container as a means to improve labour conditions and were furthermore not worried about labourers losing their jobs, the situation in the United States and the United Kingdom was very different. These countries did at first suffer from personnel lay-offs due to the introduction of the container in their ports. Lay-offs did follow later on in Rotterdam, in 1967 for example, against which the 1970 strike was an effective protest. However, these strikes did

[79] Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 109-110.
[80] Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 111. and Levinson, *The Box*, p. 281.

not aim to protest against the container, rather it aimed itself at more general employment opportunities for maritime labourers.[81]

Having sketched the situation surrounding the introduction of container shipping, it thus becomes possible to analyse whether or not the introduction of the container can be seen as a radical technological innovation/change. This analysis will once more adhere to the threefold model as set out previously. Following this, as we shall see, the introduction of the container in the port of Rotterdam can certainly be seen as an example of radical technological change.

Regarding timespan the following can be argued. The introduction of the container proper happened relatively quickly, especially in Rotterdam. During its introduction on the West Coast of the United States, the container certainly knew experienced some problems. The initial plan to ship trucks with containers on them on the ships themselves was deemed illegal by the relevant authorities, and other methods needed to be utilised. McLean's shift towards a purely shipping-based company served this purpose well, it allowed the company to introduce containers on its liners relatively quickly. When these liner services went Transatlantic and would thus come to visit Europe's most prominent ports, they brought the containers with them. Rotterdam and its port authorities were very much open to this, and labour unions had no quarrels with containerisation. These favourable conditions, combined with the cost-saving opportunities containerisation brought with it allowed for containers to quickly take hold in the port of Rotterdam. When looking at timespan then, the container certainly presents a case for radical technological change.

The concept of impact furthermore shows signs of radical technological change taking place. The nature of breakbulk goods in the port of Rotterdam was long dominated by transport and storage in crates, sacks, boxes, et cetera. The introduction of container shipping changed all this. The huge investment made in the ECT is all-telling, it shows Rotterdam's forward look in accepting that containers brought huge potential for international shipping with them. Upon the arrival of the first container ship in the port of Rotterdam and the completion of the ECT, containers brought in the largest share of Transatlantic breakbulk goods. It also solidified a uniform regime of loading and unloading breakbulk goods. The lack of organised protest against the introduction of containers must also have helped ease the transition and solidify its position as an effective manner of dealing with breakbulk goods. All in all, then, the new regime of containerisation quickly took hold of the port of Rotterdam. The regime of breakbulk shipping in the port of Rotterdam did undergo a transformation or change that can most certainly be called radical in nature.

Lastly, the precedent of the container is interesting to look at. The container was not necessarily a new invention; however, its form did change through the years. Standardised containers were used in the years after World War Two, especially by American vessels transporting goods to Europe and Asia. Thus, it was also used during the Korean War (1950-1953). The currently used form originated in 1949, in Spokane, Washington. While there was some precedent, the sheer scale of use during the Container Revolution was very much different than the period before it. Originally, the largest user of containers was the United

[81] Van Driel and Schot, Indirecte Overslag en de Komst van de Container, p. 110.

States Military, afterwards the use shifted towards private companies. This also marks a shift in use, enabling the container to spread further around the globe.

All in all, then, having looked at the threefold aspects of radical technological change, the container presents us with a clear example of radical technological innovation as well as radical technological change in practice.

Figure 4: Start van de transatlantische containerdienst van de Atlantic Container Line, Collectie Ary Groeneveld, 10313, Stadsarchief Rotterdam

1.3 Conclusion

To answer the appropriate sub-question: *How can the concept of radical technological change be described and how can it be applied in the port of Rotterdam?*

The answer, like the model of radical technological change itself, is multifold. What arises from these three case-studies is an inherent focus on transhipment within the port of Rotterdam, this is the sector in which radical technological change is most likely to arise. The concept of radical technological change has been described using three aspects, timespan, impact, and precedence. Each of the three case studies described can be analysed using these three aspects. Each case study shows that the concept of timespan is oftentimes not the most important aspect in gauging whether or not a technological application is radical in nature. The concept can oftentimes be overruled by one of the other ones, especially the concept of impact. This particular concept then, presents itself as very important when looking at the concept of radical technological change within the port of Rotterdam. Due to the very nature of this port and its prominent transhipment sector, it arises that the most important technological changes that are perceptible take place within the regimes that are adhered to.

We have analysed three case studies: mechanisation efforts starting in the late 1800s (coal tip and electric ore crane), the change from direct to indirect transhipment, and the application of containers. Of these only the coal tip and the container have been found to have been a radical technological change. The electric ore crane did not bring about a full-fledged regime seeing as its use was limited to a single complex and a single company. The shift from a regime of direct towards indirect shipment does show aspects of radical technological change, however this was more due to external factors, rather than the nature of the technology itself.

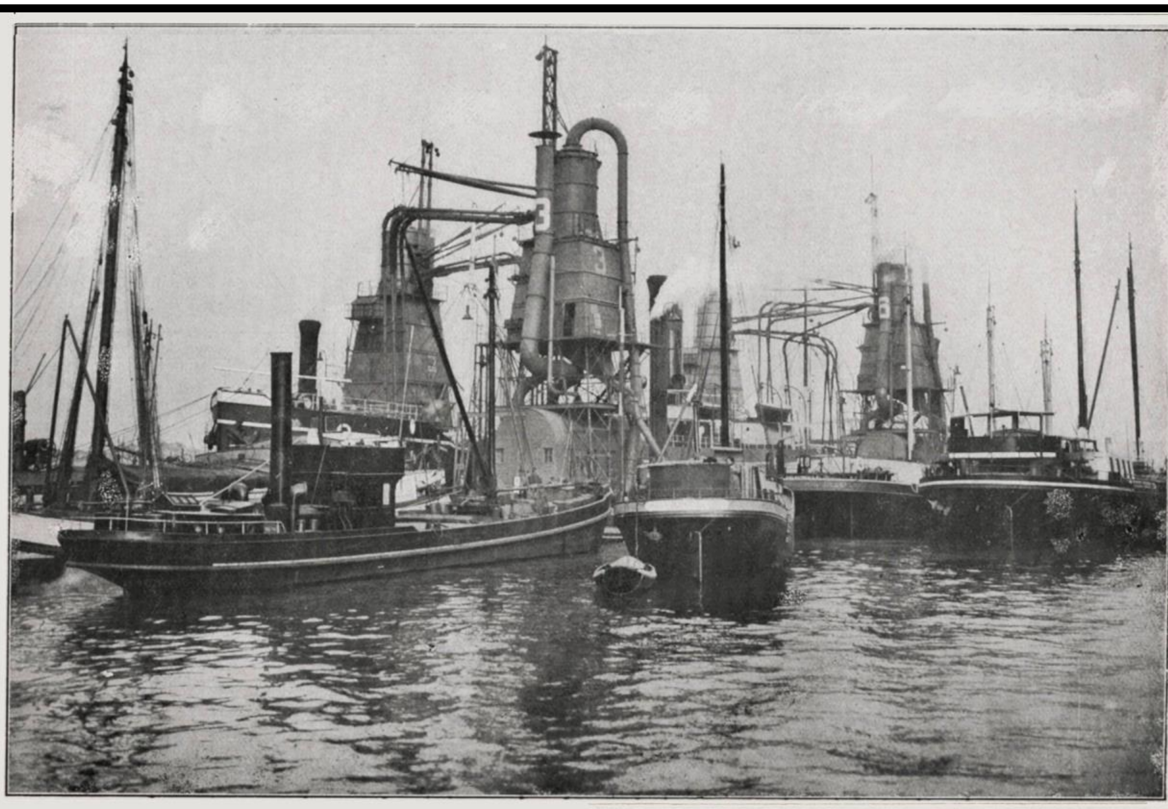
It thus remains that only the application of the coal tip as well as the container present us with clear examples of a widespread regime change in the port of Rotterdam and can thus be termed radical in nature.

Having sketched out the general context of technological innovations in the port of Rotterdam it becomes possible to look both the introduction as well as the decommissioning of the pneumatic grain elevator.

Chapter II:
The Introduction of the Pneumatic Grain Elevator in the Port of Rotterdam

As the title suggests, this chapter aims to give an overview of the introduction of the pneumatic grain elevator in the port of Rotterdam. The first pneumatic grain elevator in the port of Rotterdam was put to work in 1905, however as will become clear, this did not come to pass without rigorous resistance by several interest groups, among them dockers and weighers. The introduction of the pneumatic grain elevator thus presents an interesting case-study for the interactions between labourers and technological improvements, as well as those between labourers and employers.

There are several interesting first-hand accounts of this tumultuous time, and these will be used accordingly. However, it rests to define the introduction of these machines along the parameters of Radical Technological Change as set out in chapter I of this thesis. In order to do this a research question has been compiled, namely: *Did the introduction of the pneumatic grain elevator in the Rotterdam port constitute radical technological change?* This research question will be answered in the conclusive section of this chapter.



De schepen, die het graan van overzeese gewesten aanvoeren moeten snel gelost worden. De drijvende elevators zuigen ongeveer 200 ton per uur uit het laadruim en storten die in de lichters. Tegen het gebruik van deze machines kwam aanvankelijk veel verzet, omdat de handwerkers vreesden verdrongen te zullen worden. De bedrijvigheid nam echter door deze moderne installatie zo toe, dat juist meer arbeiders in de haven werk vonden.

Figure 5: Pneumatic Floating Grain Elevators in the Port of Rotterdam, Stadsarchief Rotterdam.

2.1 Early developments and the delegation visit of 1901:

As mentioned earlier, 1905 marks the first year of employment for the pneumatic grain elevators in the port of Rotterdam. However, earlier noteworthy developments deserve attention.

The pneumatic grain elevator was not a wholly new invention. In fact, it was to a certain extent based on traditional grain elevators that were mostly used in the United States starting in the late 1800s. These so-called bucket elevators were not mechanised and furthermore did not utilise steam power in order to propel the contents into the awaiting ships.[82]

A brief period of employment of these traditional grain elevators in the port of Rotterdam did in fact take place in 1882, by the Rotterdamsche Ballast Maatschappij, but this proved less than successful. Both labourers and transporting companies were opposed to the application of these bucket elevators and labour strikes and shipping disputes were rampant during this period. The historical documentation on this period and on the Rotterdamsche Ballast Maatschappij, compared to introduction of the pneumatic grain elevators, is scant, however there are some indications that the elevators themselves were burnt down in an act of arson not long after they were put into use.[83]

Later on, in 1896 another attempt followed, this time by the Nederlandsch-Amerikaansche Stoomvaart Maatschappij, better known under its the name Holland America Line (HAL). The HAL's attempt complimented their existing market share in grain shipment. On their return journey ships employed by the HAL would bring grain from the United States towards its European home port of Rotterdam. Significant changes in both the nature of shipping as well as changes in the grain industry in the United States prompted the company to adopt bucket elevators. Two main reasons for the adoption of the bucket elevators can be discerned. Firstly, starting in the 1890s, newly constructed ships became much larger than before, leading to efficiency bottlenecks during handling in ports. Secondly, due to changes in the United States grain market grain was no longer shipped in burlap sacks but instead shipped loose in ship holds. These changes in shipping as well as handling led the HAL to believe that the old regime of manual labour was untenable.[84]

While the application of bucket elevators in 1896 was relatively successful it did not lead to a general regime change in the port of Rotterdam. Around the turn of the century only two companies, the aforementioned Holland America Line and the Nederlandsche Veem actually utilised bucket elevators, the latter company having installed a unit in 1900.[85]

The real impetus towards the mechanisation of the grain trade in the port of Rotterdam however, started in the year 1901. This year marks the visit of representatives of the German company Verein Deutsche Handellsmüller, which was a German importers' organisation. The Verein had been in contact with another German company called G. Luther from Braunschweig

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[82] William J. Brown, *American Colossus: The Grain Elevator, 1843 to 1943* (Brooklyn: Colossal Books, 2015). 55-63.
[83] Hugo van Driel and Johan Schot, "Het Ontstaan van Een Gemechaniseerde Massagoedhaven in Rotterdam," in *Techniek in Nederland in de Twintigste Eeuw. Deel 5. Transport, Communicatie.* (Eindhoven: Stichting Historie der Techniek, 2002), p. 89.
[84] Van Driel and Schot, *Het Ontstaan van Een Gemechaniseerde Massagoedhaven in Rotterdam*, p. 89-90.
[85] *Ibid*.

(Brunswick). This particular company had developed a working pneumatic (floating) grain elevator which had already been deployed in several German ports, among them Hamburg and Bremen. Luther had received the patent to produce pneumatic floating grain elevators on the European mainland from F.E. Duckham in 1896. Duckham's design was first utilised in Millwall, London, by the Millwall Dock Company, where it quickly proved successful.[86]

Interestingly, the most prominent delegate from the Verein, F.W. Meyer was also a member of the board of commissaries of G. Luther. His son Willy Meyer worked as an engineer for that same company. These lobbying efforts proved unsuccessful when the Verein approached the HAL, who were ultimately uninterested in pneumatic elevators. A more successful attempt followed when the Nederlandsche Veem was approached. J.C. Smalt, one of the most prominent commissaries of the company was interested in the prospect of this machine. Smalt was so enthusiastic that he immediately set himself upon studying the detailed drawings and plans that had been brought by the delegation.[87]

Smalt furthermore remained in contact with Meyer, who was also active as director of the Wesermühle, a grain supplier in Hameln, Germany. Meyer reassured Smalt that elevators had already been purchased at Emden, and that there were plans for purchase in Antwerp as well. Especially the prospective Antwerp purchase could have been the final impulse for further negotiation of purchase for grain elevators. The ports of Antwerp and Rotterdam had shown what can be described as no less than a competitive streak in recent history. It is thus not outside the realm of possibilities that the message regarding Antwerp's interest in the machine served to quicken the pace of negotiations for an order of elevators to be completed.[88]

This impulse, however, does not seem to be paramount, as Smalt had already set up an extensive tour of Germany, where he would see the machines in use and gauge interest in the machine from prominent grain importers and miller companies, as well as collect the funds necessary for purchase. Smalt furthermore reported that the visit had confirmed to him that 'the floating elevators will come to Rotterdam; if we don't introduce them, it will certainly be done by others.' This comment seems to present the coming of the elevator as insurmountable. Smalt's reasoning seems clear enough, why shouldn't his company be the one to introduce them in Rotterdam and reap the benefits? After visits to Cologne, Duisburg, and Mannheim, Smalt managed to collect 50.000 Deutschmarks from the West-Deutsche Müllerverein in Berlin. This sum proved disappointing since it was not enough for the purchase of an elevator. Meyer seemed to have exaggerated his influence on the importers and was out of the picture by the time the elevators were installed in Rotterdam.[89]

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[86] *Ibid*.
For Duckham's original patent see F.E. Duckham, "Grain Appliances at the Millwall Docks," *Minutes of the Proceedings of the Institution of Civil Engineers* 125, no. 1896 (1896): 296–309, https://doi.org/10.1680/imotp.1896.19523.

[87] Charles Albert Cocheret, *Het Elevator-Bedrijf in de Rotterdamsche Haven 1908-1933* (Rotterdam: Nijgh & Van Ditmar, 1933).p. 14-16.

[88] Cocheret, *Het Elevator-Bedrijf in de Rotterdamsche Haven 1908-1933*, p. 15.

[89] *Ibid*.
For Smalt's report see Van Driel and Schot, "Radical Innovation as a Multilevel Process'' p. 65.

Smalt then, provides an interesting person in the sense that he was both a stakeholder in the port as well as the fact that he held a position of power within a prominent Rotterdam-based company, and could thus be influential in bringing the pneumatic grain elevator to fruition in Rotterdam. Smalt's role should not be underestimated, nor should he be considered as the prime mover in the introduction of the pneumatic grain elevators in the port of Rotterdam. Cocheret, in his 1933 work on the GEM and its predecessor said as much. He aimed to compose a book that was not, in his own words, a hagiography of Smalt ('geen persoonsverheerlijking nastreven').[90]

This seeming lack of complete agency is evident in other factors at play. The aforementioned delegation visits as well as Smalt's negotiations at first proved unsuccessful, especially because of the limited amount of capital he could expect from German importers to bring the elevator plan to fruition. Back home in Rotterdam, there were also doubters regarding the project. This shows that, while Smalt was indeed an important figure, the effort could not succeed by his efforts alone.

2.2 The purchase and delivery of the elevators, the Maatschappij tot Exploitatie van Drijvende Elevators:

While the first rounds of negotiation were relatively unsuccessful, a change came in 1903. During the first round of talks, the demands of the Germans were found unnecessarily strict, especially the demands of Meyer Jr. were deemed unrealistic. Coupled with this was the generally unruly situation in the Netherlands itself, where series of labour strikes broke out in early 1903. When the situation subsided in October of 1903, the negotiations proved more successful. An offer was made for purchase of two pneumatic floating grain elevators which could handle 150 tonnes of grain per hour, at a purchase price of 360.000 Deutschmark a piece.[91]

It thus became a top priority for Smalt to attract capital in order to purchase the elevators, as well as set up a joint-effort company in order to operate and apply the elevators in the port of Rotterdam. The preliminary meeting took place in January of 1904, with such companies as the Holland-America Line, Ruys & Co., and Van Ommeren sending representatives to the meeting. Also present was Antoine Plate, who was at that time chairman of the Chamber of Commerce (Kamer van Koophandel). A committee was set up in order to research the viability of the elevator project. Just fourteen days later the commission competed its report and argued that the purchase and appliance of pneumatic grain elevators was to be deemed pivotal in the context of a modern and sizeable port such as Rotterdam. Any eventual quarrels then, should be dealt with accordingly, and were not regarded as insurmountable.[92]

Having delivered its report, and a positive one at that, the committee furthermore argued that a lowering of transhipment costs from 70 cents per load to 60 cents would be enough to persuade stevedoring companies to support the elevator effort. Labour relations

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[90] Cocheret, *Het Elevator-Bedrijf in de Rotterdamsche Haven 1908-1933*, p. 9.
[91] Cocheret, *Het Elevator-Bedrijf in de Rotterdamsche Haven 1908-1933*, p. 17.
[92] Cocheret, *Het Elevator-Bedrijf in de Rotterdamsche Haven 1908-1933*, p. 18.

were also pivotal in making this decision. The committee argued that, where there would in all likelihood be resistance against the introduction of the elevators, the long-term prospect of this machine would actually prove a positive development for the labourers themselves. They would enjoy a safer and less labour-intensive working environment, and would under no circumstances lose their livelihoods, the labourers after all, were still needed to operate the machines.[93]

The advice of the committee spurned action on the business side of things. A little over a year later, several prominent Rotterdam-based companies would join together and establish a company that would exploit the pneumatic floating grain elevators for use in the port of Rotterdam. Twenty shipping agents each took a share amounting to a thousand guilders in the company. The Nederlansche Veem took twenty-four of these same shares. The stevedoring company Thomsen & Co. took ten. Furthermore, some private persons, among which Antoine Plate and Smalt respectively took three and five shares for their personal portfolios. A notable absentee was the Holland-America Line, who did not take any stock in this newly established company and would not take part in its efforts. All in all, the company took in 231.000 thousand guilders of share orders by March of 1904, the remaining 19.000 guilders would be raised during that day's meeting. Nederlansche Veem, being the largest shareholder with 38 shares, would be tasked with delivering the inaugural board of directors. It was thus that the Maatschappij tot Exploitatie van Drijvende Elevators (henceforth referred to as Elevator Company) was officially founded on the 7th of June 1904.[94]

The order for two elevators at A.G. Luther meanwhile, had come through successfully. Eventually, after some delays in which the elevators were deemed to be not ready for work yet, the two German-made elevators were finally delivered in July of 1905. The first of these machines was put into actual use in August of that year. The grain transhipment sector in the port of Rotterdam was by no means unimportant in the years in which the first elevators were put into use. In 1905, there were around 2.000 people employed in grain transhipment within the port of Rotterdam, these also included weighers and unloaders. It is estimated that the entire port of Rotterdam in the years between 1905 and 1914 employed between 10.000 and 14.000 persons in total. Labourers involved within the grain trade then, made up at least 20 per cent of total port labour. This is a share that is not negligible and might explain why the introduction of the pneumatic grain elevator proved so controversial.[95]

One can surmise that, while the elevators might have seemed daunting for labourers, their initial labour-reducing promise was relatively slim. All in all, the two elevators put into use in 1905, according to Smalt, were only able to handle around ten per cent of total incoming grain shipments. Smalt maintained that this setup was meant to not overly upset the labourers, a strategy that would, as we shall shortly see, backfire almost immediately.[96]

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[93] Cocheret, *Het Elevator-Bedrijf in de Rotterdamsche Haven 1908-1933*, p. 18-19

[94] Cocheret, *Het Elevator-Bedrijf in de Rotterdamsche Haven 1908-1933*, p. 20-21.
Voogd, *De Graanelevators En de Gisting in Het Havenbedrijf Te Rotterdam*, p. 5.

[95] Van Lente, ''Machines and the Order of the Harbour'', p. 83.
Van Driel and Schot, "Radical Innovation as a Multilevel Process'' p. 52.

[96] Van Driel and Schot, "Radical Innovation as a Multilevel Process'' p. 68.

2.3 The first elevator strike and its consequences:

Despite Smalt's claim that the elevators could only handle a fraction of total gain transports, the machines showed great promise for both the grain importers as well as the Elevator Company which was responsible for transhipment. The pneumatic floating grain elevator was able to handle 150 tonnes of heavy grains per hour, it furthermore contained a self-weighing mechanism to determine the weight of the grain that would be transhipped. The promise of the elevator is evident in its labour-saving capabilities. A skilled crew of 126 would need around seven or eight days to unload 6000 tonnes from a ship, when using two pneumatic elevators, each with a crew of 14, the job would take only two days. This constituted a huge reduction in labour input, amounting to 94 percent.[97]

Disaster however, struck almost immediately. Even before the initial period of introduction, the elevator had already been lambasted by its critics, and labelled 'the Breadrobber'. A satirical poem against the elevator was composed and published. The poem presented the elevator as unnecessary and dangerous for the livelihoods of the labourers. The elevator was furthermore described as being some kind of capitalist ploy that could be used to funnel all the profits to the bosses, something which the labourers would not profit from. Next to this early resistance, another important factor should be considered. During the first months of employment, one of the automatic weighing systems within the elevator malfunctioned, the indication of weight indicated being much too high. This proved to the spark for widespread turmoil and strike, and on the 4th of November, the labourers laid down their work under the slogan '*weg met de elevators'* (elevators begone). That the weighing apparatus would malfunction is in itself rather strange, A.G. Luther had provided multiple elevators to several customers, every one of these elevators was deemed to weigh correctly, that is within an acceptable margin of error. It does seem a stroke of bad luck in this case, but it had far-reaching consequences.[98]

When the automatic weighing mechanism failed the pneumatic grain elevator had only just been deployed. This did nothing to alleviate the intensity of the ensuing strike. In the end the conscious and deliberate choice was made to revert to a manual weighing mechanism, thus sacrificing one of the innovative aspects of the elevators. This served to placate the traders (i.e., grain importers) as well as the labourers, especially the weighers. It did however cause further a delay, seeing as the installation of manual scales would take another one and a half month. This delay served the opposition well, being able to organise themselves while the scales were being installed. At the forefront of the strike were the aforementioned weighers, a group of relatively skilled labourers who enjoyed an elite position in the grain industry and were thus one of the groups which saw their livelihoods threatened the most by the introduction of the elevator. All 450 weighers laid down their work on the 4th of November, forcing the grain importers to make serious concessions. In order to end the strike, the importers conceded not to accept grain

[97] Van Driel and Schot, "Radical Innovation as a Multilevel Process'' p. 62-63.
[98] Van Lente, ''Machines and the Order of the Harbour'', p. 89.
Voogd, *De Graanelevators En de Gisting in Het Havenbedrijf Te Rotterdam*, p. 10.
For the poem see De Does, Jubileumeditie 75 Jaar GEM, 1983, p. 10.

handled by elevators until May of 1906. This move forced the Elevator Company to close down their elevators for the time being and store them at the Maashaven. The first effort at introduction of pneumatic grain elevators had arguably failed miserably.[99]

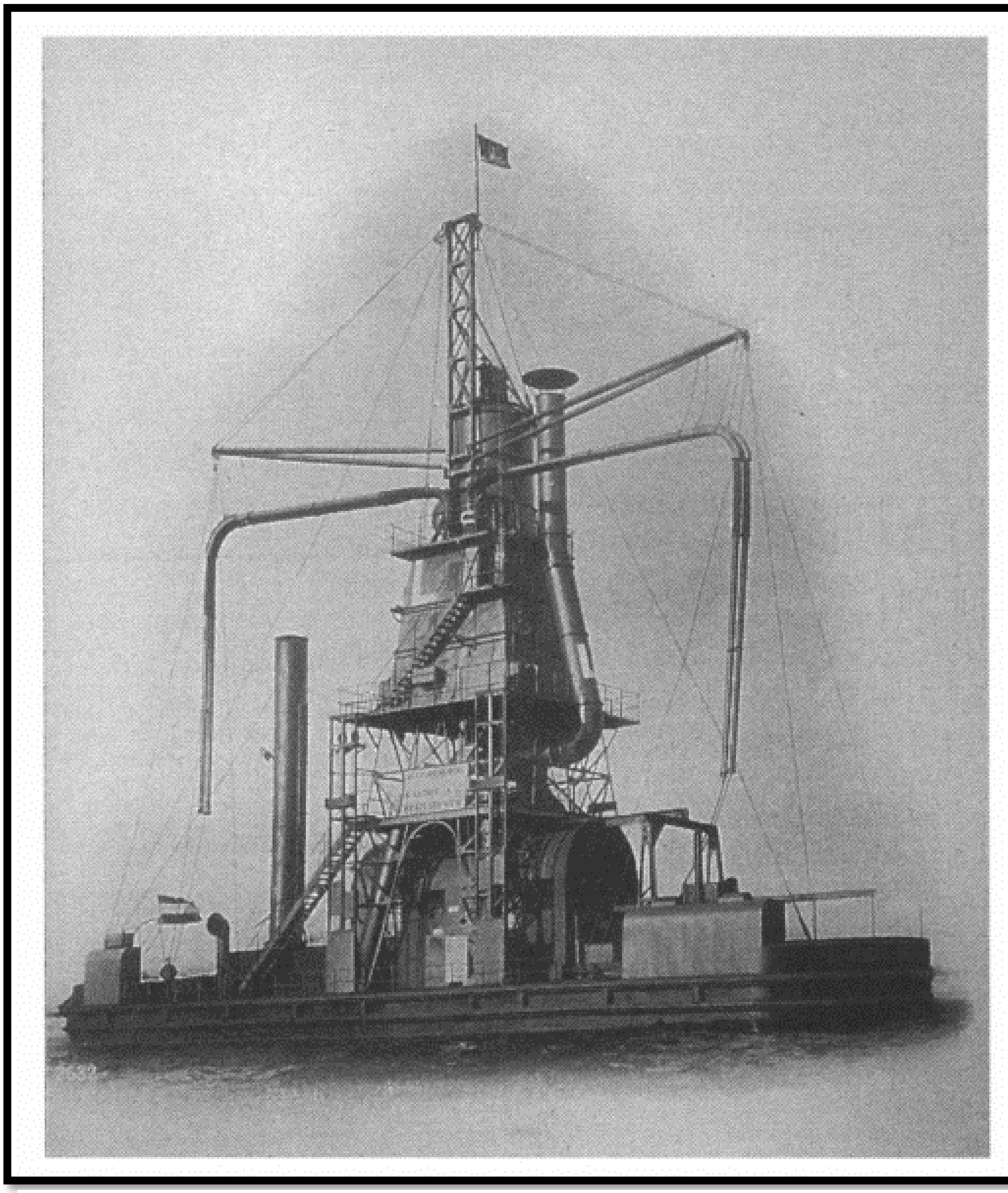

Figure 6: A pneumatic grain elevator of the type Luther delivered in 1905. In Van Lente, ''Machines and the Order of the Harbour'', p. 85.

[99] Van Driel and Schot, "Radical Innovation as a Multilevel Process'' p. 69.

2.4 The second elevator strike and the founding of the GEM

In February of 1906, a committee of prominent grain traders had offered up their final report. It concluded that, in general, opposition to the elevator eclipsed the opinions of those in favour, at least among the grain importers. It should be noted that, while the committee was deemed to be neutral, its head was F. C. Hoyack, a prominent anti-elevator man active within the Rotterdam grain trade. The committee's report once more underlined the general opinion of the grain importers, faster transhipment was simply not deemed to be in their best interest. This was especially the case when the imported grain had not yet been sold in the first place. Besides this, the elevators did not present grain importers with a significant reduction in costs, mostly because the Elevator Company decided not to underbid stevedoring companies in fear of enticing them to rebel.[100]

Despite the fact that the elevators were not in use during the entire year of 1906, the Elevator Company did not remain still. The initial elevator effort failed mostly due to external factors, not due to the technical nature of the machines, which were deemed to be very much technologically capable. Despite the tenuous situation, the company handled around 28.000 thousand tonnes of grain in November 1905 alone. Based on this data, the company was still expected to turn a 45.000 guilders profit for that year. The company's reasoning to continue the effort then, made sense when one looks at the purely numerical side of things.[101]

In the meantime, the Elevator Company did find a temporary destination for the two elevators. An agreement was made with the firm P. Thomsen & Co. to temporarily rent the elevators to said company. The duration of the rental period would last from the 29th of April 1906 until the 27th of April 1907, and Thomsen & Co. would pay the Elevator Company a total of 51250 guilders during this rental period. Next to this Thomsen & Co. were offered the chance to renew this license every following year for the sum of 57500 guilders. The last clause of this contract stipulated that Thomsen & Co. would employ personnel that was already in the service of the Elevator Company in the year 1905, thus employing just as many people as would have been employed if manual unloading were continued. Furthermore, labourers were paid half their wages, even if there was manual work to be done.[102]

When 1907 dawned the elevator-question had regained public presence. Politicians, socialist and liberal, as well as religious, argued that resistance to mechanisation would prove futile in the long run. It was furthermore argued to be irrational and self-defeating. These changes of conception underlined the increasing willingness of the importers to work with the elevators once again. By April of 1907, the Elevator Company had been able to persuade nine of the most prominent grain importers in the port of Rotterdam to resume the elevator effort.[103]

Besides the ideological implications of putting the pneumatic grain elevator into use the conflict had been increasingly characterised by more practical matters, namely control of the

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[100] Van Driel and Schot, "Radical Innovation as a Multilevel Process'' p. 70.
[101] Van Driel and Schot, "Radical Innovation as a Multilevel Process'' p. 71.
[102] Voogd, *De Graanelevators En de Gisting in Het Havenbedrijf Te Rotterdam*, p. 18.
Van Lente, ''Machines and the Order of the Harbour'', p. 92.
[103] Van Driel and Schot, "Radical Innovation as a Multilevel Process'' p. 71.

port, especially in the form of control of labour. The workers' strike had amounted to a power struggle, in which the labourers, both skilled and unskilled, were squared against their bosses, as well as the grain importers. With this the character of the strike changed. The first strike can be argued to have been more impromptu, with the lines of engagement between the parties not always as clear. The second strike however presented a clear delineation of sides, for or against the elevator, with the latter side numbers becoming increasingly smaller in the process. A key condition for the grain importers' joining the elevator effort this time around was the absence of strikes, which they hoped to mitigate by setting up an entirely new weigher's corps made up of those that would not mind working with the elevator. Furthermore, the Elevator Company offered very low prices, as well as eventual compensation if a strike were to break out. The last provision to stop the weighers in particular from striking was the promise of higher wages, which was also stipulated in the contract that was signed. As we shall see, these tactics, while seemingly solid on paper, did nothing to prevent further strikes.[104]

With the Elevator Company on the offensive in early 1907, the elevators themselves were put into use again. When another heavy strike broke out in April of 1907, the Elevator Company aimed to quell it by setting up their own weigher's teams. This precarious decision ended up bringing forth increasing factionalism in the port as a whole. On the one hand there were the labourers and weighers who were still against the widespread use of the elevator, on the other hand the weighers hired by the Elevator Company. The latter were often derogatorily referred to as 'onderkruipers' or 'scabs' by the anti-elevator party, referring to them as a sly and dishonest party who sneakily positioned themselves in favourably towards the Elevator Company. These 'scabs' were to be protected from the mob by strike-

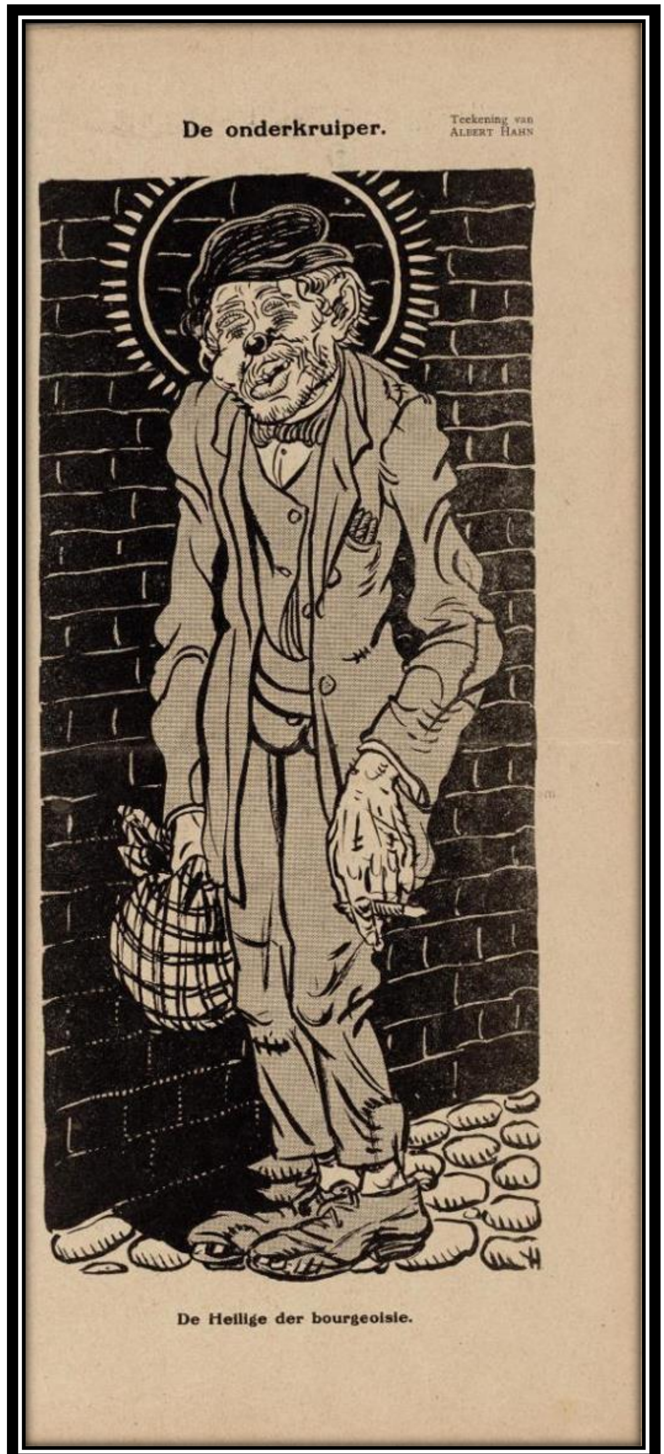

Figure 7: 'De Onderkruiper, the Saint of the Bourgeoisie' Albert Hahn, 1911.

[104] Van Driel and Schot, "Radical Innovation as a Multilevel Process'' p. 71.
Van Lente, *''Machines and the Order of the Harbour'',* p. 100-101.

breakers, and in worst-case scenarios, by local police officers. During the summer months the violence and tension continued to grow, whereupon the mayor, with the support of the city council, proclaimed the port to be in a state of siege. This practically gave the authorities free rein to quell the strike by any means necessary. Ultimately, the strike was only broken up due to the entrance of armed navy officers and their warships into the port of Rotterdam. The violent clash that followed on the 5th of July of 1907 meant that the weighers were now willing to discuss terms with the Elevator Company and the importers, whose patience had by now ran out.[105]

With the weighers resistance more or less brought down, the labourers were the only obstacle that prevented the widespread application of the elevators. The Elevator Company once again reiterated their promise to only unload ten percent of grain in the port through the elevator, at least for the coming three years. Remaining suspicious of these terms, another general strike was called on the 23rd of September of 1907. This time however, the weighers did not join the labourers, having secured their desired wage increase already. Without the support of the weighers, this particular strike had no chance of succeeding. Coupled with this was the bloc created by employers to push for widespread application of the elevators. The strike eventually lasted nine weeks, with the end result only being a wage increase for labourers.[106]

With the rigorous quelling of the strike in July of 1907, the anti-elevator party had definitively lost their leverage in the following negotiations. The weighers were placated by higher wages, and thus posed no further threat to the elevator project. The Elevator Company also managed to swiftly raise enough capital for eight additional elevators in September of 1907. This order was later reduced to six elevators. The easy-going process of raising the required capital in this case presents a marked difference from the first efforts way back in 1903, where the required capital was only raised after an intensive effort that spanned a relatively long period.[107]

The purchase of several new elevators was complimented by the founding of a new company, that would replace the Elevator Company in 1908, the Graan Elevator Maatschappij, or GEM. The GEM would be the company that owned and operated the elevators in the port of Rotterdam until their disuse. The company's shares were equally divided amongst the shipping companies/stevedore firms and the traders/importers. There was also a measure to allow bagged grain to be handled, mostly to placate the importers, who felt that pure bulk supply would be too fast to handle. Later, this concession was amended by the so-called double manipulation technique, which dumped bagged grain in barges, only to bag it again to suit the needs of the importers. This presents a slight accommodation of the older regime. However, by

[105] Van Lente, ''Machines and the Order of the Harbour'', p. 102-103.
Richard Velthuizen, "Innovation in Preservation: Floating Pneumatic Grain Elevator 'Stadsgraanzuiger 19,'" *Tekniikan Waiheita* 39, no. 1 (March 5, 2021): p. 14.
Van Driel and Schot, "Radical Innovation as a Multilevel Process'' p. 72-73.
[106] Van Driel and Schot, "Radical Innovation as a Multilevel Process'' p. 73.
[107] *Ibid*.

1913 the non-manual grain regime had firmly settled in the port of Rotterdam, with over 96 per cent of grain in the port being handled by a total of twenty-four elevators.[108]

2.5 Conclusion

Whereas it can be evident that the introduction of the pneumatic grain elevator in the port of Rotterdam was a monumental event that changed the both the power relations as well as the methods of transhipment within the port, it now rests to answer the appropriate research question, *Did the introduction of the pneumatic grain elevator in the Rotterdam port constitute radical technological change?*

In order to answer this question, it is once again evident to turn towards the threefold model of technological change.

First, the concept of timespan. As mentioned before, in order for an innovation to be truly radical, the period of introduction cannot be too long. With the introduction of the pneumatic grain elevator, one runs into some problems, however. The first effort at introduction in 1905 showed enormous potential, both financially and logistically, however it was halted by external factors, the most important one being the strike that broke out and forced the Elevator Company to refrain from using the elevators for the time being. In this sense, precious time was lost, seeing as it was only in 1907 that the elevators were once again put to work. It could certainly be possible that the introductory process would have been both quicker and easier had the differences between the pro- and against camps not been as large, let alone that these differences would not have led to the strike. In any case, the situation did lead to a strike that severely stretched the time of introduction of the pneumatic grain elevator. However, even with the two strikes taking place the time of introduction was still relatively short, within two years of the first effort, elevators were up and running in the port of Rotterdam and showed no sign of slowing down. In this case then, while the timespan of introduction could have been a whole lot shorter without the strike, the period can still be argued to have been short enough to be qualified as being radical in nature.

Second, the aspect of precedent is also interesting to analyse further. The pneumatic floating grain elevator as it was applied in the port of Rotterdam could be argued to have been conceptually the same as earlier grain elevators, the transhipment of grain from one source to another through usage of a machine. Mechanically however, the apparatus used in Rotterdam starting in 1905 was very different from earlier bucket elevators, including those briefly used in Rotterdam in the late 19th century. In this case then, it can be argued that the precedent set by earlier forms of the grain elevator and its use in the port of Rotterdam is negligible on the later application of pneumatic grain elevators, especially because its significance was not even mentioned by those seeking to render the pneumatic grain elevator serviceable in Rotterdam. To them, the pneumatic grain elevator presented something new entirely unrelated to earlier efforts in grain transhipment. The application of the pneumatic variant of the grain elevator then, can be argued to have been novel enough to be called radical in nature.

[108] Van Driel and Schot, "Radical Innovation as a Multilevel Process'' p. 74-76.

Having singled out the aspects of timespan and precedent, it is prudent to look at impact, which is perhaps the most important aspect of the threefold model in this case. Looking at all the documentary material, it is evident that the introduction of the pneumatic grain elevator in the port of Rotterdam in the years 1905-1907 presented a significant break from the past. To its adherents it became a narrative of modern versus old, as well as progress versus stagnation. Its detractors framed it as a capitalist ploy to control the labour force, or even take them out of the equation entirely. The pneumatic grain elevator proved so divisive that two strikes needed to be broken up before it could properly be applied in day-to-day transhipment. Once it was entrenched in the transhipment process however, its value was more than clear. The aforementioned statistics are more than telling in this. After the strike of 1907 had been quelled, things moved very rapidly indeed. By 1913, a mere six years after the last strike, twenty-four elevators handled 93 per cent of all grain in the port of Rotterdam, making the machine essential to the transhipment of grain as a whole. In short, the whole regime of grain transhipment in the port revolved around the application of the pneumatic grain elevator, it was both essential and insurmountable in the regime it had helped shape.

All in all, looking at the threefold model of radical technological change, the introduction of the pneumatic grain elevator in the port of Rotterdam can most certainly be termed a radical technological change, on that would go on to shape the entire grain business in the port for years to come.

Chapter III:
The Decline and Fall of the Pneumatic Grain Elevator in the Port of Rotterdam

Having looked extensively at the introduction of the pneumatic grain elevator in the port of Rotterdam, it is furthermore interesting to look at the decline and fall of this machine. Whereas the archival and written material on the period of introduction is abundant, the material on the later period is scarcer, and oftentimes more subtle. In the writing of this chapter some key materials have been used, however some claims must invariably remain in the realm of conjecture. This chapter then, serves to illuminate how and why the pneumatic grain elevator disappeared from usage in the port of Rotterdam, but due to nature of the sources, is by no means complete. At the end of this chapter, the research question will be answered, *Did the decommissioning of the pneumatic grain elevator in the port of Rotterdam constitute radical technological change?*

3.1 The post-war years of the GEM up until the 1960s

After the Second World War, the port of Rotterdam recuperated astonishingly. Two main currents within the GEM stand out that serve to show the eventual trajectory towards the eventual decommissioning of the elevators. These are the renewal of the GEM's fleet of elevators and their conversion from steam-powered elevators towards diesel-powered ones, as well as the move from of the GEM's main terminal towards the Botlek. Both currents will be described in detail.

Starting in the 1950s, the GEM aimed to modernise their fleet of elevators. In practice this meant a complete overhaul of existing elevators. In the years spanning from 1954 to 1960, a total of eighteen elevators were converted from steam-powered machines to diesel and oil machines. Archival material shows that this was a costly operation, the first planned conversion to a diesel-powered elevator was estimated to cost anywhere between 476.625 and 493.000 guilders, depending on which company the GEM would contract to fulfil this order. Naturally, larger orders, for example the conversion of two elevators instead of one would incur some financial benefits in the form of a discount. However, this was still estimated to cost more than 924.000 guilders. The GEM however, had to upgrade their somewhat mechanically outdated machines and went on to do so for the rest of the decade.[109]

With the growing minority of the first type of pneumatic elevator, namely the steam-based model, one could argue that the first era of the elevator had ended. The elevator as an important factor in grain transhipment however, had not disappeared. It was however gradually replaced by newer models, not taken out of use entirely. This happened later, as shall be shown shortly.

Next to the renewal of the GEM's fleet of elevators, another current deserves attention. With the gradual displacements of the city's most important ports westward (as detailed in the

[109] For the exact costs of the first planned conversion see Ombouw stoomelevator 16 in dieselelevator 1954-1956, Doc No. 186a, Achive No. 622, Stadsarchief Rotterdam.
For further conversions up to 1960 see Doc Nos. 186b-i, Achive No. 622, Stadsarchief Rotterdam.

first chapter), the GEM also followed suit in 1967 when they moved to a newly constructed terminal in the Botlek. The newly built facility consisted of a silo and several piers, one of which was dedicated to the use of shore-based elevators practicing an indirect form of transhipment. A preliminary document from 1960 details the company's policy in bringing this plan to fruition. It states that, in order to speed up transhipment and handle larger ships, the solely direct method of transhipment had become untenable, and the company had to go over to indirect transhipment through the use of shore-based elevators. This would allow the company to unload ocean-going vessels to both barges as well as directly into the silo for storage. It was also stated that the company expected ships with varied tonnage, from 30.000 to 60.000 tonnes. The direct method of transhipment of grain through the use of floating elevators did remain in place in the Maashaven, where the company had been based since its founding. This same locatation, as well as the Waalhaven were deemed unsuitable for this new enterprise, citing lack of space, and in the case of the Waalhaven, an increasing focus on breakbulk goods rather than bulk goods such as grain. Europoort was also briefly considered as a location for the new terminal, however it was deemed that the completion of its construction would take too long. This meant that the Botlek was the only tenable location, and its terminal was duly opened in 1967.[110]

This massive project was in fact possible because the GEM had been a very profitable company. A report from 1964 suggests that, during the years the Botlek was planned, the company had been turning a steady profit for several years and was expected to continue doing so. For example, the company made a profit of 8.150.000 guilders in 1962, as well as 5.000.000 guilders over the first three quarters of 1963. Expected profits in 1964 and 1965 were calculated at 4.500.000 and 4.000.000 guilders respectively. By the end of 1963, a grand total of 13.720.000 guilders had been invested in the Botlek enterprise, with a further 8.700.000 guilders still to be paid to complete the project. The GEM in the post-war years and the 1960s then, presents itself as a financially healthy company in which no clear signs of decline are visible, they were in fact affluent enough to start expanding even more.[111]

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[110] *Notitie inzake overslag Botlekproject.* Nieuwbouw Botlek - notulen bouwverrgaderingen 1959-1966, Doc No. 273a, Archive No. 622, Stadsarchief Rotterdam.
Persconferentie 8-6-60. Nieuwbouw Botlek - krantenknipsels 1959-1961, Doc No. 273b, Archive No. 622, Stadsarchief Rotterdam.
[111] *Opstelling betreffende de gezamelijke liquiditeit van de vennootschappen H.E.S., Onderlinge, N.B.T. en GEM per 31 december 1965.* Nieuwbouw Botlek - correspondentie i/z financiering bouw Botleksilo 1962-1966, Doc no. 273e, Archive No. 622, Stadsarchief Rotterdam.

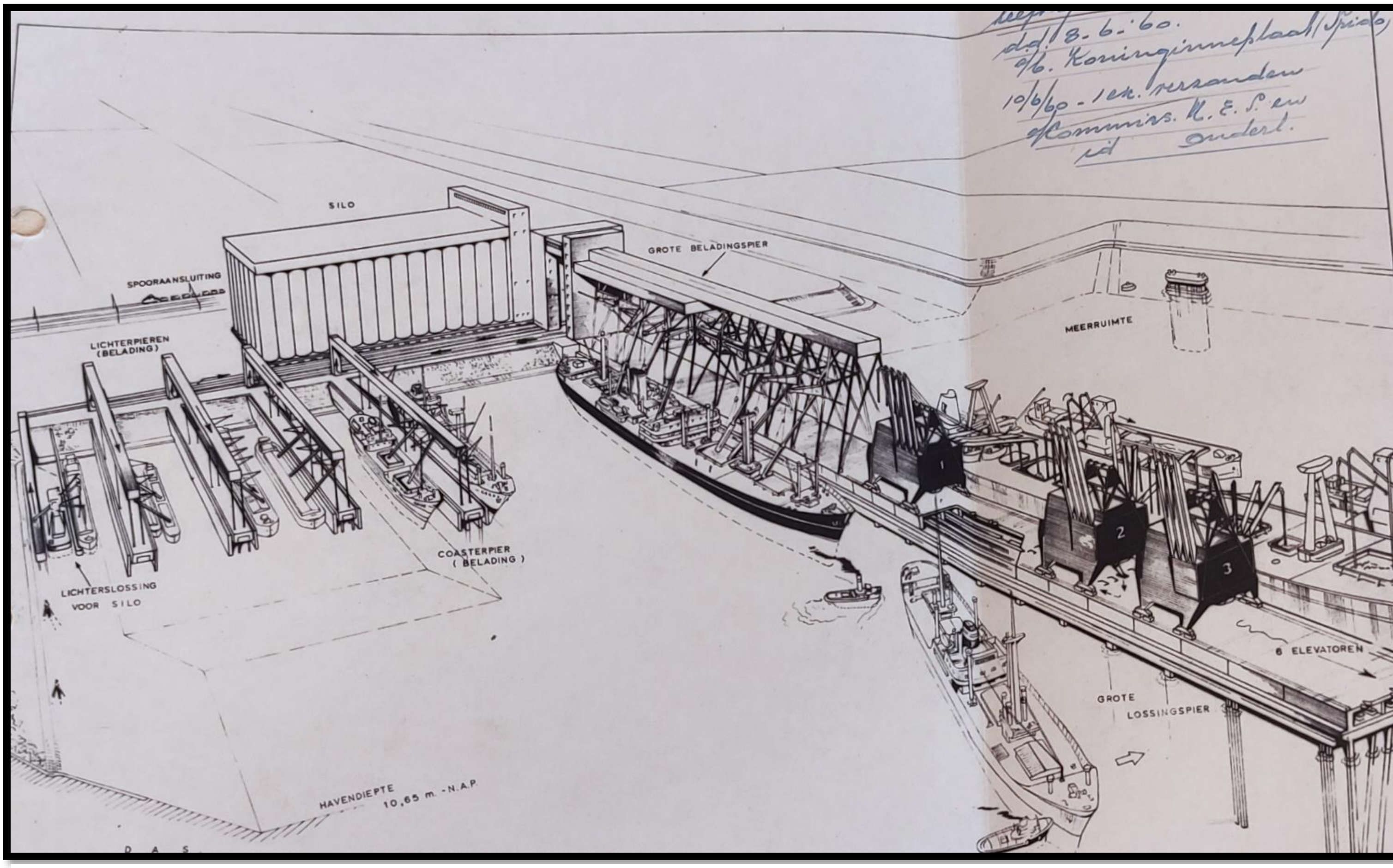

Figure 8: Plans for the Botlek Terminal, Doc. No 273b, Archival No. 622, Stadsarchief Rotterdam.

3.2 The GEM in the 1970s, the glory years

The positive precedent set in the 1960s continued throughout most of the 1970s. The early years of the decade were dedicated to further improvements in both the shore-based elevators as well as the floating ones. In 1973 the largest shore-based elevators up to that point was put into use in the Botlek. The no. 30 was powered fully by electricity and was connected to the power network of the facility. It was able to handle 500 tonnes of grain per hour, a staggering amount when compared to the first elevators, which were only able to handle 150 tonnes in that same timespan. Next to the improvements of shore-based elevators, new floating ones were also ordered to bolster the fleet. A total of two new diesel-powered floating elevators were put to use in late 1973, following an earlier order of two machines. This shows that, while indirect transhipment via shore-based elevators was increasingly important during these years, the floating elevators were still in service and were being replaced by newer models.[112]

[112] De Does, no. 7, 1973, p. 3.
De Does, no. 6, 1973, p. 6.

Some of the oldest models for example, dating from 1931, were put out of use in early 1975. Both the nos. 19 and 22 were thoroughly inspected and were found to be not up-to-scratch anymore. Later that year, in April, following the so-called '1 on 1' ruling, all remaining seven steam elevators still in service were put out of use. The company argued that the application of steam-powered elevators was no longer compatible with the company strategy of continuous improvement. The elevators were old and increasingly faulty, furthermore they caused increasing environmental nuisance, mainly in the form of the large clouds of smoke they emitted. Lastly, the company argued that the old elevators were simply not as energy efficient as the newer, diesel-powered ones, whose energy consumption was up to six times lower while working at the same capacity. With this, the era of the steam-powered elevator was officially over, all of them had simply been replaced over the years and the last few remaining ones were put out of use at the same time. This left the company with a fleet of 18 diesel-powered floating elevators, as well as 7 shore-based elevators at the Botlek.[113]

Some older models were kept in working order to serve as back-up devices, for example in the case of malfunction of newer models. All of these machines however did eventually meet their end when they were scrapped because they did not meet the requirements of back-up machines any longer. Elevators no. 9 and 25 for example, both converted to diesel-powered elevators in 1959, were eventually scrapped in 1978. Others, such as the no. 2, also converted to diesel in 1959-1960, were sold to other parties. The no. 2 in this case to a company active in the port of Gdansk, Poland, where it was shipped in May of 1978.[114]

Another interesting current highlighting the great enthusiasm present within the company during the 1970s was the construction of yet another new terminal, this time in at the Beneluxhaven in Europoort. The new terminal presented another large investment, namely around 100 million guilders. Construction was started in January of 1976 and was to be finished by the summer of 1977. Initial plans revolved around a capacity increase of 6 million tonnes, however this number would eventually grow to 12 million tonnes, bringing the total capacity of the GEM at 25 million tonnes when the Europoort terminal was opened. The terminal itself was fitted with a silo, as well as four shore-based elevators with a capacity of 800 tonnes per hour, which could later be upgraded to a capacity of 1000 tonnes per hour. Ships ranging between 16.000 and 200.000 tonnes were able to be unloaded at this new terminal. The terminal was eventually opened on the 7th of September 1978.[115]

While the Europoort terminal resembled the one in the Botlek in many ways, it presents itself as an even greater scale increase than the former. Within a little more than a decade, the GEM had been able to nearly double their total capacity, from 13 million tonnes to 25 million tonnes.   Company growth reports reflect that this made much sense business-wise. During the 1970s, the GEM continued to break total transhipment records nearly every year throughout

[113] De Does, no. 4, 1975, p. 1.
[114] De Does, no. 3, 1978, p. 5.
De Does, no. 4, 1978, p. 10-11.
De Does, no. 5, 1978, p. 12.
[115] De Does, no. 1, 1976, p. 3-5.
De Does, extra editie, April 1977, p. 8-11.
De Does, no. 4, 1977, p. 2.
De Does, no. 6, 1978, p. 2.

the 1970s. In 1970, the GEM transhipped 10.7 million tonnes of bulk goods, 4.7 million tonnes of which consisted of grains. In 1977 this number had grown to 17.6 million tonnes of bulk goods, around 5.5 million of which consisted of grains. By 1980, this number would grow even more, to a total of 19 million tonnes. The company's directors did acknowledge that this fortuitous situation could change very swiftly, especially with the rise of competing ports such as Gent and Antwerp, as well as high domestic unemployment and stagnating domestic production. It furthermore argued that the company could not sit still if it wanted to maintain its dominant position.[116]

3.3. The GEM in the 1980s and early 1990s, the decline and fall

Contrary to the 1970s, the 1980s presented the GEM with increasing problems, some of them directly related to the eventual decommissioning of the elevators. Contemporary material shows an increasing pessimism, especially when compared to the seemingly unbridled optimism of the 1970s. The root cause of this increasing pessimism was already made clear by the directors as early as the end of 1979, citing the ongoing energy crisis of 1979, as well as even more competition from nearby ports. 1979 was also the sole year in the decade in which the total transhipment of the GEM did not grow, it even declined by around 500.000 tonnes.[117]

During the early 1980s other problems were also at the forefront, one directly related to the increasing competition from other ports such as Bremen. This related to the agricultural policies set out by the European Economic Community (EEC), which increasingly favoured interconnectedness of European agricultural markets. These policies furthermore offered grain importers increasing flexibility in choosing where to import their grain from, something that could do harm to specific ports such as Rotterdam. The EEC also restricted imports of tapioca, a derivate good that was handled by the GEM, from Thailand. This furthermore hampered the company's total cargo growth, seeing as tapioca inflow was a pivotal product in maintaining positive cargo growth.[118]

Despite the disappointing growth results, the 1980s did see the rise of even larger and more productive elevators, an example of which is the 80-series. Elevator no. 85 for example, was fitted with two separate diesel engines, which was argued to be more energy-efficient, and was 49 meters tall, nearly 20 meters taller than the first models. It was able to handle ocean-going vessels up to 200.000 tonnes at a rate of 1.000 tonnes per hour. It went into operation in late 1980.[119]

Perhaps even more important was the construction of a continuously operating mechanical chain-transporter, the SKT 1, which did not have any pneumatic features. It furthermore did not have any equipment to bring bulk material to the centre of the ships' hold in order for it to be picked up, this was to be done with bulldozers, rather than by the machine itself, as had been the case with the elevators. The SKT 1 however, was still a floating mechanism, being placed on a pontoon in order to get alongside vessels and unload them. The

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[116] De Does, no. 6, 1978, p. 10.
De Does, no. 8, 1978, p. 3.
[117] De Does, no. 8, 1979, p. 3.
[118] De Does, no. 8, 1980, p. 3.
[119] De Does, no. 2, 1980, p. 3.
De Does, no. 8, 1980, p. 4.

SKT 1 was also an expensive machine, costing over 11.5 million guilders to build. Capacity remained around the same as the newest, most technologically advanced elevators, at around 1000 tonnes per hour. It furthermore boasted relatively low energy consumption, about half of what the elevators were using. Undoubtedly this played a key role in the company's struggle against an ever-increasing uncertainty regarding energy supply. The company maintained that, while this new non-pneumatic solution would surely become more important in the years to come, pneumatic transhipment would continue to be used in order to remain flexible in all possible situations. However, it was conceded that there were limits to the hourly capacity of pneumatic elevators, limits that were now being reached. The SKT 1 was put into use at the Europoort terminal in the first half of 1981[120]

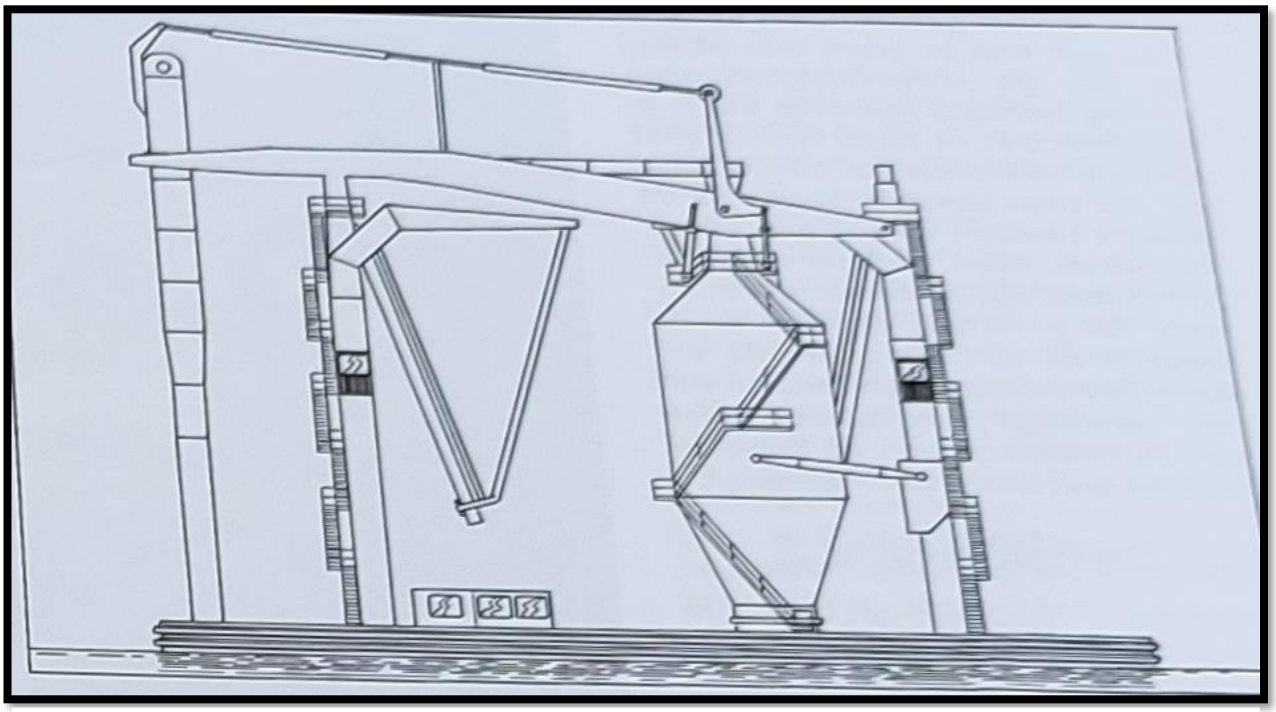

Figure 9: Rendition of the SKT 1, De Does, no. 8, 1979, p.5.

Concerns were raised as early as 1981 about whether or not the ongoing drive towards innovation in grain transhipment was wise. Next to the 80-series of elevators and the newly constructed SKT 1, the GEM also renovated the Botlek terminal in 1981, upgrading its elevators to operate from 400 tonnes to 650 tonnes per hour. The company's directors maintained that, in order for the company to function properly, innovation and expansion in capacity had to continue. In hindsight this seems like a pivotal mistake. Throughout the 1980s, the GEM focussed their efforts on improving the machinery used primarily for transhipment in grain. However, the transhipment of this specific good had not been growing as steadily as the capacity of the elevators. In fact, the flow of grains and seeds had been declining rapidly. In 1980 a total of 2.132.000 tonnes of grains and seeds had been handled by the GEM, in 1984,

[120] De Does, no. 8, 1979, p. 4-5.
De Does, no. 3, 1980, p. 9.
De Does, no. 6, 1980, p. 5.
De Does, no. 2, 1981, p. 3.

this number had diminished to only 874.000 tonnes, a staggering decline of 59 per cent, this was mainly caused by the stringent agricultural policies by the EEC mentioned before. Numbers would recover towards the end of the decade, peaking at 1.171.000 million tonnes in 1986, however this was still just over half of the total of 1980. By 1987 the total share of pure grain had also diminished severely. Only a fraction of the total products handled by the GEM were pure grains, 6 per cent to be precise, in 1970 this number had been 37 per cent of total goods handled. It seemed that the company had invested in high-capacity machinery that was simply not necessary when looking at the declining freight numbers and an increasing transhipment of derivates of grain, rather than grain itself. These derivates could more easily be transhipped by crane, a policy that the company would come to pursue by the dawn of the new decade. Towards the end of the decade then, the mood set out by the board of directors was sombre, the company would have to restructure if it was to survive into the next decade. [121]

The GEM's holding company, HES Beheer proved pivotal in this restructuring drive. It aimed to diversify the company's assets, moving beyond grain towards more varied goods such as ores and coal. The GEM had been plagued by rising costs, as well as technical malfunctions, to which the SKT 1 proved extraordinarily prone (its counterweight mechanism broke off completely during one incident in 1990), and it was agreed that the GEM would have to pursue a cost-cutting strategy throughout the 1990s. For those employees that did not want to await the outcome of the restructuring, a severance agreement was negotiated, all in all a total of 111 employees had made use of this agreement by December of 1989 alone. Meanwhile, the company director had been put on administrative leave since he did not agree with the policy set out by the holding company. Any potential investments by external parties proved difficult, no proper proposal was ever submitted to the board of directors.[122]

It was during this tumultuous period then, that the GEM decided to gradually start operating grabbing cranes to tranship grains, eventually replacing the elevators altogether. It was decided that this application would consist of floating grab cranes that would grab produce from the hold, and weighing towers, which would weigh the grain before it could be sent to its destination. It was furthermore decided that several elevators, as well as several pontoons would be converted to weighing towers in order to reach a large enough weighing capacity. The first crane was ordered on the 14th of September of 1990. The 25-tonne heavy crane had a capacity of around 1200 tonnes per hour and was constructed by Figee in Haarlem. The GEM furthermore took an option on another crane, weighing 36 tonnes.[123]

The first grabbing crane was put into operation on the 15th of August of 1991. The aforementioned 36-tonne crane that was under option was eventually also ordered, being put into operation in December of 1991. The company strategy of transhipment by crane continued

[121] De Does, no. 6, 1981, p. 3.
De Does, no. 3, 1985, p. 11-16.
De Does, Juni 1987, p. 18-19.
De Does, Juli 1988, p. 8-9.
[122] De Does, no. 1, 1989, p. 2.
De Does, no. 2, 1990, p. 2.
De Does, no. 9, 1990, p. 1-3.
[123] De Does, no. 8, 1990, p. 2-3.
De Does, no. 11, 1990, p. 2-3.

steadily onwards, despite internal criticisms, until the demise of the GEM as an independent company in 1993, when it was merged into European Bulk Services and ceased to exist as an independent company.[124]

Figure 10: Artist impression of the GEM's effort at employing cranes, 1992.

3.4 Conclusion

Despite internal criticisms regarding the operation of cranes, the application of cranes continued, and eventually superseded the use of pneumatic grain elevators. Nowadays, cranes are the only piece of equipment used to tranship grain in the port of Rotterdam, with all of the elevators eventually consigned to the scrapyard or sold to foreign parties.

Having sketched the history of how the elevators lost their primacy in the port, it now becomes possible to answer the research question set out for this chapter, namely: *Did the decommissioning of the pneumatic grain elevator in the port of Rotterdam constitute radical technological change?*

[124] De Does, no. 7, 1991, p. 1-3.
De Does, no. 8, 1991, p. 1-4.
De Does, no. 3, 1992, p. 4.

By once again looking at the threefold model of radical technological change, we can ascertain whether or not the decommissioning of the elevators can be considered a radical technological change.

First, the concept of timespan can be analysed. Contrary to the introduction of the pneumatic grain elevator, the decommissioning of said machine was a significantly more gradual process. When the SKT 1, the first non-pneumatic device used to tranship grain since the introduction of the elevators, was first put into operation in 1981 it did not spell the end for the conventional elevators. Neither did the introduction of cranes in the early 1990s. Rather, the differing regimes of transhipment existed side-by-side for some time. There are examples of instant decommissioning of elevators, for example when the entire fleet of old elevators was scrapped in 1978, in favour of newer models. These newer models served as a replacement of the older ones however, and thus the elevator as a whole remained very much in active service. It was only gradually, after the GEM ceased to exist as an independent company that all of the elevators came to be scrapped or sold. In regard to timespan then, the decommissioning of the elevators was too gradual to be termed radical in nature.

Second, when looking at the concept of precedent several remarks can be made. When cranes came to the fore to replace the elevators, the technology at play did not seem remarkably new, especially not compared to the technological breakthrough that pneumatic elevators presented. Cranes had been in use for decades throughout the port of Rotterdam, especially to tranship coal and ores. The only new aspect was that they were now used to tranship grain, which had not been the case before. All in all, besides their higher capacity and larger stature, the cranes were based on the basic concept of cranes as they had been decades before and can thus not be termed radical in nature.

Third and last, the concept of impact is perhaps the most interesting to look at in this case. The application of cranes to tranship grains did prove impactful for the business conducted by the GEM and its successor. This impact can be argued to come from necessity, rather than from design. Fraught by decreasing imports of grain, as well as decreasing revenues, the decision was made to opt for a more responsive transhipment strategy that was furthermore cheaper to maintain. The regime of grain transhipment therefore changed from one of continuous work to a more responsive one which had to be ready to tranship if and when necessary. Conclusively, whereas the regime did change after the introduction of the cranes, this had more to do with the general state of grain transhipment being sub-par, rather than due to the application of a new technology, rendering the application of cranes non-radical in nature.

All in all, then, looking at the documentary evidence and at the threefold model of technological change, the application of cranes to tranship grain cannot be termed radical in nature. In this it differs from the introduction of the pneumatic grain elevator, which was, as we have seen, truly radical in nature.

Conclusion:

The distinct case studies that have been analysed show the immense influence that technological innovations and applications can have on port regimes. The analysis at the end of the first chapter has shown that, while interesting, not all can truly be named radical in nature.

Furthermore, having covered both the introduction and decommissioning of the pneumatic grain elevator, as well as an array of other technological applications earlier on in this thesis, it now becomes possible to answer the main research question, namely: *Why can the introduction and eventual decommissioning of the pneumatic grain elevator in the port of Rotterdam be considered examples of radical technological changes?*

The introduction:

Following the research presented in the second chapter of this thesis it becomes clear that the introduction of the pneumatic grain elevator can most certainly be considered a radical technological innovation. When looking at the threefold model of radical technological change it was found that timespan, precedent, and impact were all deemed to be radical in nature. The elevators were put to work in a relatively short period, they were not overly based on earlier technologies, and most importantly, they completely changed the regime of grain transhipment in the port of Rotterdam. This impact is not to be understated, as the further chapters have brought us to a point where elevators of some shape or form had been at work in the port of Rotterdam for a period of over 80 years. The introduction of the pneumatic grain elevator in the port of Rotterdam in 1905, and again in 1907 then, presents us with a clear-cut example of a radical technological change.

The decommissioning:

The decommissioning of the pneumatic grain elevator on the other hand presents us with a wholly different outcome. Burdened with a bleak financial picture, as well as disappointing results when looking at cargo flows, the GEM felt itself forced to react accordingly. It opted for the increasing application of cranes instead of elevators, arguing that these were more adaptive to the new situation, as well as more economical. It did however maintain that it would continue to use both pneumatic applications as well as the cranes. Because of this, there is no clear-cut point where the elevators were taken out of use, and the cranes took over. It is clear however, that this increasing use of cranes instead of elevators eventually spelled the end of the latter. This process, however, cannot be termed radical under the conditions of the threefold model of radical technological change. The decommissioning of the pneumatic elevator was gradual, rather than sudden. Furthermore, the technologies that came to the fore in the application of the cranes was not necessarily new or innovative, at least not much as the pneumatic grain elevator had been. Lastly, whereas the regime of grain transhipment did change, this had more to do with decreasing grain transports in general, rather than the application of the cranes per se. It can thus be claimed that, while an interesting case study, the decommissioning of the pneumatic grain elevator does not present us with a case of radical technological change.

All in all, then, it can be argued that the introduction of the pneumatic in the port of Rotterdam presents itself as a radical technological change, whereas the decommissioning of these machines does not constitute a radical technological change. Both cases, as well as the case studies addressed in the first chapter, however, show us what technological innovations can achieve given the right conditions, and what sometimes cannot be achieved through the application of these technologies.

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